ORTHODONTICS FOR DENTAL STUDENTS

FOURTH EDITION

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Preface

In this Fourth Edition an effort has been made to make the text more acceptable and understandable to international readers because malocclusion is not limited by national frontiers. The text is regarded by this new team of authors as an introduction to ortliodontics and is written primarily to aid the undergraduate student. It is no substitute for clinical instruction at the chairside, to which it is complementary. It is not intended for those studying for higher qualifications but it is possible that the general dental practitioner will find assistance in the diagnosis of various orthodontic anomalies and in the treatment of the more simple forms. The aim of the authors remains, as in previous editions, to introduce the subject to the undergraduate in a logical manner so that the underlying principles of normal growth and development, together with the causes of malocclusion and its treatment, can be more readily understood. We have to acknowledge the part played by Tom White in developing this approach which we still endorse. The introduction of ancthcr author from Glasgow University and one from India has made it possible to sustain an orderly approach which will be suitable for undergraduate students in other parts of the world. No attempt has been made to present a comprehensive picture of the whole orthodontic field and the methods of treatment that are described may not be the only means of overcoming a particular orthodontic anomaly.

We continue to be grateful for the memory of Tom White and for the help and encouragement of our friends from all over the world.

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1. Introduction

DEFINITION

The word orthodontics is derived from the Greek words ορθός meaning right or correct, and οδόντος meaning tooth. AUhough etymologically this term is quite correct, it is in fact an inadequate description of the subject as it is conceived today. The following definition is as practical as any:

'Orthodontics is the study of growth and development of the masticatory apparatus; it deals with the prevention and treatment of irregularity and malocclusion of the teeth'. In applying this circumscribed definition, however, it is important to appreciate that because growth of the face and jaws is closely correlated with that of the whole body, the study of orthodontics must embrace the general growth and development of the individual.

HISTORY OF ORTHODONTICS

Although Hippocrates (460-377BC) was the first to comment on craniofacial deformity, the first written reference to orthodontic treatment is by Celsus (25BC-AD50), who described the movement of teeth by digital pressure. The first description of an orthodontic appliance is by Fauchard in 1723, although similar appliances had probably been used for some years previously. At that time the usual procedure was to ligate irregular teeth to a rigid arch form until they moved into alignment, and such devices were used on an empirical basis by dentists throughout the nineteenth century. Up to the end of the nineteenth century orthodontics was understood to be merely a means by which irregular teeth could be straightened. Little significance was attached to the mutual relations of two arches, and the functional movements of the mandible

were largely ignored. It was not until Edward Angle published his classification of irregularities and malocclusion of the teeth in 1899 that orthodontics made any progress as a science. Upon this classification were based the advances of the next thirty years. More recently, however, great progress has been made towards a better understanding of the aetiology of malocclusion and in the techniques available for its treatment. Worthy of mention are C. S. Case, M. Dewey and M. Hcllman in the U.S.A. and A. Bjork, J. C. Brash, E. S. Fricl, G. Korkhaus and A. Lundstrom in Europe.

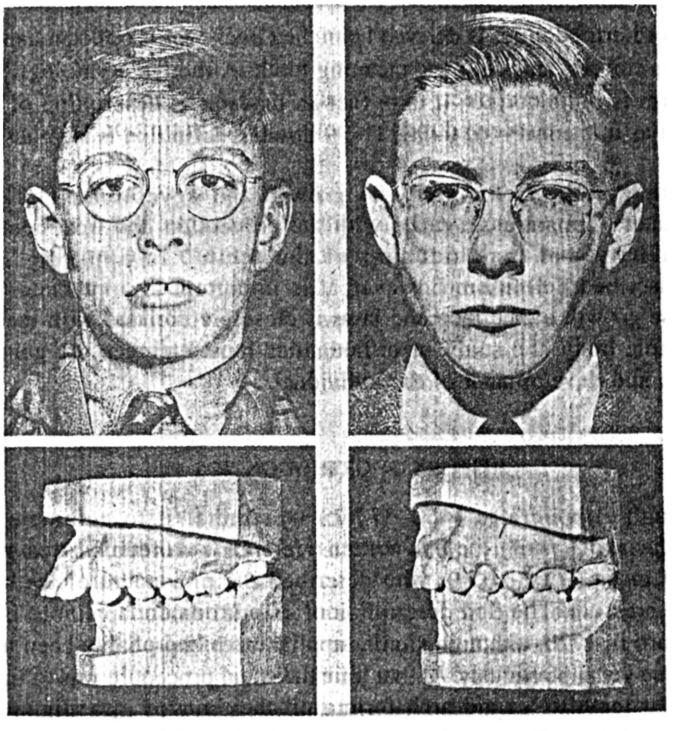


Fig. 1. A boy for whom appearance as well as function was improved by simple orthodontic treatment.
A Before treatment.
B After treatment.

INTRODUCTION

NATURE OF MALOCCLUSION

Before any malocclusion can be studied, it is necessary to be fully acquainted with normal occlusion. In orthodontics, as in any biological study, it is particularly important to appreciate that there is no single condition which can be defined as normal.

Within the very wide spectrum of morphological features that presents, although there may be only one 'ideal', there will be a range of values that can be regarded as normal.

Studies of dental development have shown that, as the child grows, tooth alignment and occlusion may change in a variety of ways even where the occlusion eventually develops quite normally. It is therefore necessary to have sonic knowledge of such variations before attempting to identify cases where there is a developing malocclusion. It is, moreover, likely that the extent of normal variation, and even the type of variation is not the same in all ethnic groups. The dividing lines between normal occlusion and malocclusion arc therefore ill-defined; it may be difficult to decide whether some features lie at the extreme range of normal variation or whether a malocclusion is present. Because of this area of uncertainty the proportion of the population with nonnal occlusion is reported differently in different surveys, depending on the age of the sample and the way in which the normal range has been defined.

THE NEED FOR ORTHODONTIC TREATMENT

Irregularity and malocclusion of the teeth are the expression of an inharmonious development of those parts which contribute to the masticatory apparatus. The need for treatment may arise for the following reasons:

Appearance

The great majority of patients seeking orthodontic treatment do so because they are dissatisfied with the irregular appearance of their teeth. Shaw (1981), in a large survey of adults and school children, showed that a regular arrangement of the anterior teeth is an important factor to anyone appraising a new acquaintance.

School children with projecting upper incisors or displaced canines will often be teased unmercifully by their peers because of their appearance and, though some with a strong personality may survive this ordeal without psychological injury, many will suffer agonies of non-conformity.

These problems can usually be successfully treated by orthodontic appliances.

Trauma to the supporting tissues of the teeth

This condition is usually first observed by a dentist, the patient being unaware of any problem until a tooth becomes loose. Fig. 2 shows a traumatic occlusion in which one lower incisor has been trapped labial to the upper incisors. Occlusal force is transmitted across the long axis of Ihc lower incisor, which is forced forwards against the labial plate of Ihe lower alveolar process. Without treatment this displacement is usually progressive with eventual loosening and finally loss of the tooth. With careful occlusal guidance this situation can usually be intercepted and prevented from development or at least treated before irreversible damage has occurred.

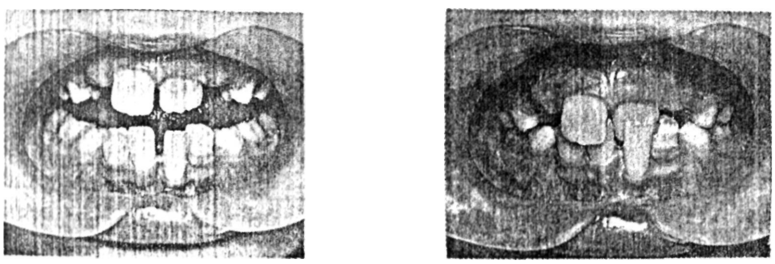


Fig. 2. Gingival recession around a lower central incisor, associated with labial displacement of the tooth.

Trauma to teeth

Trauma to a tooth itself may arise from abnormal occlusion. Where dental irregularity places excessive stress on an individual tooth or group of teeth, wear facets appear on the enamel surfaces and progressive attrition may eventually destroy the crown. Carefully planned tooth movement can correct the relationship of teeth and obviate the need for later complex restorative treatment.

Trauma to the oral mucosa

An abnormal position of upper or lower incisors may cause them to occlude against the mucosa of the opposing jaw instead of against antagonist teeth. When this occurs, particularly at the gingival margin, p.il.ilal to the upper incisors and labial to the lower incisors, mucosal ulceration may result causing recurrent pain and periodontal damage, Repositioning the incisors by orthodontic treatment can relieve this trauma and improve function and appearance.

Risk of Trauma to the Upper Incisors

Teeth which project and are not covered by the lips are especially susceptible to fracture. Boys are probably more at risk than girls as a result of their greater involvement in contact sports. Thus, in addition to the need to improve facial appearance, orthodontic treatment may well be justified to reduce the risk of injury to the teeth.

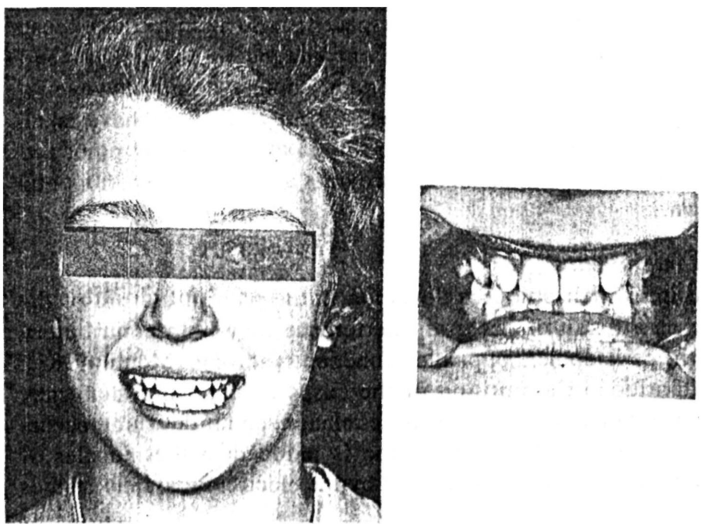


Fig. 3. A case where early extraction of upper lateral incisors has allowed the canines to erupt adjacent to the centrals; they have been shaped with a stone to resemble lateral incisors.

Dental Caries

It has been postulated that irregular teeth are more susceptible to decay than teeth which arc well aligned (Miller, J. and Hobson, P. 1961). A number of studies have investigated this relationship with conflicting conclusions, but it seems likely that irregularity itself cannot be implicated. Caries arises from bacterial action within the plaque which is deposited on tooth surfaces. It can be discouraged by avoiding a build up in the thickness of plaque and by reducing bacterial acid production within the plaque layer by the use of fluorides. Where irregular teeth arc kept scrupulously clean they arc no more at risk of caries than well aligned teeth. In view of the increased difficulty in maintaining good oral hygiene in this situation, however, dental irregularity must be regarded as a contributory factor to caries.

Periodontal Disease

Although the aetiology of periodontal disease is not yet fully understood, the diffusion into the gingival sulcus of toxic substances produced in plaque is one factor which has been clearly implicated (McPhee and Cowley, 1981).' Any feature permitting the build up of thick layers of plaque on the tooth surfaces will therefore contribute to periodontal disease, and dental irregularity is one such factor. The mechanical impaction of food into the interdental spaces is also an immediate cause of periodontal trauma. This may be encouraged by the drifting and rotation of malaligned teeth which open contact points that would normally protect the gingival papillae. Where extractions have taken place and teeth have been allowed to tilt, an absent contact point and enlarged interdental attachment area provides a site prone to periodontal breakdown.

Occlusal interference

Malocclusion which produces deviation in the path of closure of the mandible as a result of occlusal interference may be a contributory factor in the development of pain dysfunction syndrome (Mohlin 1983).

Irregularities in the position of the cusps of opposing teeth may prevent mandibular closure in a centric relation, and if deviation occurs it means that asymmetric contraction is induced in the muscles of mastication. This has been confirmed by the electromyography studies of Moss.

Although the aetiology of pain dysfunction is not well understood it appears often to be related to muscle spasm in the head and neck region and is associated with periods of stress and anxiety. As, empirically it is frequently relieved by eliminating mandibular deviation, there seems little doubt that in many cases malocclusion is a predisposing factor. Treatment to eliminate occlusal interferences, either by tooth movement or by cuspal grinding, is usually indicated where mandibular deviation is present.

An Adjunct to Restorative Dentistry

Where teeth have drifted as a result of dental extractions or periodontal disease, it is often necessary to reposition them to facilitate restorative procedures. The uprighting of tilted molars and premolars prior to bridge

[1] McPhee, T. J. and Cowley G. (1981). *Essentials of Periodonlology and Periodontics*. Third Edition, Chapter 4. Blackwell. Scientific Publications.
[2] Moss, J. P. (1982). An Electromyographic Study of Post-extraction Orthodontic Patients, *Swedish Dental Journal*. Supplement No. 15, 171-7.

construction, or the closure of spacing (Fig. 3, page 5) before making a partial denture, arc examples of the way in which orthodontic procedures may assist other disciplines.

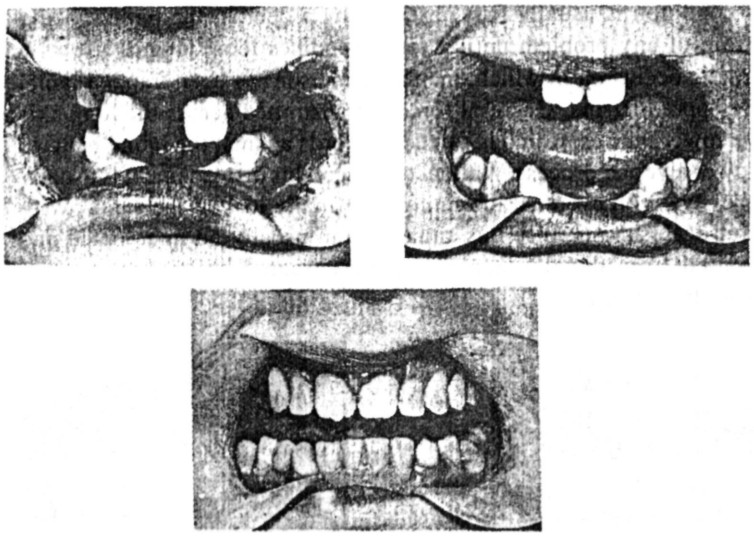


Fig. 4. A case of partial anodontia (oligodontia) in which a large upper central diastema was closed with an orthodontic appliance before fitting parlial dentures.

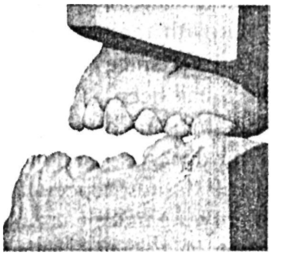
THE AIMS OF ORTHODONTIC TREATMENT

All branches of dentistry have one common aim, the establishment of as good an occlusion as possible, not only in the functional but also in the aesthetic sense. Achievement of this aim may be sought by restoring the contour of the natural crown of the tooth where this has been damaged by caries, or by removing the teeth entirely, where pathological processes have made this necessary, and replacing the natural teeth by prostheses. The aim of orthodontics is to achieve a functional and aesthetically harmonious occlusion by altering pennanently the positions of the natural teeth. As we shall see later, this is accomplished by the careful stimulation of alveolar bone tissue to alter its shape and to support the teeth in a more favourable position. Naturally such tooth movements can only be carried out with extreme care and many factors have to be considered. Furthermore such treatment cannot be undertaken rapidly; many months, or even years, may elapse before the operator can admire the results. This protracted treatment period may make orthodontics to some an unattractive study and some patients can find it difficult to

maintain co-operation over such a long period. Nevertheless, there arc few more rewarding aspects of dentistry than to alter an unsightly and ill-functioning occlusion to one which is harmonious and effective (Fig. 1).

It is important that in planning our treatment objectives, we suit our treatment to the individual patient, bearing in mind the strain that prolonged treatment may have on the tolerance of some patients. Some minor irregularities may be perfectly acceptable and require no Ircatment. Where treatment is necessary, some patients may best be served by a quick straightforward treatment with a simple appliance, while others will benefit from complex appliances to achieve ideal occlusion. In cither case the use of appliances should be kept to the minimum necessary to attain the desired result so that there is minimum interference with normal growth changes and function.

Fig. 5. Case of extreme prenormality of the mandible and maxillary retrusion which is unlikely to benefit from orthodontic treatment and will require surgical assistance.



OHJECTIVES OF A COURSn IN ORTHODONTICS FOR THE UNDERGRADUATE

The following arc considered to be the aims for equipping ihe undergraduate for entering general practice:

i. to recognise normally from abnormally developing occlusion.

ii. to know when to refer a case for orthodontic advice,
iii. to be able to select cases for treatment by the general practitioner from those which should be referred for specialist advice (Fig. 5, page 8).
iv, to know enough of normal development and the aetiology of malocclusion to be able to avoid creating malocclusion when undertaking routine dental care.
V. to be capable of undertaking simple inlcrceptive measures,
vi. to be able to differentiate cases requiring treatment from those for whom treatment may not be necessary.

2. Normal Development

Although we might seem to be concerned primarily with the relations of tooth crowns to each other, we cannot ignore the greater concept of the whole masticatory apparatus, of which the tooth crowns are only a part. Their relations during function are an expression of the sum total of a number of influences which contribute to the development of the masticatory organ. In order to recognize and understand deviations from satisfactory development it is necessary to have a thorough knowledge of the processes whereby normal occlusion is evolved.

GROWTH AND DEVELOPMENT OF THE HEAD

It is considered convenient to divide the study of human development into two parts, that which takes place before birth and that which occurs after birth. This has the advantage of segregating embryology and early development. It must, however, be remembered that birth is an arbitrary, though none the less convenient, dividing line. Growth immediatcly before birth is very similar to that which takes place afterwards. The growth and development of the head and face will be discussed from the stage of birth onwards, and the reader is recommended to refer to that part of a standard work on embryology which deals with the development of the face before birth.

At birth the head of the infant is relatively large, the size being due to the advanced state of growth of the brain. The face at this age forms only one-eighth of the bulk of the head, whereas in the adult it forms one-third to one-half of the bulk. This is illustrated in Fig. 6. The vault of the cranium being so large in the infant that the face appears to lie under the bulge of the forehead. A comparison of the proportions of the face itself will reveal that the infant face is relatively much broader and

shorter than that of the adult. This difference is particularly marked below the level of the orbits. It is obvious, therefore, that there will be less increase in bulk of the cranium after birth as compared to the rest

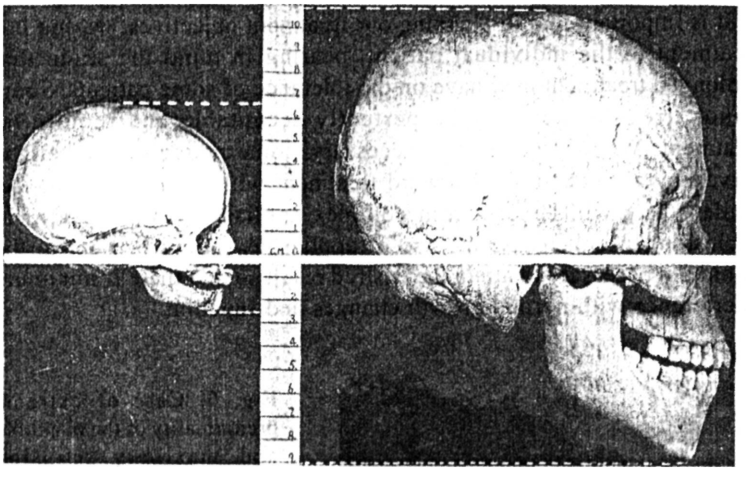


Fig. 6. Comparison of infant and adult skulls to illustrate the changes of proportion that occur with growth.

of the body. In fact the volume of the brain at seven years is three-quarters of that of the adult, and at fourteen years is almost as great as that of the adult.

Growth includes the increase in size of all tissues, both hard and soft. Ever since the observations of Hunter on the growth of the jaws, there has been an interest in studying the mode of growth of bones. This study has a special significance in orthodontics because this subject is one dealing with bones in particular. Very little is known of the growth of soft tissues, especially muscle. Nor do we understand fully the effects of growing muscle upon growing bone. Bone may grow in either of two ways:

(i) By addition of bone tissue to the surface under the periosteum—(appositional growth),

(ii) By the growth of fibrous tissue or cartilage which is progressively converted to bone, as occurs in sutures, synchondroses, and the condylar cartilages—(interstitial growth).

In the latter case, under certain conditions, the growth of the fibrous tissue or cartilage may occur more rapidly than its conversion to bone. Subperiosteal apposition of bone is necessarily a slow process, because the growth of the bone tissue takes place only at the slow rate at which

calcium can be mobilized. A rapid increase of size, however, may occur as a result of growth of cartilage or fibrous tissue, which is later converted to bone at leisure. It will be found that where increase of size is rapid, growth takes place by means of an increase of sulural fibrous tissue or cartilage. For the most part, during the early years of life, the face is growing rapidly, and the greatest amount of growth takes place in the sutures. This is gradually replaced by surface apposition as the rate of growth decreases.

I'or the purpose of studying growth of the head, it may be sub-divided as follows:

(A) Growth of the cranium:
  (i) the vault,
  (ii) the base.

(H) Growth of the face:
  (i) the upper face,
  (ii) the mandible.

(A) *Growth of the Cranium*

The vault of the cranium is divided into segments by sutures which are sufficiently wide to be palpable at birth. The edges of the bone adjoining the sutures become approximated during the first two years of postnatal life. Concurrently with growth in the sutures, appositions and absorption adjust the shape of each bone to the lessening curvature of the skull as the cranium is enlarged and, after the age of seven years, account for much of the growth of the cranial vault. Apposition of bone on the external surface also increases the thickness of these bones. The development and extension of the frontal sinuses, particularly about the age of puberty, accompany rapid additions of bone to the facial surface of the frontal bone in the superciliary region.

The base of the cranium grows at several cartilaginous sutures, the most important of which is the spheno-occipital synchondrosis, between the bases of the sphenoid and occipital bones (Fig. 7). The great wings of the sphenoid and squamous part of the occipital bones are separated by the wedge-shaped petrous portions of the temporal bones. Growth at these obliquely placed sutures contributes to increases of width and length of the cranium. The sutures between the sphenoid and frontal and ethmoid bones are also important cranial growth sites up to the age of eight years.

The spheno-occipital synchondrosis is active throughout the growing period and does not close until late adolescence or early adult life. The manner in which growth takes place here is similar to that of the epiphyses of the long bones. It is affected in the same way by bone

dyscrasias. The direction of growth is along an axis which is directed forwards and upwards. It therefore carries the upper part of the face and

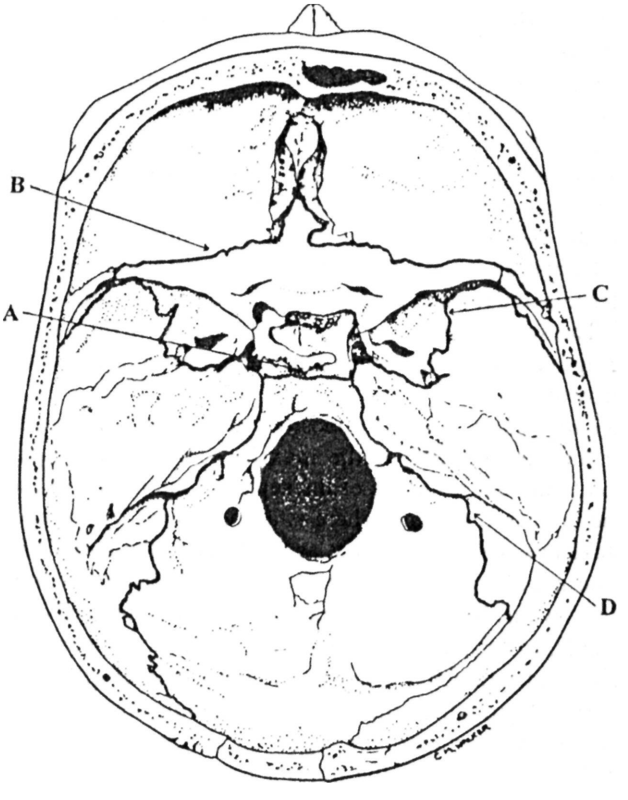


Fig. 7. Internal view of the base of the cranium. The sites of the most important centres of growth are indicated by heavy lines.

A Spheno-occipital synchondrosis.

B Suture between the lesser wing of the sphenoid bone and the frontal bone.

C Suture between the great wing of the sphenoid bone and the petrous portion of the temporal bone.

D Suture between the temporal bone and the occipital bone.

the anterior half of the base of the cranium bodily upwards and forwards. This upward movement is compensated by downward growth of the face itself.

(B) *Growth of the Face*

(i) The Upper Face. It is known that the face grows in two ways, by

sulural growth or apposition of bone tissue between the bones, and by surface apposition. What proportion of growth each contributes is still uncertain, but it is believed that apposition of bone at the alveolar border is of great importance, and that much of the increase of size takes place under the periosteum,

Sutural growth: The system of sutures that unite the bones of the upper part of the face to the cranium includes the following sutures: fronlo-nasal, fronlo-maxillary, zygomatico-frontal, zygomatico-temporal, zygomatico-maxillary and pterygo-palaline (Fig. 8A). Growth at these sutures carries the upper face downwards and forwards, and increases the height of the orbit, but not the infra-nasal height (Fig. 8B). By the age of seven years the orbits almost attain their full adult size. After this age the sutures may play, little part in vertical growth of the face. The sutures of the midline are probably of little significance after the age of two years, when surface apposition accounts for the lateral growth.

Surface appositon: Surface apposition takes place over most of the facial or anterior surface of the maxilla. This is accompanied by apposition to the outer surface of the supra-orbital region of the frontal bone. The increased thickness here is accompanied by enlargement of the frontal sinus within. Similarly, as the body of the maxilla increases in size, the maxillary antrum is extended by resorption within on the surface of its walls. Because the infra-orbital canal is inclined downwards and forwards, extension of its facial end by surface apposition carries the infra-orbital foramen away from the lower border of the orbit.

The forward growth of the maxilla is accompanied by addition of bone to the anterior surface of the zygomatic process. The latter, however, is relatively slower, so that the inferior root of the zygomatic process occupies first a position over the second deciduous molar, and later over the roots of the first permanent molar. The body and alveolar process of the maxilla therefore grow forward at a faster rate than the zygomatic arches.

Brash has shown that the alveolar borders grow downwards, outwards and forwards, carrying the teeth with them. This increase of height of the alveolar process is accompanied by additions of bone to the palate, though to a lesser extent, causing an apparent deepening of the palate. The downward growth of the alveolar borders is followed by a downward extension of the maxillary antrum, and the floor of the nose. As the downward growth of the alveolar process is more rapid than that of the palate, the floor of the antrum comes to lie below the level of the inferior meatus of the nose. For this reason the ostium maxillare, which at birth

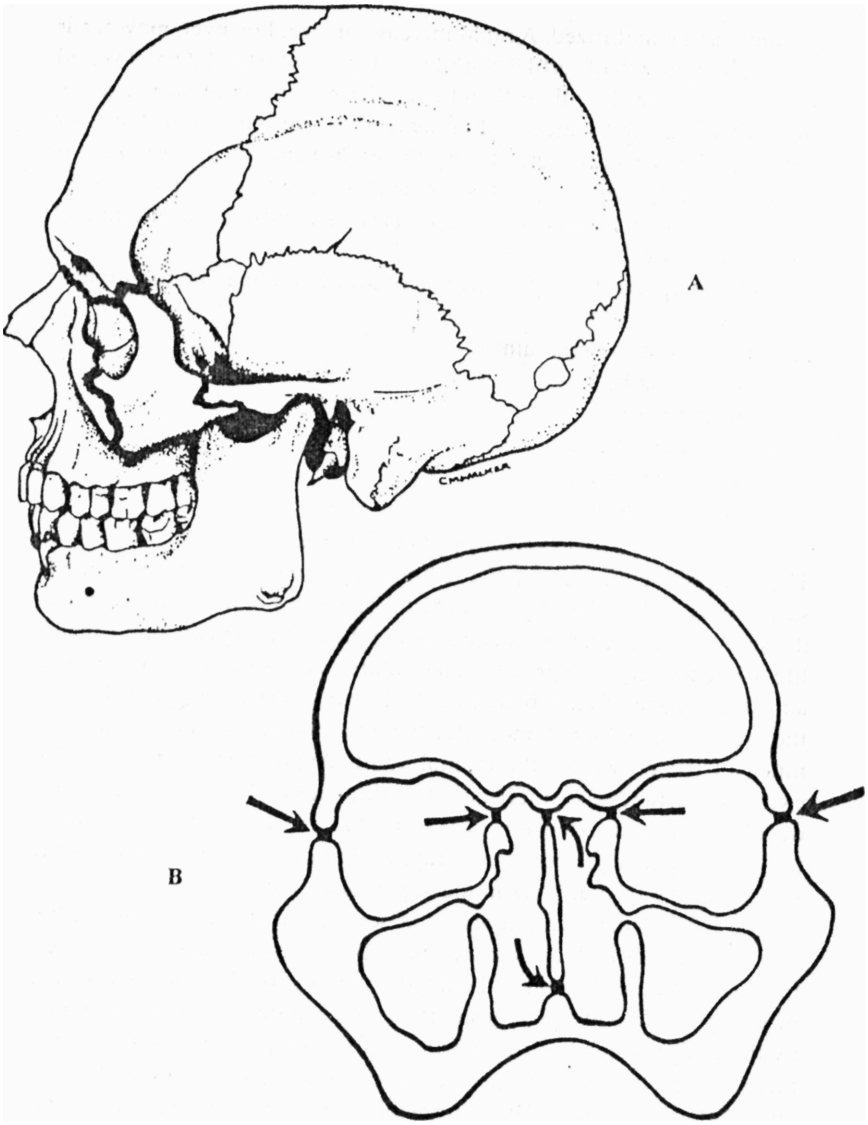


Fig. 8.

A Drawing of a skull lo show the sites of sutures at which growth of the upper face occurs.

B Coronal section of the upper face to show the sites of sutures which contribute to vertical growth. It will be seen that growth in the sutures increases the height of both the nasal and orbital cavities.

was at the level of the antral floor, appears to migrate upwards on the inner wall of the antrum. Attention of the student is drawn to the large amount of vertical growth that takes place in the maxilla between the ages of five and fifteen years. This is largely accounted for by apposition of bone at the alveolar margin, and contributes to the marked tendency lor an upper molar to migrate mesially after loss of the tooth mesial to it (Fig. 9).

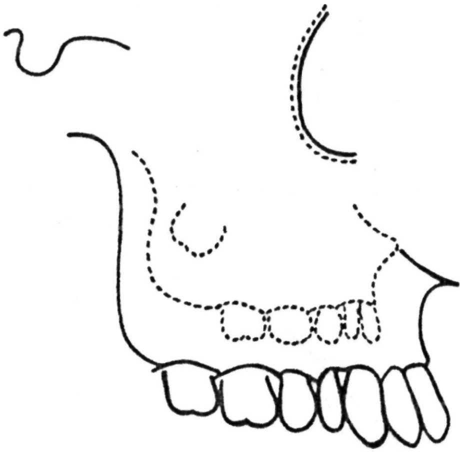


Fig. 9. Drawing to show the considerable distance that an upper molar will move in the vertical direction as a result of its own eruption and then subsequent apposition of bone to the alvelolar border.

It has been shown by Brash that the zygomatic arch of the pig grows outwards by addition of bone to its outer surface and resorption on the inner surface. There is no reason to suppose that the mode of growth here is any different from the human. The downward and outward growth of the alveolar process will account for the lateral growth of the lower part of the maxilla. This is followed by resorption of the bone on the inner surface of the walls of the antrum.

(ii) Growth of the mandible. At birth the mandible is little more than a curved bar of bone.

The coronoid, angular and alveolar processes arc undeveloped (see Fig. 6). At each upper end of the mandible a cap of cartilage represents the condyle and merges into the ramus. These two caps arc the centres from which growth causes an increase of mandibular length. The growth here is by surface apposition of cartilage and it is possible that interstitial growth of cartilage occurs also. Concurrently with extension of the bone upwards, backwards and outwards, there is moulding of the surface by resorption and apposition of bone to develop and preserve the shape of the neck of the condyle (Figs. 10 and 11).

The coronoid process, which may be regarded as a process for the attachment of muscles only, grows by addition of bone to its posterior surface; there being resorption at the anterior border as the vertical

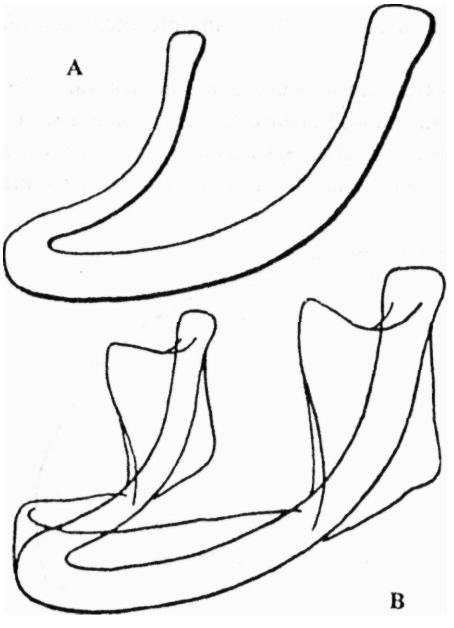


Fig. 10. Drawing to show how the functional processes arise from the 'body' of the mandible.
A The body extending from one condyle through the symphysis to the other condyle.
B The body with the functional processes added.
{By kind permission of N. B. B. Symons).

ramus grows upwards, backwards and outwards with the condyle. This contributes also to the length of the alveolar process. The region of the angle of the mandible is augmented by addition of bone to the posterior

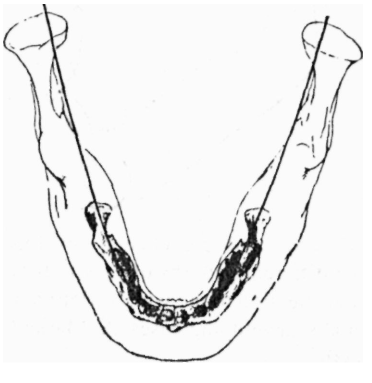
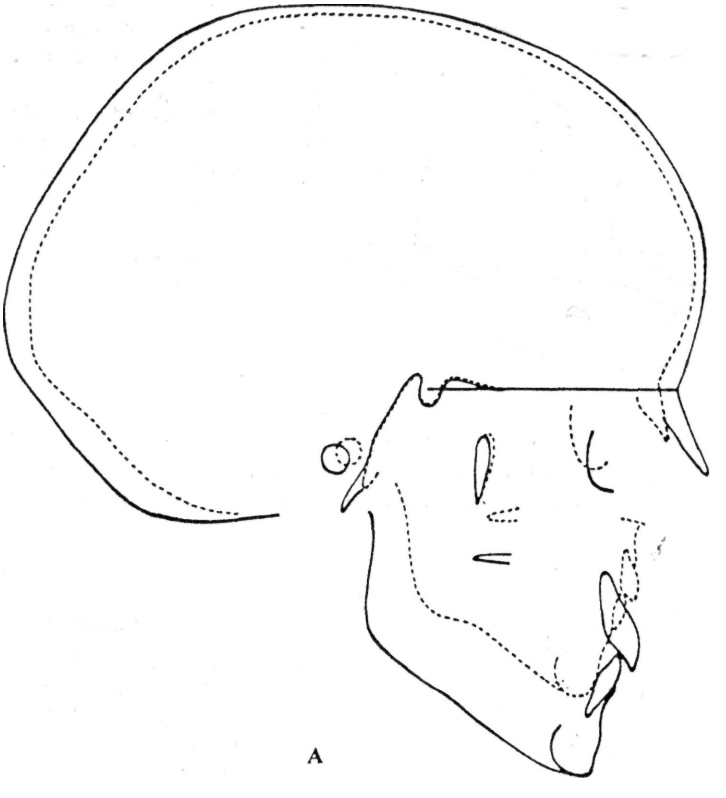


Fig. 11. Drawing to show the relative sizes of an infant and adult mandible. Attention is drawn to the marked similarity of contour on the lingual aspect of the mandible in the mental region.

border of the ramus. This apposition decreases the size of the angle made by the posterior and inferior borders of the mandible from about 175 degrees at birth to 115 degrees in the adult. A small amount of growth occurs along the inferior border of the mandible. Apposition of bone to the lateral and anterior surfaces of the mandible increases its thickness.

The alveolar process grows upwards, outwards and forwards by addition of bone to its free border and, because the anterior border of the ascending ramus slopes upwards and backwards, the alveolar border increases in length. Brash considered that this growth of alveolar bone



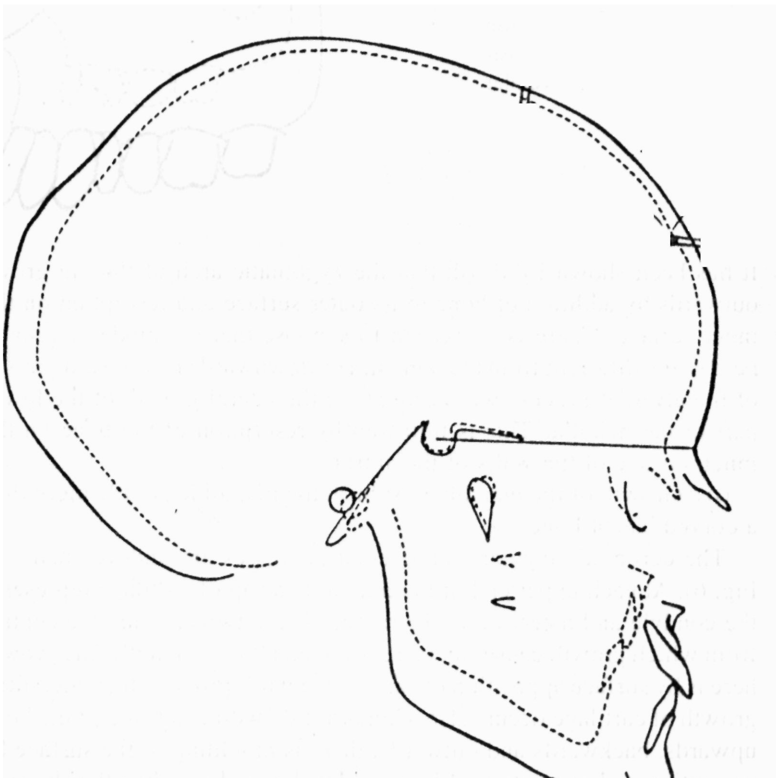
A

Fig. 12. Lateral skull tracings of two boys whose occlusion developed quite normally. These tracings contrast two different patterns of growth between the ages of five and fifteen years and draw attention to the wide vanation of growth pattern which may be found in normally developing cases. A Marked vertical growth. B Marked horizontal growth.

is important in providing sufficient space for the accommodation of the permanent teeth.

The two halves of the mandible are united by a suture in the mid-line. This is closed by about the age of one year. After this age, lateral growth in the anterior part of the mandible takes place by apposition of bone on the outer surfaces and a little resorption on the inner surfaces. The upward and outward growth of the condyles and growth at the posterior borders of the vertical rami increase the width of the posterior part of the mandible.

The mental foramen during the early years of life is situated under the mesial cusp of the first deciduous molar. In the adult it lies below and between the roots of the first and second premolars. John Hunter has shown that the change in position of the foramen is due to the backward and outward inclination of the canal. As bone is added to the outer surface of the body of the mandible, the foramen is carried



B

backwards. It must be remembered also that the upward and forward growth of the alveolar process carries the teeth forward relative to the mental foramen. The inferior dental canal increases in length by additions to its posterior end, the inferior dental foramen.

This account of growth changes which accompany development of the bones of the head has, for the sake of brevity, been simplified. It should be appreciated by the student, however, that there is quite a large individual variation in the direction and amount of growth in the skull. This is illustrated in Fig. 12, which contrasts the growth changes of two cases in which normal occlusion developed without orthodontic treatment.

It will now be appreciated that the foundations upon which the developing occlusion is based are themselves undergoing change during the period of growth and development.

GROWTH AND DEVELOPMENT OF THE DENTAL ARCHES

Before describing the stages of development whereby a normal relation of the dental arches is established, it is necessary to understand the series of 'normal occlusions' as the relations of the teeth alter with age; therefore there is a series of normals.

However, after the eruption of the third molars the normal relation changes very little. Ideal occlusion will not be described as it is a hypothetical relation based on tooth morphology and would vary between the different ethnic groups.

Adult Occlusion

The shape of each dental arch varies with the skull type, from a parabolic to a horse-shoe shape. The upper teeth occupy an arch of greater size than do the lower teeth, hence an overbite exists between the upper and lower teeth. As will be seen later the overbite is the amount by which the upper teeth cover the labial surfaces of the lower teeth in the vertical plane when the teeth are occluded. The incisor overbite of an adult is usually between one-quarter and one-third of the crown height of the lower incisors.

In a normal occlusion the permanent upper central incisors occlude on their palatal aspect with the incisal edges of the lower central and lateral incisors. The upper second incisors occlude with the lower lateral incisors and canines, and thereafter each upper tooth occludes with its opposite number in the lower arch and the tooth distal to it. The third upper molars, however, oppose only the lower third molars. The relation

of the first permanent molars is important, and will be discussed in more detail. The large mesio-palatal cusp of the upper molar engages the central fossa of the lower molar, and the mesio-buccal cusp of the maxillary tooth fits into the mesio-buccal fissure of the mandibular tooth (Fig. 13). The relation of the second and third molars is similar

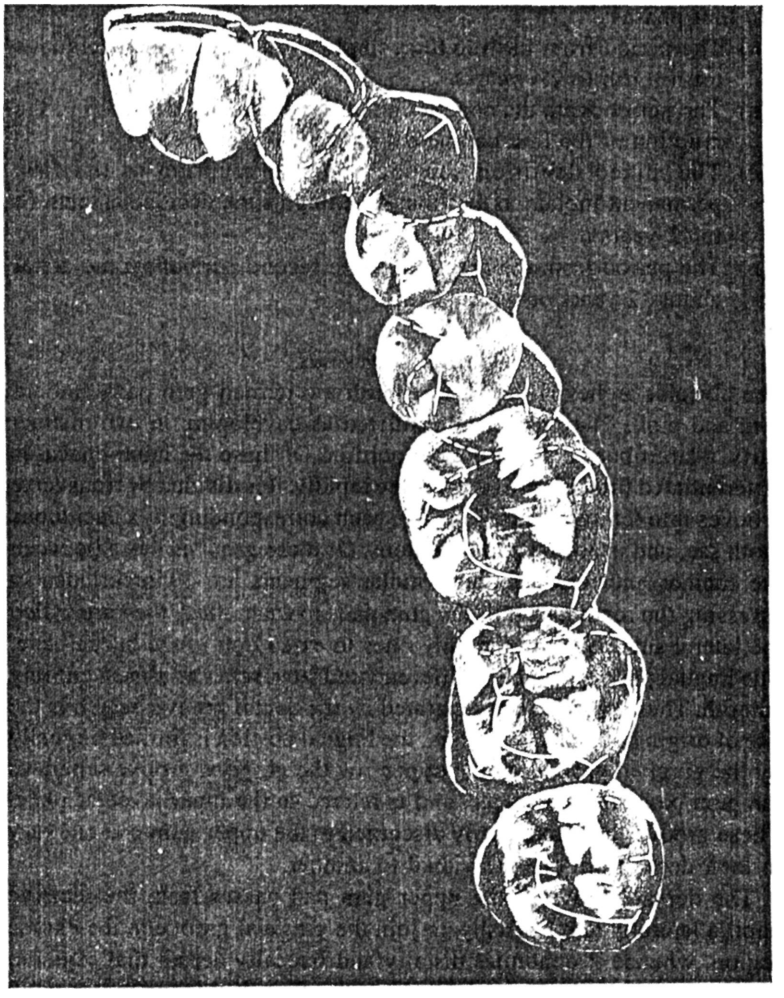


Fig. 13. The occlusal surfaces of the mandibular teeth of an adult. The dotted outlines indicate their relationship with the upper teeth. *(E. Sheldon Friel).*

but although the cuspal relationship of the teeth is so precisely defined, it is still possible to find considerable individual variation of arch form among cases with normal occlusion.

NORMAL DEVELOPMENT OF THE DENTAL ARCHES

The development of the dentition from birth to adult life may be divided into four phases:

(A) Tlic period from birth to the complete eruption of the deciduous teeth (birth to 2'/2 years).

(B) The period from the completion of the deciduous dentition to the eruption of the first pcnnanent molars (2'/2 to 6 years).

(c) The mixed dentition period; from the eruption of the first permanent molars to the final shedding of the deciduous teeth (6 to 12 years).

(D) The period from the eruption of the second permanent molars at about 12 years onwards.

(A) *The Gum Pads*

The alveolar arches at the time of birth arc termed gum pads and are firm and pink. They may be considered as developing in two distinct parts, a labio-buccal and a lingual portion. Of these the labio-buccal is differentiated first and grows the more rapidly. It is divided by transverse grooves into ten segments (Fig. 14), each corresponding to a deciduous tooth sac, and is at first papillomatous. Of these grooves those between the canines and first deciduous molar segments are of importance in assessing the relationship of the gum pads to each other; they are called the lateral sulci, and are the only ones to extend on to the buccal side. The lingual portion, which is differentiated later, remains almost entirely smooth. These portions are separated by the dental groove, which is the site of origin of the dental lamina; the lingual portion is limited lingually by the gingival groove. In the upper jaw the gingival groove separates the gum pad from the palate, and is related to the inner alveolar plate. These grooves are more easily discerned in the upper gum pad but vary in their depth from one individual to another.

The dental groove of the upper gum pad passes from the incisive papilla laterally and lingually, to join the gingival groove in the canine region, whence it continues distally and buccally across that segment of the gum pad which corresponds to the first deciduous molar tooth crypt. The gingival groove defines the limits of the palate, both anteriorly and laterally, by three almost straight borders forming part of an oblong.

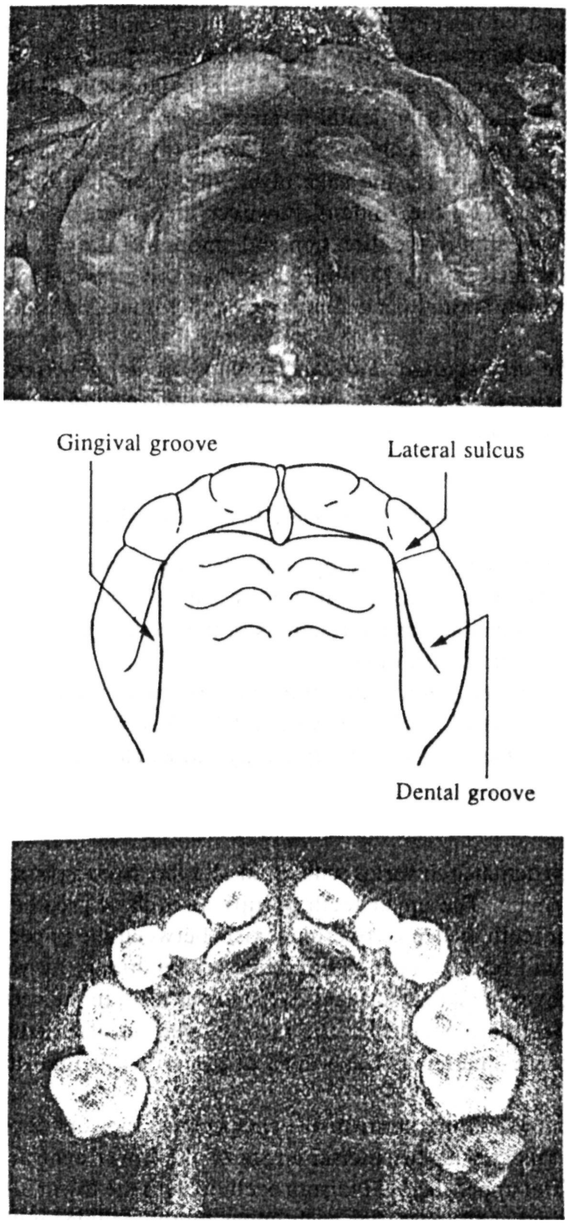


Fig. 14. Photograph, drawing and radiograph of upper gum pad at birth.

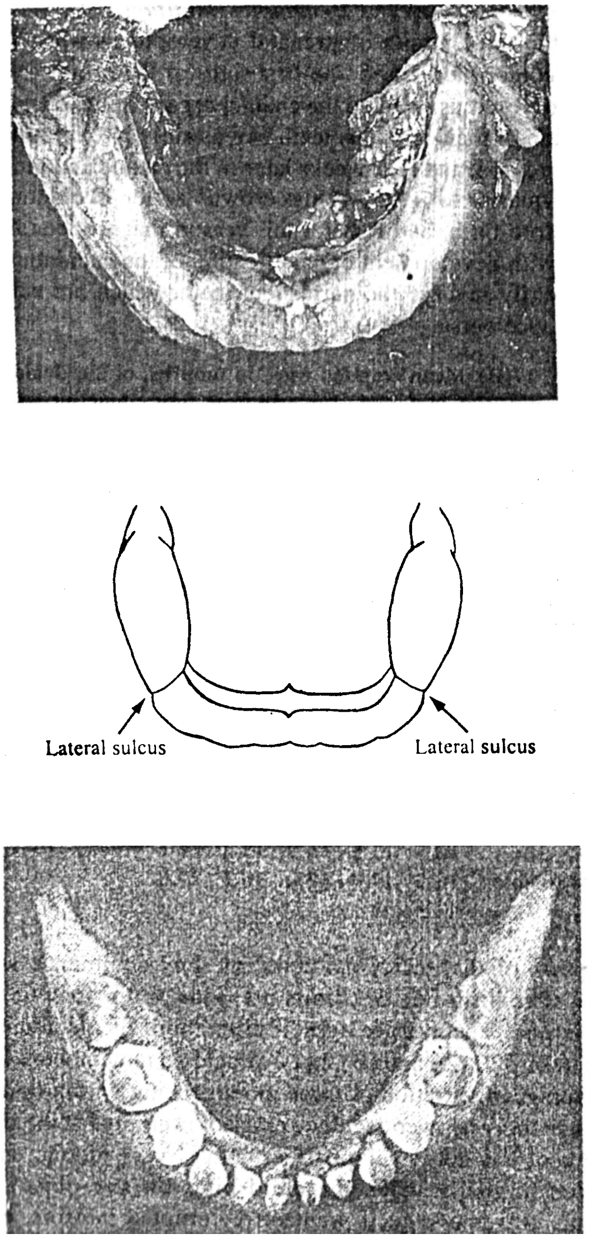


Fig. 15. Photograph, drawing and radiograph of lower gum pad at birth

The lower gum pad is U-shaped, and once more it is found that the alveolar pad is limited on the lingual aspect by a continuous groove. Anteriorly, the gum pad is slightly everted labially (Fig. 15). The gum pad is divided by transverse grooves into ten segments, but not so clearly as in the case of the upper.

The groove distal to the canine is continued on to the buccal surface and is again called the lateral sulcus.

At rest the gum pads are separated by the tongue, which protrudes over the lower gum pad to lie immediately behind the lower lip, and may even protrude a litlle bclwecn the lips. At this age, the upper lip appears very short. The gum pads do not have a definite relationship when occluded, although with care it is possible to bring them repeatedly into a fairly constant relationship to each other. The limits of anlero-

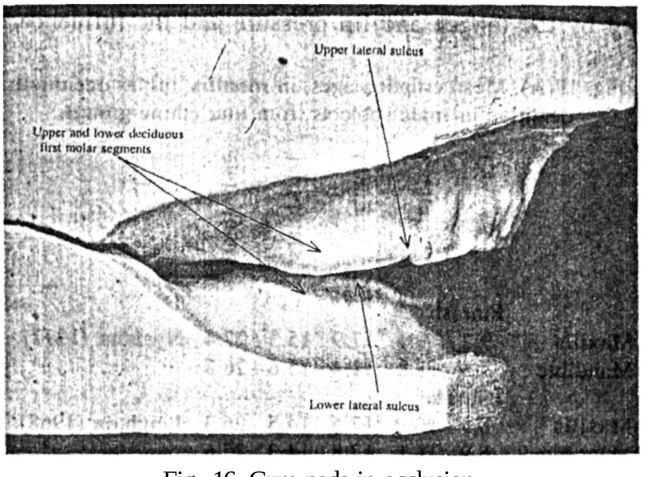


Fig. 16. Gum pads in occlusion

posterior movement vary greatly, but are usually rather small, and there is no lateral movement. The upper gum pad is wider than the lower, and when the two are approximated there is a complete overjet all round of the upper over the lower gum pad, with a considerable overjet anteriorly (Fig. 16). The lateral sulcus of the lower gum pad is usually posterior to that of the upper, a relation which, if it were to persist, would be abnormal. The degree of overjet of the upper gum pad varies considerably although it is not yet known whether this is of any significance. Clinch and Sillman have, indeed, shown that there is rarely

any contact between the gum pads anteriorly when they arc approximated, contact being found only in the first molar region.

It is not uncommon for a vertical space to exist between the upper and lower incisor segments of the gum pads, even when they are pressed into occlusion. This is usually occupied by the tongue and is not necessarily a precursor to an anterior open bile. Its presence appears to be linked with the position of the tongue.

At birth, the gum pads arc not sufficiently wide to accommodate the developing incisors, which arc crowded and rotated in their crypts. During the first year of life the pads grow rapidly, and the growth is most marked in the lateral direction. This increase of width permits the incisors to erupt in good alignment and to be spaced. In spite of sufficient increase in size of the arches at this period, the incisors may erupt while still in their irregular relation to each other. This, however, is only a temporary persistence of what has been a normal condition and is later corrected by the tongue and lip pressure and the influence of the

Fig. 17(A). Mean eruption ages, in months, of the deciduous dentition in male subjects from four ethnic groups.

	Centrals	Laterals	Canines	1st Molars	2nd Molars	
	Finnish					
Maxilla	9.2	10.1	17.9	15.3	27.4	Nyström (1977)
Mandible	7.0	11.8	18.4	15.6	26.3	
	British					
Maxilla	8.9	10.2	17.5	14.5	26.3	Lcighton (1968)
Mandiblc	6.9	11.1	17.8	14.7	25.6	
	Iraqi					
Maxilla	10.7	10.1	18.8	16.3	26.0	Baghdady (1981)
Mandible	9.2	14.0	19.0	16.9	26.0	& Ghose
	South Indian					
Maxilla	12.1	12.6	20.4	16.0	27.5	Reddy (1981)
Mandible	8.1	15.4	22.3	17.7	25.9	

occlusion, provided that sufficient supporting bone has been afforded by growth. During the first year of life, with the development of the deciduous teeth, there is also a rapid increase of the labio-lingual dimensions of the gum pads. The length of the gum pads increases more moderately and second molar segment becomes more clearly defined.

(D) *The Deciduous Dentition*

At about the third month of prenatal development when the various clefts of the face have fused, the first signs of the primitive tooth band appear, and from this develop the enamel organs of the deciduous teeth. Calcification of the deciduous teeth begins early in the fourth month in the incisor region, and four weeks later in the canine and molar regions. From one-quarter to a half of the crowns of the deciduous teeth arc formed before birth, and it is for this reason that any condition which interferes with development or calcification of the deciduous teeth does not necessarily involve the permanent teeth, which arc calcified after birth, and vice versa.

Fig. 17(B). Mean eruption ages, in months, of the deciduous dentition in female subjects from four ethnic groups.

	Centrals	Laterals	Canines	1st Molars	2nd Molars	
	Finnish					
Maxilla	9.4	10.2	18.1	14.6	26.7	Nyström (1977)
Mandible	7.1	11.8	18.8	15.1	25.3	
	British					
Maxilla	9.4	10.9	18.7	14.9	26.3	Leighton (1968)
Mandible	7.6	12.0	18.7	15.0	25.8	
	Iraqi					
Maxilla	10.6	11.4	19.9	16.4	27.0	Baghdady (1981)
Mandible	8.4	14.3	20.3	17.0	25.1	& Ghose
	South Indian					
Maxilla	10.5	12.5	16.0	13.2	27.1	Reddy (1981)
Mandible	10.5	13.0	18.0	16.3	27.0	

Key 9.2 = $9^2/_{10}$ months

Eruption of the deciduous dentition may commence six or seven months after birth but the limits are wide, 'from four to ten months being normal. The average ages of eruption of the deciduous teeth are shown in Fig. 17 (A) and (B), but it should be remembered that they are only average, a variation of three months being within normal limits.

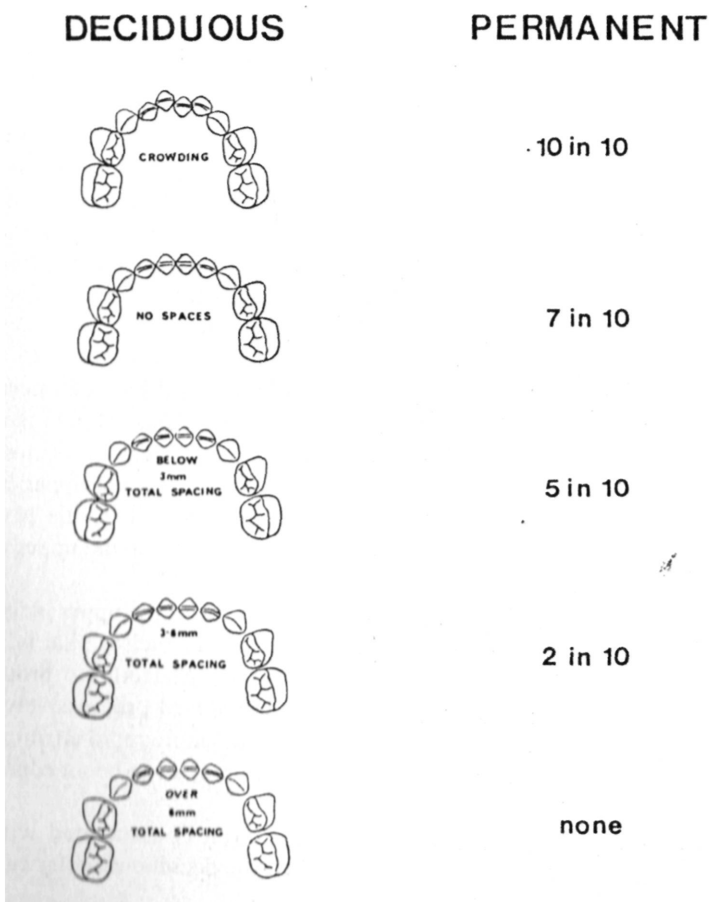
Occasionally a lower deciduous incisor is erupted at the time of birth. As the root has not developed the tooth is very mobile, and is easily deflected lingually when the child bites on any object. It may be necessary to remove such prematurely erupted incisors, especially if they cause ulceration of the lower surface of the tongue, or present difficulties in suckling, but if radiological investigation shows them to

be of the normal series, every reasonable effort should be made to keep them.

Spacing of the Deciduous Teeth

It was believed at one time that abnormalities of the deciduous dentition were extremely rare, because normal spacing of the deciduous teeth masks any tendency of their successors to crowding; only serious

Table of 'Probabilities' Which May be Applied When Using LOWER Deciduous Tooth Spacing to Predict the Chances of Crowding in the Permanent Dentition'



' Leighton, B. C. (1971). *Dent. Practnr dent. Rec.* 21: 359-72

deficiency of growth would be manifested by crowding or imbrication of the deciduous teeth. Another reason for the belief was the old saying that 'one is unlikely to observe what is not sought'. The possibility of abnormality in very young children was not considered. Since many parents await complaints of toothache before taking a young child to the dentist, orthodontic irregularities of the deciduous dentition often pass unnoticed.

Spacing of the deciduous teeth is variable. In most normal cases spacing occurs between all the teeth as they erupt (Fig. 18). Occasionally spaces develop between the deciduous incisors subsequently to their

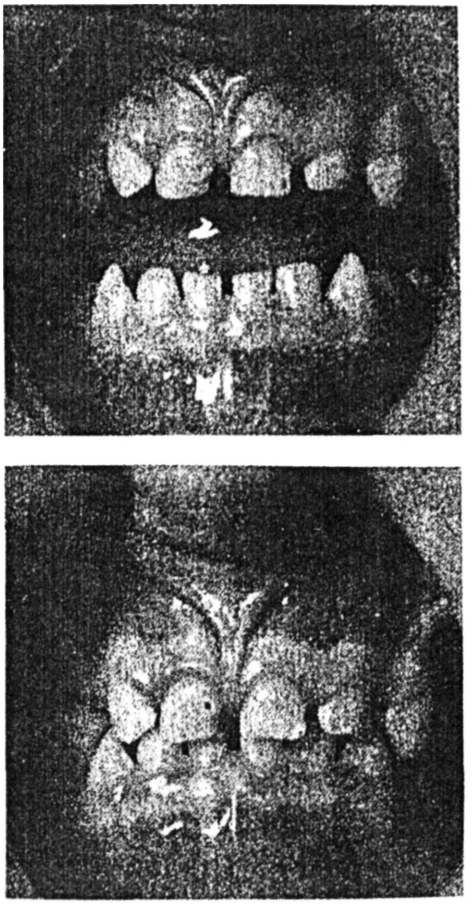
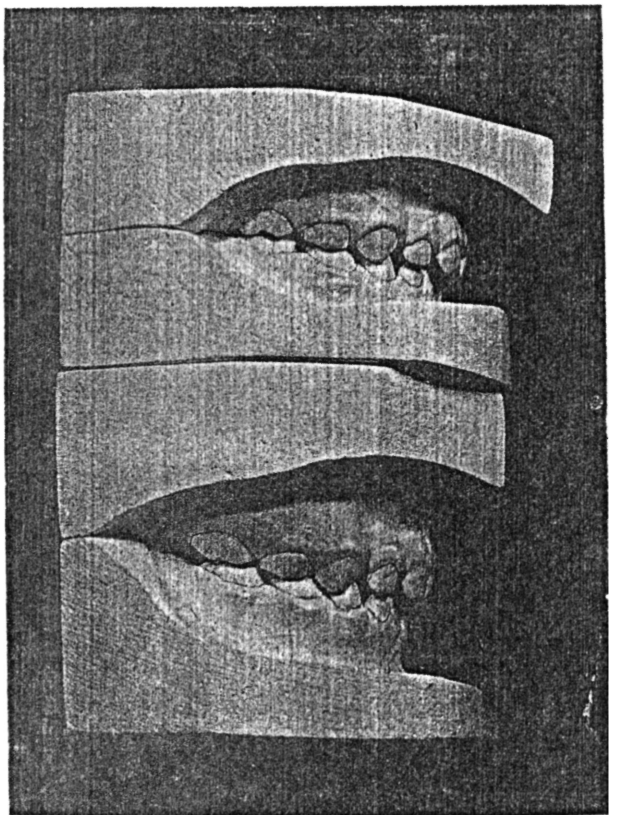


Fig. 18. Spacing of deciduous incisors at four years of age.

Fig. 19. Spread of spacing of lower deciduous incisors.
A. At 18 months. B. At 30 months.

A



B

Fig. 20.
A. End to end molar occlusion as seen at three years of age.
B. By forward migration of the lower arch of teeth this may become normal during the next two years.

eruption (Fig. 19). Failure of incisor spacing to appear before five years of age occurs in about 20 per cent of cases and usually indicates crowding in the permanent dentition. Although some increase of intcrcaninc width may be expected at the time of eruption of the permanent incisors, this is rarely more than 4 mm. It is possible to use the amount of spacing between the lower deciduous teeth as a means of predicting the degree of crowding to be expected in their permanent successors. The table shown on page 28 offers some guidance in making such a prediction.

Before going into the variations that may normally occur in the deciduous dentition, a few words on the changing occlusion of these teeth might be appropriate. Any spaces which exist between the deciduous molars usually close by the time of the eruption of the first permanent molars. The spaces between the deciduous incisors persist until these teeth are replaced. The distal surfaces of the upper and lower second deciduous molars may be in the same coronal plane at the time of their eruption, but this is adjusted by the age of six years, when the distal surface of the lower deciduous molar is about 2 mm mesial to that of the upper (Fig. 20). This is thought to be due to the bodily forward movement of the mandible in relation to the maxilla. It is also claimed by L. J. Baume that the spacing between mandibular teeth is greater especially in the canine region, and the closing of the spaces allows the lower molars to move forward more than the upper molars.[1] The lower first permanent molars are therefore only about 2 mm mesial to the upper molars at the time of eruption; this is not sufficient to permit them to assume a normal antero-posterior relation. This relation is not corrected until the second deciduous molars are lost. Because the lower second deciduous molars are larger mesio-distally than the upper, and the upper and lower premolars are smaller than either, the lower permanent molars are able to move further forwards than the upper and assume a normal relation (Figs. 21, 22, 29).

When the deciduous incisors erupt, the overbite of the upper incisors is equivalent to the height of the crown of a lower incisor, that is, the lower incisors are covered by the upper when the teeth are brought together in occlusion. This deep overbite is reduced progressively by the eruption of the deciduous molars, and by the more rapid attrition of the incisors, until at the age of six years there may even be an edge-to-edge relation of the incisors (Figs. 21, 22).

Forward movement of the mandibular arch is associated with a reduction of overbite and a flattening of all the deciduous molar cusps.

[1] Baume, L. J. (1950). *J. Dent. Res.* 29: 123.

This reduction of the overbite is a factor which facilitates the forward movement of the mandible. Another factor is the greater increase of width of the upper arch compared to that of the lower.

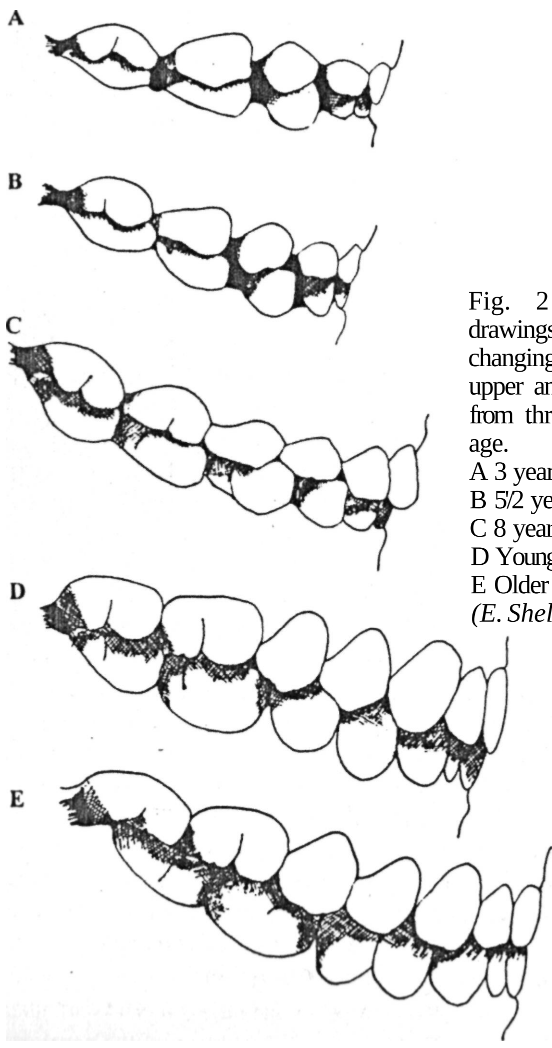


Fig. 21. Scries of drawings to illustrate the changing relations of the upper and lower molars from three years to old age.
A 3 years
B 5/2 years
C 8 years
D Young adult
E Older adult
(E. Sheldon Friel)

Normal Variations in the Position of the Deciduous Teeth

Chapman has shown that there are certain irregularities of the deciduous (detition which may only be variations of the normal.[1] It should be

[1] Chapman, H. (1935). *Brit. Dent. J. 58: 201*

emphasised that they are variations only, and do not occur in every normal case.

(a) Antero-posterior Variations

(i) Lower canines may be hidden by the upper canines up to the age of 3 1/2 years (see Fig. 20); that is, they may be in the same coronal plane. Later this is corrected by the relative forward movement of the mandibular arch.

(ii) Spaces between the molars may be present up to the age of five years. While these spaces are present the molars often oppose each other individually.

(iii) There may be a space between the lower canine and the first deciduous molar up to the age of 9 years. This is called the Primate Space. In the upper arch it may be seen between the lateral incisor and the canine.

(iv) On eruption the distal surfaces of the upper and lower second deciduous molars are often in the same coronal plane, known as a Flush Terminal Plane, although the mesial surfaces of the lower molars arc in advance of those of the upper (sec Fig. 21). On eruption the firs! permanent molars take up a similar relationship and only move forward into correct occlusion on the loss of the deciduous molars. A mesial step instead of a flush terminal plane in the second deciduous molar relationship may indicate a Class III, and a distal step a Class II tendency.

(b) Transverse or Lateral Variations

(i) Arch width increases between five and eight years, more so in the upper arch than the lower, thus allowing forward movement of the mandible. The breadth of the arch in the region of the upper first permanent molar increases by 1-2 mm up to eleven years and may increase a small amount after this age.

(ii) There may be a space between the upper deciduous central incisors at the time of their eruption, and this space may persist between the permanent central incisors, but normally closes by eight or nine years (Fig. 23).

(iii) The deciduous incisors may be rotated, but this condition, especially in the lower incisors improves by four years of age.

(c) *The Permanent Dentition*

Except for the cusps of the first permanent molars the permanent dentition is formed after birth. There is therefore a greater possibility of enamel hypoplasia occurring as a result of dietary disturbances. These teeth may also be poorly calcified if illness occurred at the time they were being formed. The first appearance of the permanent dentition is

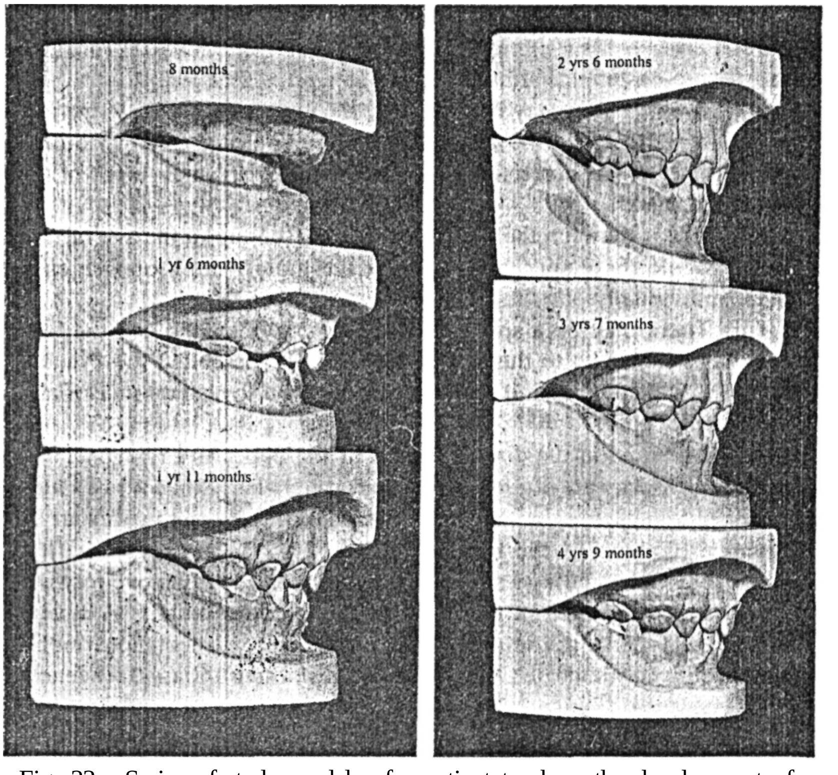
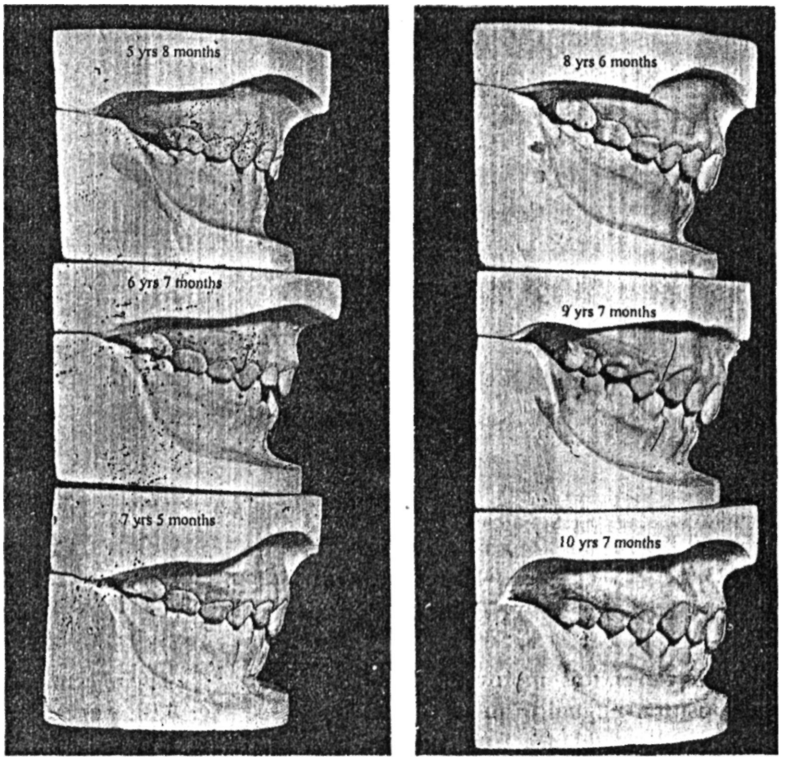


Fig. 22 Scries of study models of a patient to show the development of normal occlusion. Models were taken at the following ages:
8 months; 1 year 6 months; 1 year 11 months; 2 years 6 months; 3 years 7 months; 4 years 9 months; 5 years 8 months; 6 years 7 months; 7 years 5 months; 8 years 6 months; 9 years 7 months and 10 years 7 months.

at the age of about six years when the first molars erupt. The average ages of eruption of the permanent teeth are given later (see Tables on pages 38 and 39), but it should be remembered that they are only average, a variation of twelve months being within normal limits. In the Indian population the eruption of permanent teeth occurs-about one year later than those in Britain.

Before the deciduous incisors are shed, there are forty-eight teeth or parts of teeth present in the jaws. The amount of space available to accommodate them is limited (Figs. 24 and 25). The upper and lower pennanent canines are excluded from the arch, developing close to the floor of the orbit and inferior border of the mandible respectively. The lower second permanent molars develop under the anterior border of



the coronoid process and the upper second molars develop in the maxillary tuberosity. All permanent incisors develop on the lingual or palatal side of the roots of their predecessors (Figs. 24 and 26).

In this position they arc unlikely to be damaged by a blow to the deciduous incisor crowns. Just before eruption, however, they move labially causing absorption of the deciduous incisor roots (Fig. 26). It is at this stage (5-6 years) that an upward blow on the deciduous incisors may cause damage to the developing permanent incisors. The developing central incisors often erupt separated. This may be a persistence of their separation by the mid-line suture before eruption.

Friel has observed[1] that, before eruption, the lateral incisors are usually placed more lingually than the centrals. The eruption of the centrals, by placing a narrower part of the tooth adjacent to the lateral, allows the latter to move labially (Fig. 27). In cases where there is insufficient

[1] Friel, E. S. (1954). *Trans. B.S.S.O.,* p. 134.

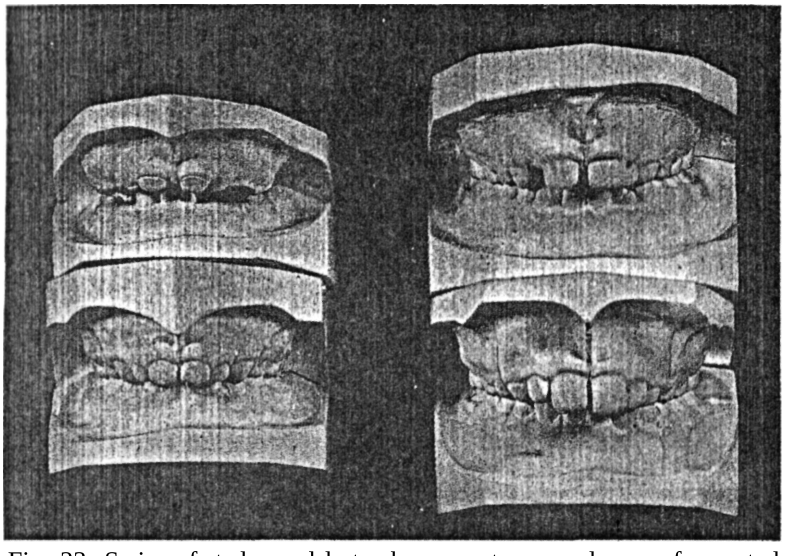


Fig. 23. Series of study models to show spontaneous closure of a central diastema of the deciduous and permanent incisors.

space, however, this improvement is prevented, and the lateral remains in a position lingual to that of the central (see Fig. 42B, page 65). Occasionally guidance from the lips may cause lingual inclination (lingual tilting) of the central incisors as they erupt. The lateral incisor which will have been released to move labially will then erupt into a more labial position than the central, being displaced by lack of space arising from the shortening of the anterior part of the arch. (See Fig. 45, page 72).

The developing permanent canines, especially the upper, often cause displacement mesially of the roots of the permanent incisors, up to the age of eight or nine years; this causes a distal divergence of the crown of these incisors (Fig. 28, page 40). This has been called the 'Ugly Duckling Stage'. This is corrected later when the canines erupt and the pressure is transferred from the roots to the crowns of the incisors. It is significant that at this stage the space thafsometimes persists between the upper central incisors usually disappears. It is important to recognize certain differences of mesio-distal size between the deciduous and permanent teeth. The deciduous incisors are all smaller than their successors. The difference in the sum of the mesio-distal widths of the deciduous and permanent teeth is called Incisal Liability. This is about

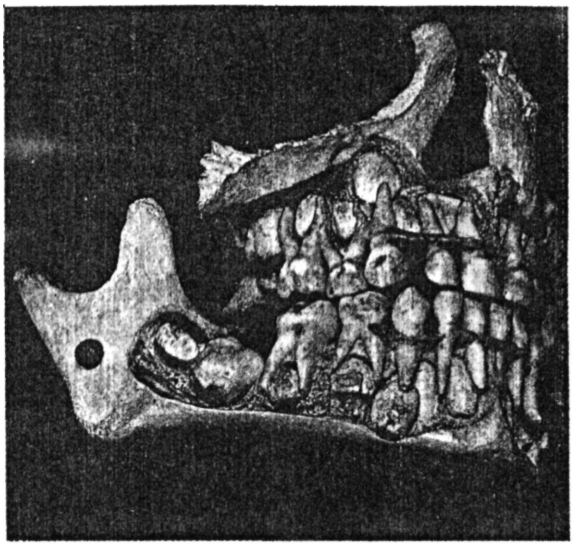


Fig. 24. Dry specimen of the jaws of a child at four years of age dissected to show the positions of the developing permanent teeth in their crypts.

7.6 mm in the upper arch and 6 mm in the lower arch.The first deciduous molars are slightly larger than the first premolars, but the second deciduous molars arc considerably larger than their successors; this discrepancy is greater in the lower arch. The permanent canines are larger than their predecessors. Therefore there may be some temporary crowding if the canines are replaced before the deciduous molars. As has already been mentioned, more space is made available for the lower first permanent molar than for the upper, thus permitting the necessary adjustment to the permanent molar relation (Fig. 29). This space is called the Leeway Space as described by Nance. The combined width of deciduous canines and first and second molars is greater than that of the permanent canine and premolars in the lower arch by 1.7 mm but only by 0.9 mm in the upper arch.

When the permanent incisors erupt there is an immediate increase of the depth of overbite, due to their greater length. This overbite is progressively reduced. During the age of changing dentition from six to twelve years, the dental arches may increase slightly in width. The

Mean eruption ages, in years, of the permanent dentition in male subjects from five ethnic groups. Key 7.6 = 7 6/10 years

	Centrals	Laterals	Canines	1st Premolars	2nd Premolars	1st Molars	2nd Molars	
	British							
Maxilla	7.0	8.2	11.5	10.4	11.5	6.1	12.0	Clements (1953)
Mandible	6.1	7.3	10.5	11.3	12.3	6.1	12.0	*et al.*
	Kenyan African							
Maxilla	6.9	8.0	10.9	9.9	10.7	6.3	11.5	Hassanali (1981)
Mandible	5.8	6.9	10.0	10.0	10.9	6.0	11.4	& Odhiambo
	Kenyan Asian							
Maxilla	7.2	8.4	11.2	10.0	11.1	6.7	12.2	Hassanali (1981)
Mandible	6.6	7.5	10.6	10.6	11.4	6.5	11.9	& Odhiambo
	Iraqi							
Maxilla	7.4	8.7	11.5	10.0	10.9	6.1	12.2	Ghose (1981)
Mandible	6.2	7.6	10.6	10.6	11.4	5.7	11.8	& Bagdhady
	North Indian							
Maxilla	7.1	8.5	11.6	11.0	11.6	6.6	12.5	Amrit (1979)
Mandible	6.7	7.6	11.3	11.2	11.9	6.6	12.0	& Singh

increased dimensions of the arches, particularly of the upper, are due to:

(a) The labial and buccal inclination of the permanent teeth; this is greater than that of the deciduous teeth which are nearly vertical to the occlusal plane.

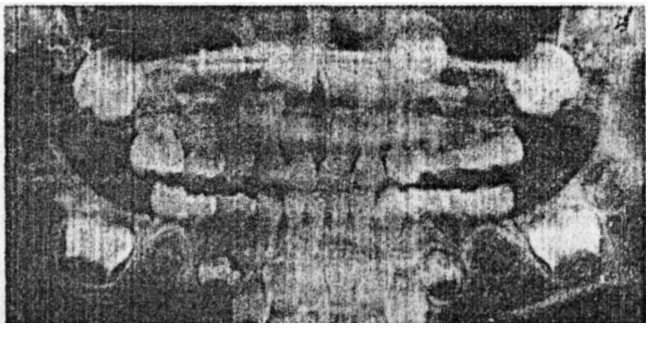


Fig. 25. Orthopantomograph showing the state of the dentition at four years of age.

Mean eruption ages, in **years**, of the **permanent** dentition in **female** subjects from five ethnic groups. Key 6.6 = 6 6/10 years.

	Centrals	Laterals	Canines	1st Premolars	2nd Premolars	1st Molars	2nd Molars	
	British							
Maxilla	6.6	7.8	10.7	9.8	11.1	5.9	11.5	Clements (1953)
Mandible	5.8	7.0	9.4	10.5	11.6	5.8	11.2	*et al.*
	Kenyan African							
Maxilla	6.5	7.7	10.3	9.4	10.1	6.1	11.4	Hassanali (1981)
Mandible	5.6	6.6	9.2	9.6	10.2	5.7	11.1	& Odhiambo
	Kenyan Asian							
Maxilla	6.9	8.0	10.6	9.7	10.7	6.3	11.5	Hassanali (1981)
Mandible	6.3	7.2	9.7	9.8	10.7	6.1	11.1	& Odhiambo
	Iraqi							
Maxilla	7.4	8.3	10.9	10.0	10.8	6.0	11.8	Ghose (1981)
Mandible	6.2	7.5	10.0	10.2	11.0	5.7	11.4	& Bagdhady
	North Indian							
Maxilla	7.1	8.4	11.0	10.5	11.2	6.6	12.0	Amrit (1979)
Mandible	6.6	7.8	10.4	10.6	11.3	6.6	11.6	& Singh

(b) The greater labio-lingual and bucco-lingual diameters of some of the permanent teeth.

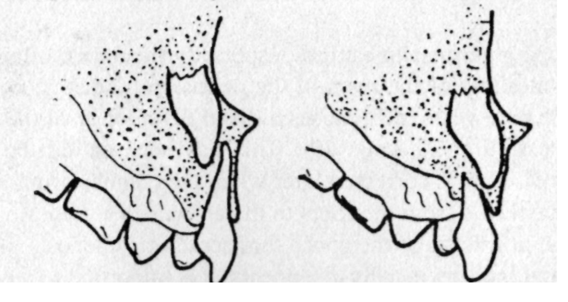


Fig. 26. Drawing to show how the developing upper incisors move labially to a position over the deciduous incisors between the ages of three and six years, *(after E. S. Friel)*

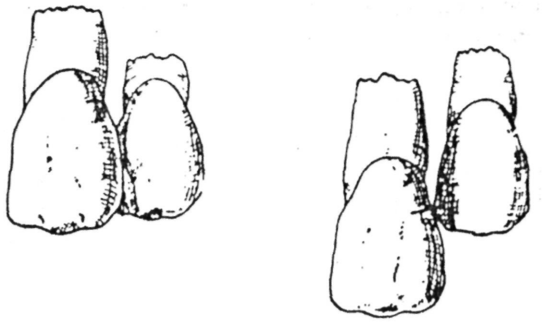


Fig. 27. Drawing to show how upper lateral incisors are released to move labially as the centrals move occlusally.

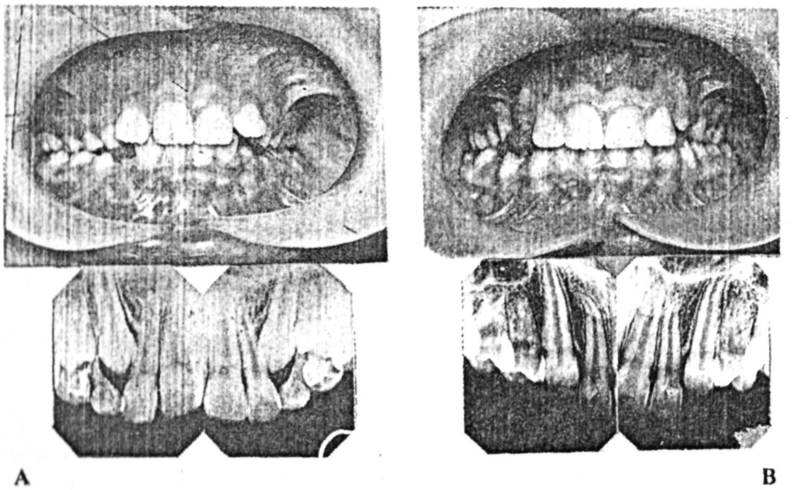
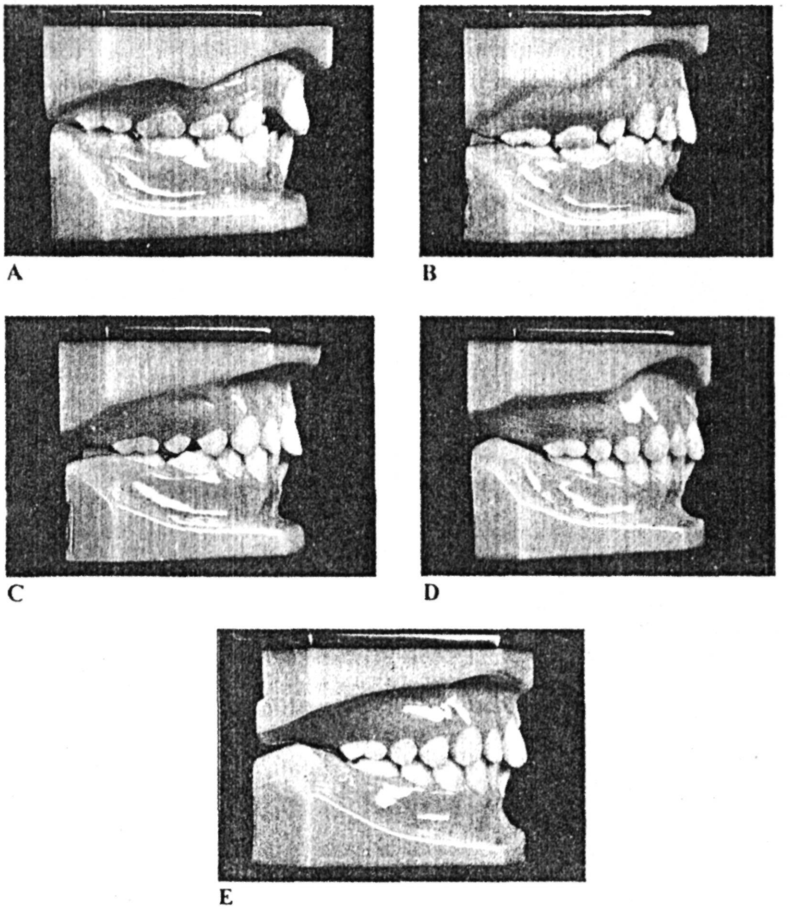


Fig. 28. Case to show how upper lateral incisors may be inclined distally on eruption. This is associated with the presence of the developing canines adjacent to their roots, and may be resolved spontaneously when the canines erupt.
A. At 10 years 2 months B. At 11 years 6 months

In addition there is often some real increase of width of the arches due to the downward and outward growth of the alveolar border. This increase may be estimated by measuring the width of the arch between



A B C D E

Fig. 29. Series of models to show normal changes of antero-posterior relationship of the molars. Replacement of deciduous molars allows the first permanent molar occlusion to change from a cusp to cusp to a normal relationship.
A. 7 years 6 months B. 8 years 8 months C. 9 years 6 months
D. 10 years 3 months E. 11 years 6 months

the palatal surfaces of the premolars and molars. It occurs largely between six and nine years of age and rarely exceeds 4 mm.

At about the age of puberty it can be expected that many cases will show some lingual inclination of both upper and lower incisors. It has been suggested that this is due to a change in balance of muscle forces

arising from The continued growth of the jaws after cessation of growth of the tongue. The change may at limes be responsible for an increasing imbrication (crowding) of the incisors at this stage (late imbrication of the incisors) (see Fig. 30). The permanent dentition is completed by the eruption of the third molars at sixteen to twenty-five years, or even later.

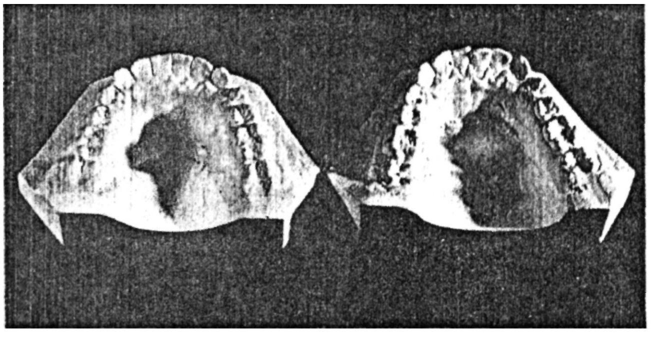


Fig. 30. Models to show spontaneous development of incisor imbrication a year or so after puberty. This is known as late imbrication of incisors.

The reader will now realise that the masticatory apparatus in the growing child is undergoing constant change. It is important to develop this dynamic concept. The occlusion of a growing child or adolescent should never be regarded as static.

3. Functional Development

The achievement of a normal occlusion is dependent upon a number of factors and may easily be thwarted by failure of any one of them. These factors will now be discussed in some detail as it is considered that a thorough appreciation of them is essential before embarking on a study of the aetiology of malocclusion. In order to set them out logically, the experience of a developing tooth is traced to its final position in the mouth. This will be determined by factors which have been grouped under the following headings.

(A) The position, size and relationship of the bone in which the tooth develops,
(B) The position and relationship of the tooth within that bone,
(c) The path which the tooth follows to reach the mucous membrane before eruption,
(D) The forces which guide its course after eruption,
(E) The forces which start to operate when the tooth makes contact with its opponent.

(A) BONE RELATION

The relationship of the maxilla or mandible to other bones and to each other is probably determined by heredity and ethnic tendencies, but may also be influenced adversely by a number of factors including congenital conditions which may not be hereditary, hormonal imbalance, traumatic and pathological conditions which interfere with growth. This bone relationship will have a marked effect upon the nature of the ultimate occlusion.

(B) TOOTH RELATION

There is some evidence that the developmental position of a tooth is also under strong hereditary control. Similar atypical malpositions of individual teeth are seen in twins and siblings. The developmental position may be modified by the proximity of other tooth germs; this is likely to occur where there is insufficient space, or where extra teeth are present. It occasionally happens that a tooth is completely misplaced for no apparent reason.

Fig. 24 shows the state of development of a child of four years. It will be noticed that the permanent incisors develop lingually to the roots of their deciduous predecessors. The upper permanent canines develop high in the maxilla near to the floor of the orbit and the mandibular canines near to the inferior border of the mandible. This remoteness from the other teeth, especially in the case of the upper canines, releases these teeth from the limitations imposed by the presence of neighbours; as a result, ectopic eruption or failure of eruption are not uncommon phenomena. Premolar crown development is completed below the deciduous molars, and between their roots. A deeper position of the developing premolars beyond the embrace of their predecessors is seen at limes, and this may allow them freedom to migrate to abnormal positions. The lower permanent molars develop at the root of the coronoid process, oriented with a mesial inclination. This is corrected subsequently as the tooth erupts forward and upward along a curved path. Similarly each upper permanent molar develops, facing backwards, in the tuberosity of the maxilla. The upper permanent molars swing downwards and forwards as Ihey erupt through an arc of a circle whose centre would be somewhere in the region of the apex of the next tooth mesially.

(C) ERUPTION

Several theories have been propounded to explain the mechanism whereby eruption is achieved; each of them alone fails to explain all the phenomena that have been observed. It is probable that the process is a combination of all these factors:

(i) Blood Pressure: The soft tissues at the developing end of the tooth arc very vascular. It has been shown that increased vascularity occurs when eruption is taking place rapidly.

(ii) Growth of the Root: In most cases, eruption is accompanied by

growth of the root of the tooth. This, however, is not the case with every tooth. Sometimes a tooth will fail to erupt until the root is fully formed. Many teeth erupt before root formation is complete; in fact in those cases where a tooth is erupted at birth, there may be very little root present.

(iii) Epithelial Coils: Warwick James [1] describes the opening out of the epithelial remnants of the tooth band and enamel organ over the tooth, to cause the progressive opening of a channel through which the tooth erupts. He maintained that these epithelial coils determine the site of eruption, but that other forces such as blood pressure and growth of the root impel the tooth along the channel.

(iv) Hammock Ligament: Sicher describes a band of fibrous tissue which slings the tooth between the walls of the crypt.[2] It passes across the open apex of the root, where it is seen to contain many droplets of fluid, and is attached to the bone half-way up the wall of the crypt. The fluid is believed to act as a cushion to protect the developing tooth germ. It may well be that the hammock ligament, as it is called by Sicher, protects the hone of the fundus of the crypt from pressure, and at the same time transmits pressure from growth of the root and blood pressure, to the roof of the crypt overlying the crown.

Histological evidence suggests that the number of layers of bundle bone in the fundus of the crypt is proportional to the distance the tooth has to travel to the occlusal plane. It is suggested that apposition of bone itself is responsible not only for eruption of the teeth, but also for the varied repositionings performed by the teeth during eruption.

Although the histological evidence cannot be disputed it is difficult to find a theory to explain eruption. The hammock ligament appears to play an important part in the eruption of teeth. The suggestion that the tooth and dental follicle are passive in the processes of eruption, the movement being due only to apposition of bone, is difficult to reconcile with those rare cases where a tooth erupts into the floor of the nose or under the inferior border of the mandible. It is probable that eruption is a complex process, to which several factors contribute; certainly it would seem that differential bone growth and the hammock ligament play a part in causing movement, which may be guided by the epithelial coils mentioned by Warwick James.

Whatever the part played by the gubernaculum and the hammock

[1] James. W. Warwick (1923). *Trans. B.S.S.O.*. p. 7
[2] Sicher, H. (1952), *Oral Anatomy,* London. Kimpton.

ligament, the path of eruption is likely to be modified by the presence of adjacent tooth roots and teeth. The presence of teeth mesialiy and distally is important in determining the mesio-distal limits to the path of eruption. Very little limitation is set bucco-lingually before eruption, unless the space for the tooth has been invaded by another tooth. This is only likely to occur where the deciduous predecessor has been lost some time before the eruption of its successor. Failure of absorption of ihc roots of deciduous teeth may cause a deflection in the path of eruption of the succeeding permanent teeth.

The permanent incisors usually erupt occlusally and outwards from a position lingual to their deciduous counterparts. The canines erupt a little mesialiy as well as downwards and outwards. The premolars erupt vertically, but often emerge in a position more buccal than the deciduous molars. The permanent molars follow a curved path of eruption as described previously.

(D) INTRA-ORAL FORCES

At the time that a tooth erupts into the mouth, its roots are separated by a considerable margin from the wall of its socket. This permits plenty of latitude for its guidance by other forces to its final position. Advantage has been taken of this phenomenon to apply digital pressure to an erupting tooth when it appeared to be malaligncd with the other teeth. It is at this stage that physical forces are most likely to influence the position of the tooth. These forces which are encountered by the tooth may be divided into bucco-lingual forces, which arise largely from the musculature of the lips, cheeks and tongue, and mesio-distal forces which are exerted through adjacent teeth. Forces generated by the muscles may be either passive, due to muscle tonus, which is contipuous but very light, or active forces associated with muscle activity which arc always intermittent.

Passive Muscle Forces

As has been said, certain muscles exert a constant tension (muscle tonus) upon the jaws. At rest a muscle is in a state of tonus. In this state, a small proportion of fibres contract; the proportion of fibres is constant but they are not always the same fibres, successive groups taking over the function of maintaining tension. It is known that the number of fibres contracted is proportional to the amount of stretch put upon the muscle. It is not yet known, however, how growth of bones affects muscle tonus.

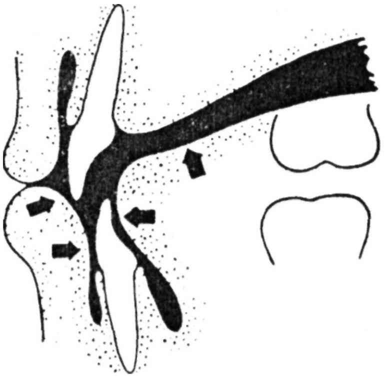


Fig. 31. Diagram of a sagittal section to show the normal relationship between tongue, incisors and lips at rest. It will be noted that the teeth arc parted a little, and that centrifugal pressure from the tongue is opposed by centripetal pressure from the lips.

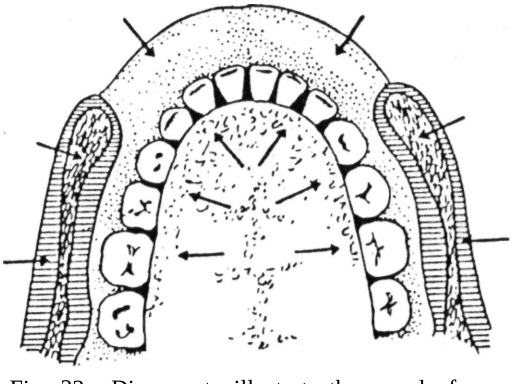


Fig. 32. Diagram to illustrate the muscle forces which arc exerted on the dental arches labio-lingually and bucco-lingually. *(After H. G. Wcilkin)*

The muscles which have a direct effect on the jaws arc those of deglutition, expression and mastication. The tongue within the lingual vestibule is applied to the lingual surfaces of the tcclh and the hard and soft palate (Figs. 31, 32). The lips and cheeks are applied to the labial and buccal surfaces. There is tension from the Orbicularis Oris muscle on the upper incisors and it should be remembered the Orbicularis Oris muscle derives some of its fibres from the Buccinator which blends with it at the angle of the mouth. The Buccinator muscle also has origin from the pterygomandibular raphe. From the posterior aspect of this ligament arise some of the fibres of the Superior Constrictor Muscle of which other fibres are inserted into the prevertebral fascia and base of the cranium. There is thus a continuous chain of muscle encircling the

pharynx and dental arches (Fig. 33). The Buccinator muscle passes backwards and inwards around the maxillary tuberosity to be inserted into the pterygomandibular raphe. It therefore often limits buccal movement of the upper third molar, causing the upper dental arch to

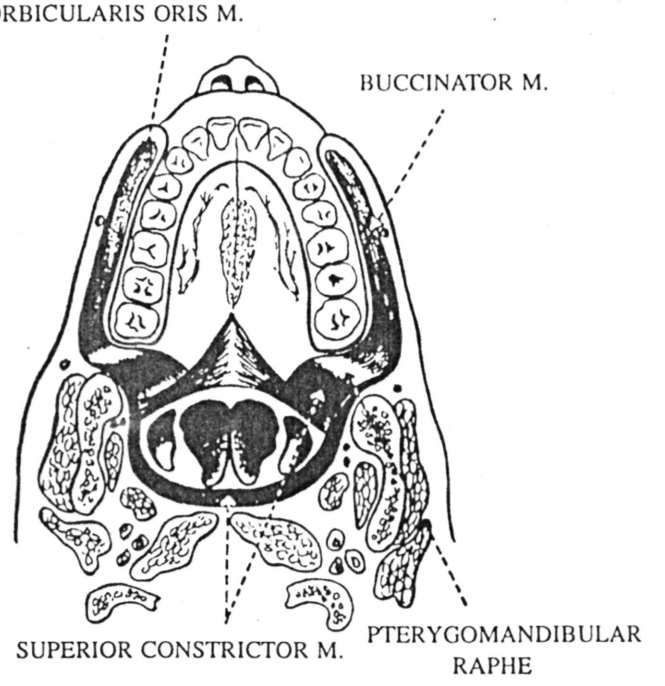


Fig. 33. Diagram of a transverse section at the level of the upper teeth to show the relationship of the Superior Constrictor,,Buccinator and Orbicularis Oris muscles to the teeth.

assume a horse-shoe shape. Three of the muscles of mastication, the Temporalis, Masseter and Medial Pterygoid support the mandible against gravity and the action of the submandibular muscles. The former exert an upward pull and the latter a downward pull.

When an individual is at rest, the mandible is held in such a position that the upper and lower teeth are normally separated a little. The upper and lower premolars are from 2-8 mm apart. This distance is called the 'free way space' or 'interocclusal clearance'. The position of (he mandible is maintained by the balance of muscle tonus. This balance affccls not only the vertical but also the antcro-posterior relation of the

teeth at rest. It is believed that this balance is difficult to alter in many cases.

The true rest position is of considerable importance to orthodontists, because it is the position from which all mandibular movements begin.

Active Muscle Forces

Active muscle forces exert pressure only intermittently; the degree of force, however, is greater than that of muscle tonus. Both the degree of force and the frequency with which it is exerted varies greatly. One of the most frequently performed activities is deglutition which is thererotic of considerable significance to the orthodontist. However, the part played by other activities such as speech, mastication and expression should not be ignored.

Deglutition

At birth the infant is capable of performing certain basic reflex actions. For example, respiration and deglutition, which are complex movements involving many muscles, arc performed with precision already, whereas co-ordinated movements of the organs of prehension, locomotion or speech are not possible. Because of their effect upon the structures of the mouth, the mechanisms of respiration and deglutition will be discussed in detail. The muscles of deglutition and respiration are perhaps unique among the voluntary muscles in that they are functionally very well developed at birth. The behaviour of these muscles is rigidly controlled by a series of strong reflexes; for instance, tactile stimulation of the lips elicits an immediate sucking response. This particular response is superseded later by less primitive behaviour. Unlike other parts of the body, the mouth not only develops reflexes but also eliminates those already in existence. Failure to abandon these might result in abnormal behaviour of the muscles concerned.The manner in which these reflexes arise before birth is still unknown, but comparative anatomy can supply examples of animals where certain movements are possible immediately after birth. Until more is known of the mechanism whereby reflex movements and combinations of movements are made possible, this problem will remain unsolved.

During the first six months of life the infant breathes exclusively through the nose. Warwick James cites a case reported by Richardson where a congenital obstruction of the nasal airway prevented nose breathing.' It was observed that the infant became cyanosed before taking

' James, W. Warwick (1936), *Birmingham Med. Rev. 11;56*

a breath through the mouth, owing to the very strong instinct to breathe through the nose. After six months of age, the lips are often apart at rest. This parting of the lips occurs so frequently in children of six months to five years of age, that it may be considered normal. It must be emphasized, however, that the opening of the mouth is confined to the lips which form the anterior sphincter, the soft palate being still in contact with the tongue thus closing the posterior sphincter.

The ability to feed from the breast is present in the newborn child, although for the first few days the muscles are often unable to maintain their action for a long period. During feeding the nipple is drawn into the mouth by negative pressure within. The nipple is enveloped by the upper lip and palate above, and the tongue below; the latter lying over the lower gum pads and protruding between the nipple and the lower lip. A large part of the nipple is drawn into the mouth to ensure that milk is delivered to the back of the tongue. By means of rhythmic waves of pressure from before backwards, the tongue, supported by the mandible, expresses milk from the nipple on to the back of the tongue. This is aided by a certain amount of suction. During the action regular breathing continues. The milk is prevented from entering the larynx by the high position of the opening to the larynx, and by the well-formed arycpiglottic folds. The movements of the tongue and those of the pharynx seem to be independent. The tongue is used merely to express milk from the nipple and is unable to collect milk from the mouth and pass it to the pharynx. Any excess milk in the mouth dribbles down the chin. Later, however, the ability to control food within the mouth is acquired. At this age the tongue lies between the upper and lower gum pads when feeding and at rest. After the eruption of the deciduous teeth, the tongue at rest is usually confined to the lingual vestibule. The lingual vestibule is that part of the mouth enclosed laterally by the teeth when in occlusion and the alveolar process, *above* by the palate, and *below* by the floor of the mouth. Posteriorly the tongue is continuous with the pharynx. By the age of five years most children retain the tongue within the lingual vestibule during swallowing.

The adult accomplishes the act of swallowing in a slightly different manner. The food, after mastication, is assembled on the dorsum of the tongue; in order to achieve this the teeth are parted a little and the cheeks are contracted. The teeth are then brought into occlusion; this closes the lingual vestibule and separates it from the labial and buccal vestibule (Fig. 34). At the same time the lungs are being filled with air. Then a wave-like contraction of the tongue, against the palate and teeth, passes from the tip of the tongue posteriorly. The pressure of food on

the posterior part of the tongue stimulates the involuntary actions thai follow. The posterior part of the tongue is elevated to pass the bolus ol food into the pharynx. Simultaneously, the soft palate is drawn upwards and backwards to close the nasopharynx. The bolus passes down the

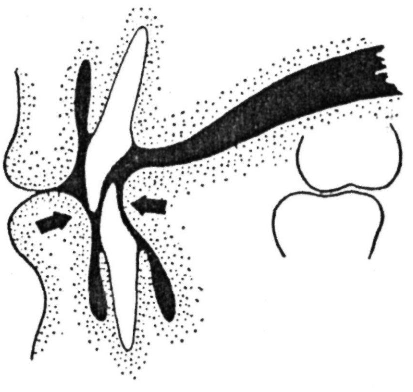


Fig. 34. Diagram of a sagittal section to show the normal relationship of the tongue, teeth and lips at the moment of swallowing, it will be noted that the teeth are together and that the tongue is confined to the lingual vestibule.

slope of the posterior third of the tongue, and the larynx is arched backwards. The larynx then begins to rise, and the epiglottis is pushed downwards and posteriorly against the posterior wall of the pharynx. The bulk of the food is momentarily held by the epiglottis at this stage, and the laryngeal opening is still open to the pharynx, under cover of the epiglottis which acts as a hood. The larynx then moves forward, and draws the epiglottis away from the posterior wall of the pharynx to permit the food to pass. The bulk of the bolus is guided laterally into the lateral food channels. Contraction of the Superior, Middle and Inferior Constrictor muscles in turn carries the bolus into the oesophagus. At this stage the opening to the larynx is closed completely by the sphincter muscles to squeeze out any residue of food that may have penetrated the larynx.

Both of the actions of swallowing described above are used when feeding. During the day, however, adults and children indulge in periodic swallowing of the saliva at intervals of one to three minutes. The infant does not swallow saliva periodically but allows it to dribble from the mouth. The action of swallowing saliva is preceded by the creation of a negative pressure in the mouth to draw the saliva from the buccal and labial vestibule and from the ducts of the salivary glands, on to the dorsum of the tongue. Thence the action is the same as for swallowing food.

(E) OCCLUSAL FORCES

Occlusal Contact

The movement of the mandible from its rest position to the position of maximum contact is under voluntary control; this is modified by a discharge of impulses arising from the proprioceptive nerve endings situated in the temporomandibular joint, tendons, muscles, and periodontal membranes of the teeth. The mandible is guided by the effect of these impulses to a position of full occlusal contact which, however, may not necessarily be the position of centric occlusion. (The latter may be defined as that relationship where the teeth are in contact maximally and the condyle on each side is resting in the depth of the glenoid fossa). This mechanism is protective, in that it guides the mandible away from a position in which there may be premature contact of an individual tooth before maximal dental contact is established. The path taken by the mandibular teeth from the rest position to that of maximum occlusal contact is known as the path of closure.

It is against this background that the tooth erupts into its first contact with an opponent. If the contact should be made before the position of maximal contact is reached, then it may either cause the mandible to deviate to a new position on closure, or it may be guided by the inclined plane of cuspal contact to a new position. This is likely to occur in the case of molars because of their cuspal morphology (see Fig. 13 on page 21). The large mesiopalatal cusp of the upper molar will probably lie somewhere within the central part of the confluence pf fissures on the lower molar. Subsequently the inclined plane of this relationship will guide these teeth into a normal relationship, provided contact is made sufficiently frequently. If, however, the discrepancy of relationship is very great, then the mesio-palatal cusp of the upper molar would not lie opposite the central pan of the lower molar, but would be engaged outside it and become guided to a more abnormal relationship. Similarly, cuspal guidance may be responsible for the elimination of small malrelationships of the teeth.

A proper understanding of the effects of premature occlusal contact upon the path of closure is vital before proceeding to study the aetiology of malocclusion.

Approximal Contact

It is a Well-known clinical phenomenon that contact between neighbouring teeth in a complete adult dentition is maintained by a tendency for the posterior teeth to move forward. Certainly at the time

of eruption of these teeth, there seems to be a tendency for slight crowding of the teeth to be emphasized.

Brash has shown that both upper and lower alveolar borders grow outwards and forwards and towards each other. He has, however, not indicated why this particular direction should be selected. He also maintained that the curvature of the roots of the teeth is evidence of this forward movement, the developing apices are left behind as the tooth moves forward with the alveolus.

Moss and Piclon in a scries of experiments on monkeys, have shown thai the transcplai fibres of the periodontal membrane are an essential factor in inaintaining approximal contact between adjacent teeth. By slicing away the contact points between molars and premolars, they showed that contact was restored if the transcptal fibres were left intact, but remained open as long as the fibres were destroyed by periodic scarification. Their final experiment involved the division of a molar into anterior and posterior halves which moved apart when their mesial and distal contacts were sliced away but the transcplai fibres were left intact. Separation of the two halves of the molar failed to occur when the transcptal fibres were destroyed.

Maintenance of approximal contact is essential in a complete dentition to prevent interdental packing of food, especially in individuals consuming an abrasive diet when occlusal and interproximal attrition is extensive. If, however, a tooth is lost then the occlusion may deteriorate as adjacent teeth are left unsupported by contact points; they may tilt and drift into the extraction space under the action of occlusal forces and the contraction of scar tissue over the healing socket.

Mastication

The forces of mastication exerted upon the teeth arc various, but may be divided *for the purposes of description* into those applied in the following directions:

(i) vertically,
(ii) antero-posteriorly,
(iii) transversely.

Each of these will be considered separately.

(i) Vertical movements of the mandible.

In this case the mandible moves from its position of rest vertically into occlusion, and then applies direct vertical pressure to the upper teeth. In the mesio-distal direction, there is a forward resultant, most marked

in the third molar region, as has already been described. In the bucco-lingual direction it will be noticed that although the molar axes are not vertical, the upper and lower molars are directly opposed (fig. 35). The axes of the incisors, however, are not directly opposed labio-lingually; the upper incisors being inclined labially. The forward resultant of occlusal pressure is absorbed partly by the lips and partly by the palatal curvature of the upper incisor roots. The roots of the lower incisors resist lingual pressure because they are flattened mesio-distally, and arc mutually supported as arc bricks of a Roman arch built without mortar.

(ii) Antero-postcrior movements of the mandible.
Movements of the mandible in this direction are not used frequently in mastication because the overbite of the incisors causes the molars and premolars to be disengaged if any but the smallest excursions are made.

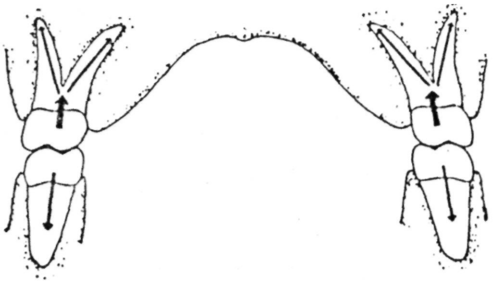


Fig. 35. Diagram of a coronal .section through the molar region of the dental arches to show the direction of forces during mastication.

However, for some actions, the mandible is protruded sufficiently to bring the incisal edges of the incisors into occlusion. The movement is at first an incising action, and later a shearing action.

(iii) Transverse movements of the mandible.
In the molar region, lateral excursions of the mandible at first cause the large mesio-palatal cusps of the upper molars (sec Fig. 13) to glide up the buccal cusps of the lower molars, and if movement is continued, the cusp to cusp contact of the buccal cusps of the opposite side disengages the molars. Shearing actions may be performed by the premolars and canines; the buccal cusps of the lower premolars engaging those of the upper premolars.

This explanation has perhaps over-simplified the movements of mastication. It is not intended to be a complete guide to all the possible movements, which vary from one individual to another, hut merely to give a general account of the more frequent movements seen in the normal individual.

This account of the factors which find expression in the adult occlusion has necessarily been rather detailed in order that the student may study intelligently the mechanism whereby development becomes deranged. The experience of teeth from their initial differentiation to final occlusion has been traced through five stages. The apical arch, or positions assumed by the tooth apices, is determined by the developmental positions of the teeth in the jaws and the form and relation of the jaws themselves. The morsel arch, or arch of tooth crowns, on the other hand, which must within limits conform to the apical arch, is additionally under the influence of those factors which operate on the tooth crowns after their eruption. These are for the most part physical pressures arising from muscular function. The interplay of these two groups of influence produces an arrangement of the teeth which is infinite in its variety and, from the point of view of aesthetics and function, may or may not be acceptable.

4. Malocclusion

The foregoing chapters might give the reader the impression that normal occlusion was a sharply defined condition. It might seem that a standard pattern of tooth relation and dental arch relation existed and even a constancy in the relation of the dental bases to one another. This impression might be confirmed by the following definition of malocclusion:

A condition where there is a marked departure from the accepted normal relation of the teeth to other teeth in the same arch and to teeth in the opposing arch.

It must be realized that the significant term in this definition is 'normal relation' or, more specifically, the word 'normal'. Many variations arc possible within a state of normality, and each ethnic group may have a 'norm' which is not that of other groups.

We have already seen in the foregoing chapter that variations in tooth position can and do occur during normal development. In a similar manner slight variations in tooth position and relation can occur from one individual to another in established normal dentitions. For'example, the depth of the incisor overbite may be capable of some variation from one individual to another and yet the occlusions may be regarded as nonnal. Where such variations in the depth of the incisor overbite are associated with manifestations of malocclusion, however, they acquire greater significance. Similarly the shape of the dental arches is capable of considerable variation from one individual to another, and likewise the relation of the dental bases. Heredity, including ethnic variation, plays an important part, since much of this variation within the limits of normality may be due to the physical type of the individual.

What then are the limits of normality? When is a certain pattern of tooth or dental arch relation to be regarded as abnormal? When can the

term 'malocclusion' be applied? To. lay down a precise border line is quite impossible. Most cases of malocclusion are readily delectable but a proportion show such slight discrepancies that- they might well be regarded as being within the limits of normality for the individual. Although the occlusion may not be 'ideal', it might satisfy the requirements of 'Structural Balance, Functional Efficiency and Aesthetic Harmony' (Andrew Jackson).

It must also be realized that the interpretation of 'normal' in relation to an occlusion may vary from one orthodontist to another.

As has already been seen, the development of the masticatory apparatus is dependent upon the interaction of several factors. Normal and abnormal growth processes produce a form of masticatory apparatus which is moulded and influenced in its development by the interaction of muscle forces and by the influence of the correct intercuspation of the teeth as they continue to erupt and meet teeth in the opposite arch.

Should interference arise with the proper activity of these factors of normal development, an abnormality may result. Malocclusion can be the result of a complex of factors, only some of which are recognizable with our present degree of knowledge. The conditions which are thought to encourage the establishment of malocclusion are dealt with in the next chapter.

Malocclusion may be simple or it may be complex. It may be considered in the following groups. (Reference to classifications of Dental Arch Relation and Dental Base Relation will be found later).

(A) *Teeth.* Malpositioning of *individual teeth or groups of teeth* in normally related dental arches and jaws. Lack of space in the arch for malposed teeth is thought to be due to the migration of other teeth which have encroached on the space. In this way a simple malocclusion can immediately become complicated and more difficult to treat.

(B) *Dental Arches.* Malrelation of the *dental arches to one another* upon bony bases which are themselves normally related. This will bring in a complication of the conditions described in (A). It is important to remember that a malrelation of the dental arches can lake place in all dimensions, anlero-poslcriorly, laterally and vertically. Many cases exhibit elements of all three dimensional variations from the normal relation of the arches. It will be appreciated that the superimposition of malrelated arches upon a condition of malposed teeth will complicate both the diagnosis and the subsequent treatment.

(C) *Dental Bases.* The conditions outlined in (A) and (B) may have

yet an added complication. The dental bases may be related to one another in such a way that a normal relation of the dental arches can hardly be established either by nature or by the orthodontist. In other words the shape and the relation of the mandible to the maxilla is unfavourable to the production of a normal occlusion. It may be necessary to confine treatment to an improvement in aesthetics alone and to sacrifice one or more teeth in order to attain this objective.

(A) MALPOSITION OF INDIVIDUAL TEETH

An erupted or partly erupted tooth may occupy a position other than normal by being inclined, i.e., the crown of the tooth may occupy an abnormal position while its root apex is normally placed. On the other hand, the crown and the root of the tooth may be bodily *displaced* in the same direction. In addition, a tooth may be *rotated* on its long axis. The various anomalies are designated according to the direction and nature of the malposition (Fig. 36).

Mesial inclination describes a tooth which is abnormally tilted so that its crown leans along the line of the dental arch towards the mid-line of the arch.

Mesial displacement describes a tooth which is bodily displaced towards the mid-line of the dental arch.

Distal inclination—the opposite of mesial inclination. Where a tooth is tilted along the line of the dental arch so that its crown is too far away from the mid-line of the arch.

Distal displacement describes a tooth which is bodily displaced in a direction away from the mid-line of the arch.

(Median diastema is a term which is commonly applied to the space which results when two upper central incisors are in distal inclination or distal displacement. More simply, the term *'mid-line space'* may be used).

Lingual inclination refers to a tooth so tilted that its crown leans towards the tongue. *Retro-clination* is a term frequently used also to refer to the lingual tilting of the anterior teeth.

Lingual displacement describes a tooth bodily displaced towards the tongue.

Labial inclination—a term used to describe the outward tilting of incisor and canine teeth towards the lips *(proclination* may be used also to describe this condition). In the case of the molars and premolars, the term *'buccal'* inclination is used. (Fig. 37).

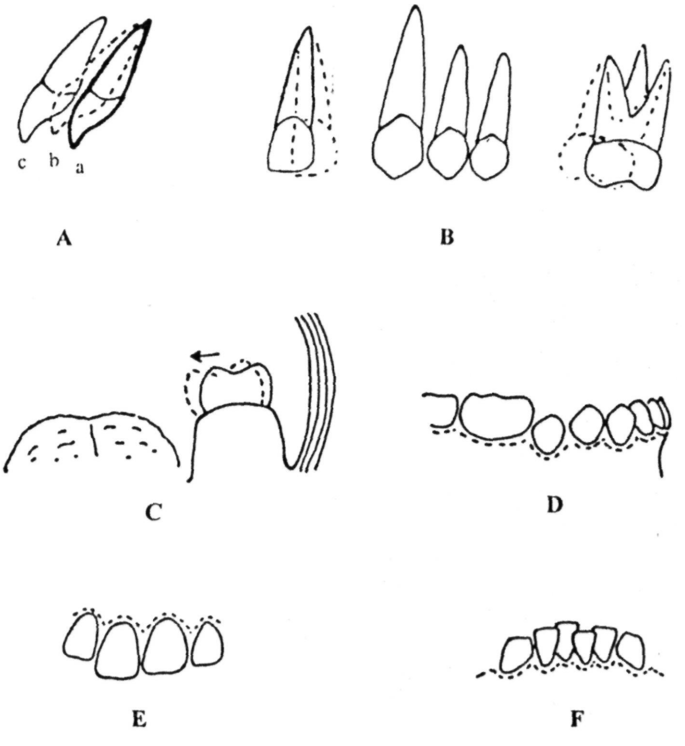


Fig. 36

A a) Normal position of incisor tooth
  b) Inclined position
  c) Bodily displacement

B Dotted lines indicate second molar in mesial inclination due to loss of first molar; central incisor in distal inclination due to loss of lateral incisor.

C Premolar tooth in lingual inclination (dotted lines).

D Second premolar in infraclusion and incisors in lingual inclination.

E Upper right central incisor in supraclusion.

F Imbrication of lower incisors.

Lxibial and buccal displacement arc used similarly to describe bodily displacement of teeth in an outward direction.

Infraclusion—a term used to describe a tooth of which the occlusal surface or incisal edge has not reached the same level as the rest of the teeth in the arch, i.e., it does not appear to have erupted sufficiently.

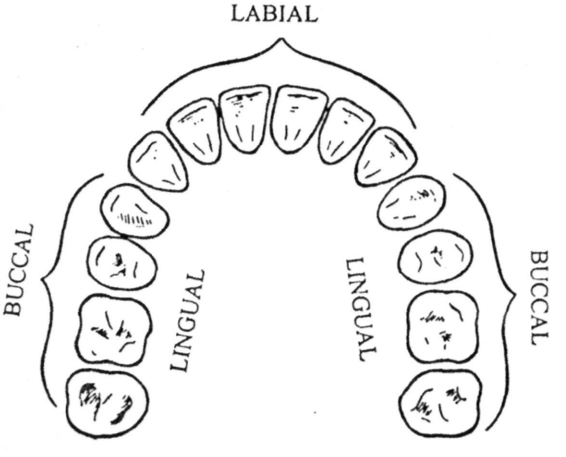


Fig. 37. Terms used to describe inner and outer aspects of the dental arches.

Supraclusion—the opposite of infraclusion, i.e., the tooth appears to have 'over-erupted'.

Mesio-lingual rotation describes a tooth which is rotated around its long axis so that its mesial aspect is turned towards the tongue (Fig. 38).

Disto-lingual rotation describes a rotation in the opposite direction (Fig. 38).

Imbrication describes teeth (especially lower incisors) which are irregularly arranged within the arch due to lack of space for them (Fig. 36).

Combinations of these individual malpositions may occur, e.g. an upper canine tooth may be in *infra-labial inclination* where it has erupted high in the sulcus and outside the dental arch, a position not infrequently assumed by the upper canine tooth.

Transposition is a term used to describe a condition where two teeth appear to have exchanged places during the development of the occlusion. Perhaps this is most often seen where an upper canine and an upper first premolar or lateral incisor on the same side of the arch arc transposed (see Fig. 49 on page 81).

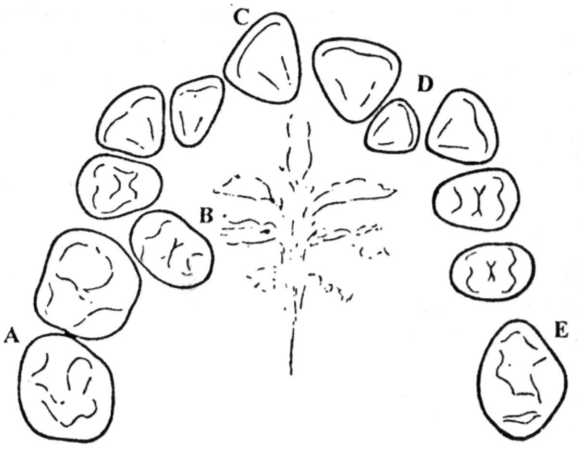


Fig. 38
A Forward migration of right first and second permanent molars due to early loss of second deciduous molars.
B Lingual displacement of upper right second premolar.
C Disto-lingual rotation of upper right central incisor.
D Lingual inclination with slight disto-lingual rotation of upper left lateral incisor.
E Upper left second molar in mesial displacement with mcsio-lingual rotation.

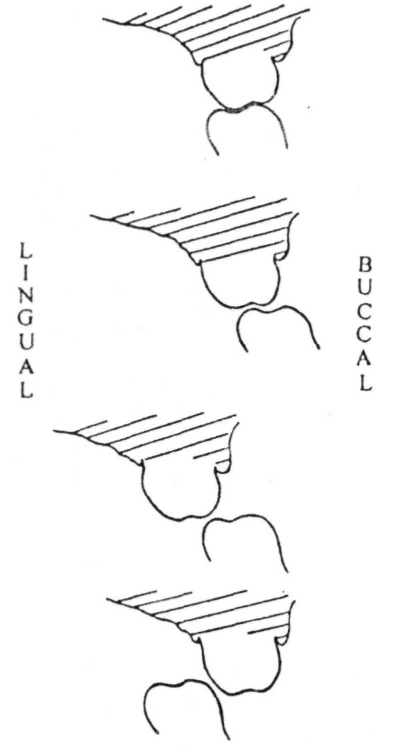
(B) MALRELATION OF THE DENTAL ARCHES

The following terms arc used to describe variations from the normal relations of the dental arches, or segments of the arches, to one another; the mobile body, i.e. the mandible, being described relative to the fixed body, i.e. the maxilla:

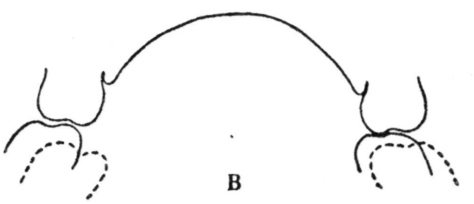
(i) *Post-normal occlusion.* This is used to describe a condition where the lower dental arch appears to lie too far back in relation to the upper arch when the teeth are closed in centric occlusion and the mandibular condyles are in their normal position within the glenoid fossae (See Classification, page 69).

The term applies to dental arch relations only and does not include

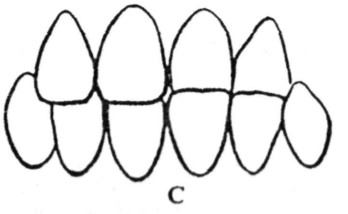
the relation of the mandibular basal bone to the maxillary basal bone. Furthermore, the term post-normal occlusion does not necessarily indicate that the anomaly lies in the position of the lower dental arch; a similar arch relationship can be produced by a forward position of the upper dental arch or both conditions may coexist. If the teeth alone arc viewed as, for example, by the examination of plaster casts without a clinical examination of the patient, the two conditions may appear identical. In this way, errors in diagnosis and treatment planning may occur.



A



B



C

Fig. 39
A Variations of bucco-lingual occlusion.
B Deviation of the mandible on closure, resulting from mild narrowncs.s of the upper arch.
C Lingual occlusion ol upper left incisors.

(ii) *Pre-normal occlusion.* This is used to describe a condition where the lower dental arch is in advance of the upper when the teeth are closed in centric occlusion and the condyles arc in their normal position within the glenoid fossae (See Classification, page 74). The prefix 'pseudo' has been added to describe a condition which, though appearing similar from a view of plaster casts alone, is created by the lingual inclination or lingual displacement of the upper incisor teeth to such an extent that their crowns lie lingual to those of the lower incisor teeth when the jaws are closed, thus 'posturing' the mandible in a forward

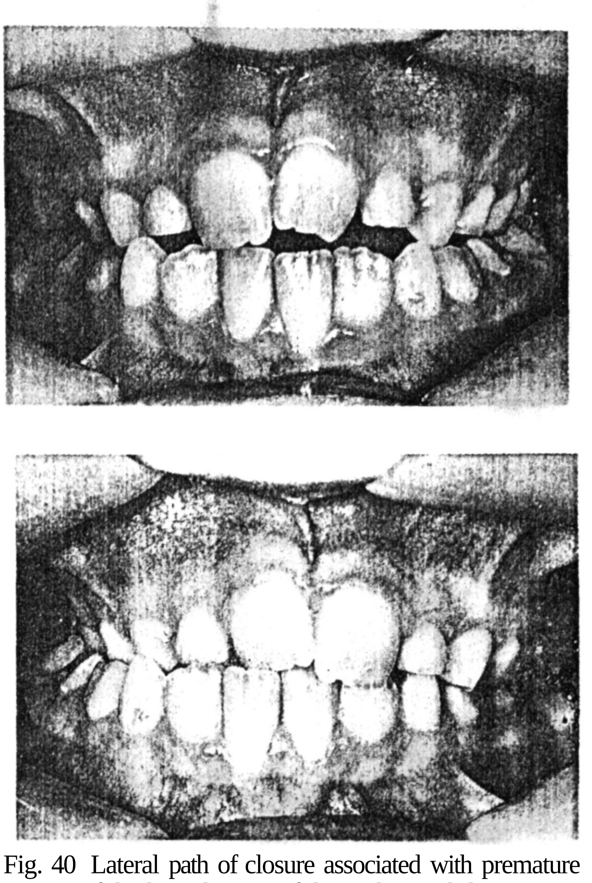


Fig. 40 Lateral path of closure associated with premature contact of the buccal cusps of the molars and the canines.

position and preventing it from assuming normal relationship to the maxilla.

(iii) *Crossbite.* In the transverse direction, on one or both sides, the occlusion may be such that the buccal cusps of one or more upper posterior teeth may occlude within the fossae of the lowers. In such cases the upper arch may appear rather narrower than normal while the lower arch may appear correspondingly wider (Fig. 39).

Where the discrepancy is mild it is likely that a cusp-to-cusp

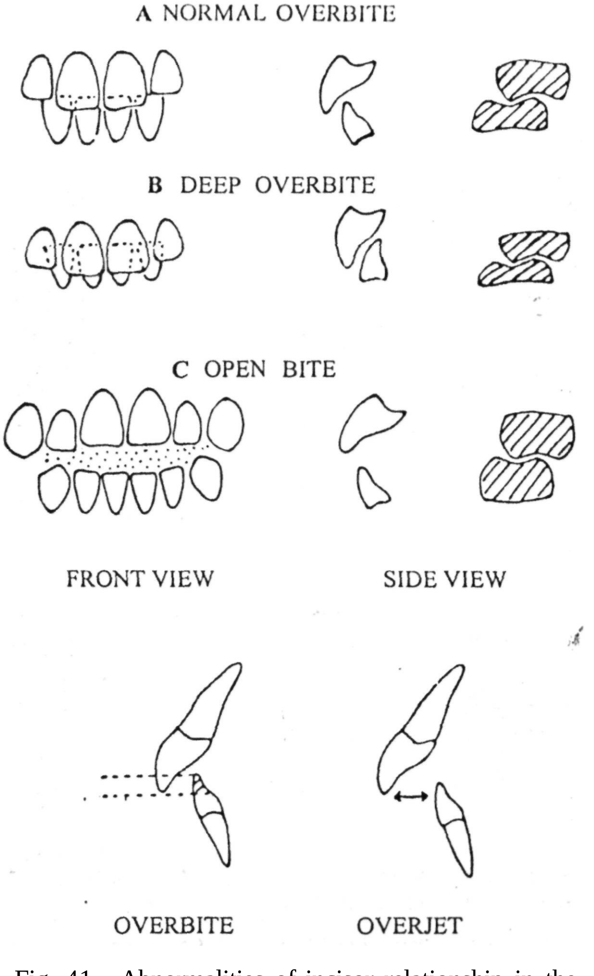


Fig. 41. Abnormalities of incisor relationship in the vertical and horizontal planes.

relationship of the teeth will cause premature contact of the affected cusps as the jaws close. In order to avoid this the mandible may assume a position other than centric occlusion by deviation to one side. This will give the false impression that one side alone is affected (Fig. 40).

The term crossbite has occasionally been extended to include conditions where the upper arch is completely contained within the

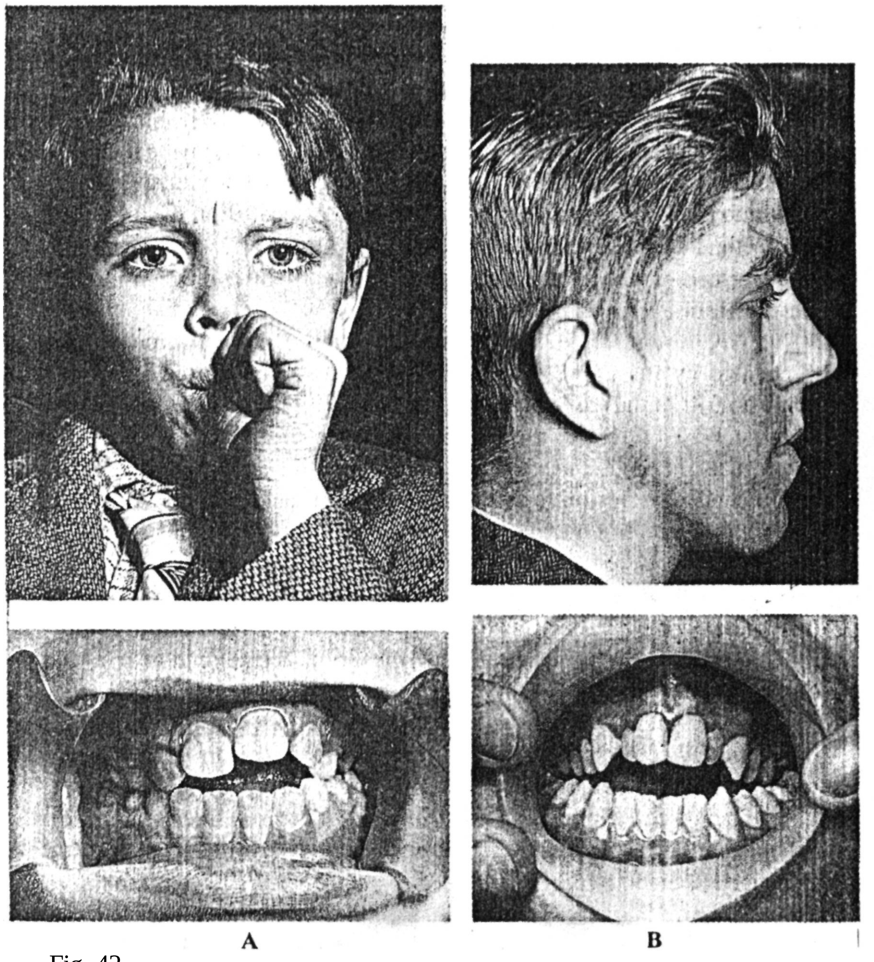


Fig. 42
A Localised open bite due to mechanical interference with eruption occasioned by habitually biting on the thumb.
B Open bite due to skeletal defect, (see also Fig. 5, page 8).

lower, or where the lower arch is contained within the upper on closure. In such cases there is no contact of the occlusal surfaces of the posterior teeth. Both of these conditions are described more clearly by the terms *buccal occlusion* of the lower teeth or *buccal occlusion* of the upper teeth. Similarly the term anterior crossbite is used occasionally to describe a condition where one or more upper incisors occlude lingually to the lowers. This is more usually described by the term lingual occlusion of upper incisors.

(iv) *Open-bite.* In these cases only the most distal teeth in the arches may occlude when the jaws are closed, a space existing between the rest of the teeth in the upper jaw and those in the lower, such space progressively increasing anteriorly (Fig. 41). Open-bitc may be localized to a section of the arch only, i.e. the anterior segment or a buccal segment, in which case there may be a normal degree of occlusion of the rest of the teeth. Instead, therefore, of describing a patient as having 'open-bite' it is necessary to indicate the position, e.g. 'anterior open-bite' or 'left posterior open-bite'.

(v) *Overbite* refers to the amount by which the lower incisors are concealed by the upper incisors when the teeth are closed in centric occlusion. It is thus a vertical measurement (Fig. 41).

(vi) *Overjet* refers to the distance between the labial aspect of the lower incisors and the incisal edge of the upper incisors when the arches are in centric occlusion. It is thus a horizontal measurement (Fig. 41).

(vii) *Incomplete Overbite* is a term used to indicate that a vertical space exists between the lower incisors and the palatal aspect of upper incisors or the palate when the posterior teeth are in centric occlusion (Fig. 43B).

This space may be penetrated by the tip of the tongue at rest and during swallowing (Fig. 42).

(viii) *Complete Overbite* is used to indicate that the lower incisors have erupted into contact with either the upper incisors or the palate leaving no space when the teeth are in centric occlusion (Fig. 43A).

(ix) Increased *Interocclusal Clearance* (or increased free-way space). When a child closes his jaws into centric occlusion there may be an increased incisor overbite which is brought about by an excessive distance between the occlusal surfaces of the upper and lower posterior teeth when the mandible is in the rest position. When the posterior teeth are occluded the anterior teeth will present an increased incisor overbite. When this condition is associated with a postnormal occlusion, with an accompanying lack of effective contact with the palatal surface of the upper incisors, the lower incisors tend to elevate until they find

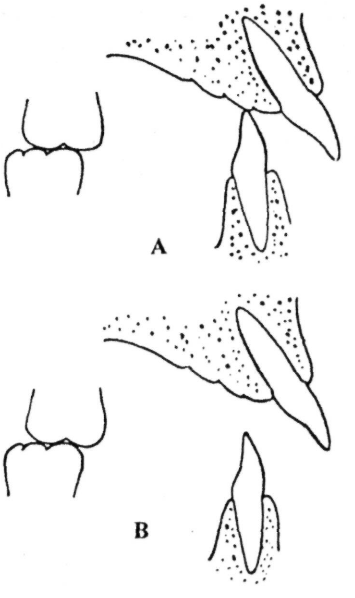


Fig. 43.
A Complete incisor overbite
B Incomplete incisor overbite

an antagonist which may even he the palatal mucosa. Sichcr has suggested that the posterior alveolar processes 'crudely speaking, do not seem to be able to take advantage of the space that is provided for their growth and thus do not grow to their full height'. Sicher' further suggests that 'since mandibular and maxillary alveolar processes have not grown to their full height, too wide a space remains between the upper and lower teeth'. In the absence of a more satisfactory explanation, Sicher's suggestion may account for the phenomenon noted in some cases of postnormal occlusion where the occlusal surface of the posterior teeth in the lower dental arch seems closer to the lower border of the mandible than usual having regard to the age and state of development of the occlusion. (See Variations from typical swallowing, page 93).

(C) SKELETAL MORPHOLOGY UNFAVOURABLE FOR THE PRODUCTION OF NORMAL OCCLUSION

As will be described in succeeding chapters, certain conditions may affect the shape and size of either or both jaws and also their relationship,

' Sicher. H. (1957). *Amer. J. Orthodont.* 43:679.

not only to each other in all dimensions but also to the rest of the skull. For example, the mandible may be underdeveloped or a cleft may affect the structure of the maxilla. In either case the development of normal occlusion is highly improbable depending as it does on the accommodation of a full adult dentition perfectly aligned within a dental arch which possesses adequate bony support.

Postural defects in the positioning of the mandible relative to the maxilla, which may result from causes to be described later, may be accompanied by development of malocclusion.

Certain inherited bone shapes and forms may not permit the production of an occlusion which can be accepted as being of a normal pattern (see Skeletal Classification, page 75). A prenormal occlusion not infrequently accompanies a large and prominent mandible, especially if it is associated with a maxilla which is short antero-posteriorly. Such a condition may appear in several generations. In order that the teeth shall be in a stable position upon such bony bases, the lower teeth may have to assume a position relative to the upper teeth which does not permit the exact form of occlusion generally regarded as normal. The incisor teeth may meet edge-to-edge or the lower incisors may be in advance of the uppers and yet the teeth are in a position of stability.

Perhaps it is inadvisable to adopt too narrow an outlook upon 'normal occlusion' but we should consider what may be normal for an individual whose teeth have assumed a position of equilibrium upon his inherited basal bones. Here, only an aesthetic improvement may be achieved by orthodontic treatment designed to alter the axial inclinations of the upper and lower incisor teeth. It would appear that no orthodontic therapy can produce a permanent alteration in the size of the basal areas of the jaws themselves, nor in their relationship to one another except where there is a postural defect in the positioning of the mandible. Howpver, an improvement *in appearance* by treatment may be possible where the skeletal shape is unfavourable to normal occlusion. In such cases little alteration can be achieved *in the occlusal relations* without moving the teeth into a position of instability from which relapse to the former state after treatment would be inevitable.

CLASSIFICATION OF MALOCCLUSION

In order to acquire a better understanding of the many deviations from normal occlusion and to assist in diagnosis and treatment planning, it becomes necessary to group the varieties of malocclusion into order. This is difficult as occlusal anomalies are many and varied. Orthodontics

has been described, admirably, as a 'Science of Infinite Variation'.[1]

Many attempts have been made to introduce a classification of malocclusion which would embrace this wide field of variation and which would be generally acceptable. None has achieved this object though the classification introduced by Edward Angle in 1899 has done much to clarify thought in addition to producing a useful aid in diagnosis and treatment planning. Angle based his classifications upon the 'mesial-distal relations of the teeth, denial arches and jaws'.[2] It is, however, now only applied to the dental arch relations and, for this purpose, the classification is still commonly in use today. It is not used as a definite diagnostic criterion as intended by Angle, but rather as a diagnostic aid and also for the purpose of description.

Edward Angle held the opinion that, *providing all the teeth were present,* the first permanent molars could be considered as fixed anatomical points within the jaws. He believed that study of the relation of the lower first permanent molars to the upper first permanent molars when these teeth had erupted into occlusal contact would indicate whether or not normal arch and jaw relation existed.

It is known that the first permanent molars are not necessarily fixed in their position in the jaws but that they tend to move forwards during development (see page 31). The forward movement may become excessive if the deciduous molars are removed prematurely from the same buccal segment (see Fig. 65, page 100). Thus when using any classifications based on tooth relations *allowance must be made where undue movement of the first permanent molars is suspected.* Cephalostatic radiography has shown that the relation of the dental arches and teeth does not necessarily reflect the relation of the basal areas of the jaws and it has become customary to use the Classification of Angle only to indicate the relation of the arches of tooth crowns to one another and not the jaw relations as originally intended by Angle.

CLASSIFICATION OF DENTAL ARCH RELATIONS

Class I.

The lower dental arch is in normal relation to the upper dental arch as evidenced by the occlusion of the mesio-buccal cusps of the upper first permanent molars in the buccal grooves of the lower first permanent molars, *providing no drifting of these teeth has occurred,* and, if the

[1] Jackson, A. F. (1947). *Trans. B.S.S.O.*

[2] Angle, E. H. (1907). *Malocclusion of the Teeth.* S. S. White, 7th Edition.

deciduous molars arc still present, due allowance has been made for the wider mesio-distal width of the lower deciduous molars (sec page 31). This produces the correct intcrcuspal relationship of the posterior teeth. This class, therefore, does not involve antero-posterior malrelation of the dental arches as a whole. However, since it is a category of malocclusion, Class I does include irregularity of individual teeth which may create local malrelation of *segments* of the dental arches.

Class II.

Typically the lower dental arch is in distal relation to the up[)cr dental arch ns evidenced by the disto-buccal cusp of the upper first permanent molar occluding in the buccal groove of the lower first permanent molar, by an abnormal intercuspation of the premolars to the extent of the

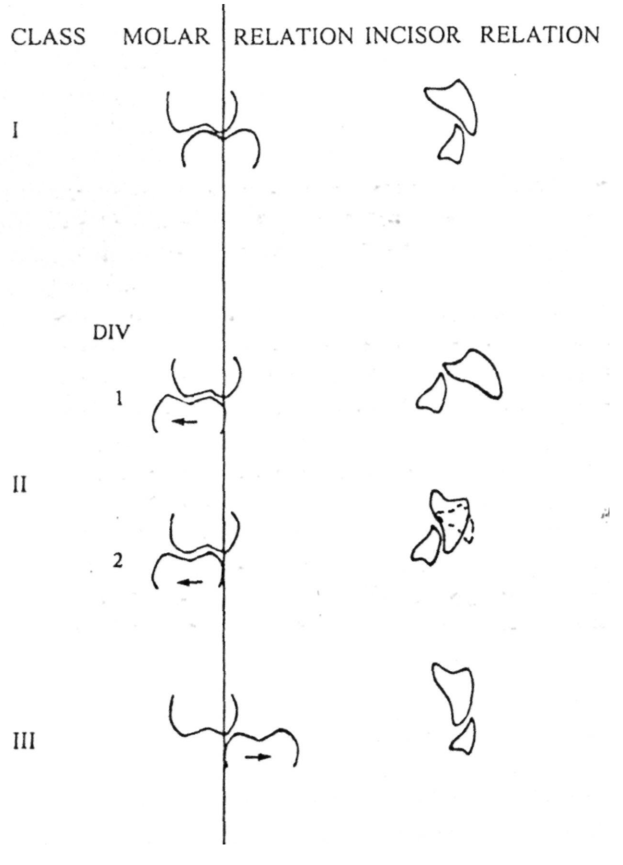


Fig. 44 A

lower first premolar occluding where the lower second premolar normally occludes and by the occlusion of the lower canine slightly distal to the upper. Although this is the classic description of Class II, it is possible to find lesser degrees of distal position of the lower arch relative to the upper dental arch, measured in terms of less than one premolar unit, which may not produce this typical picture. Such lesser

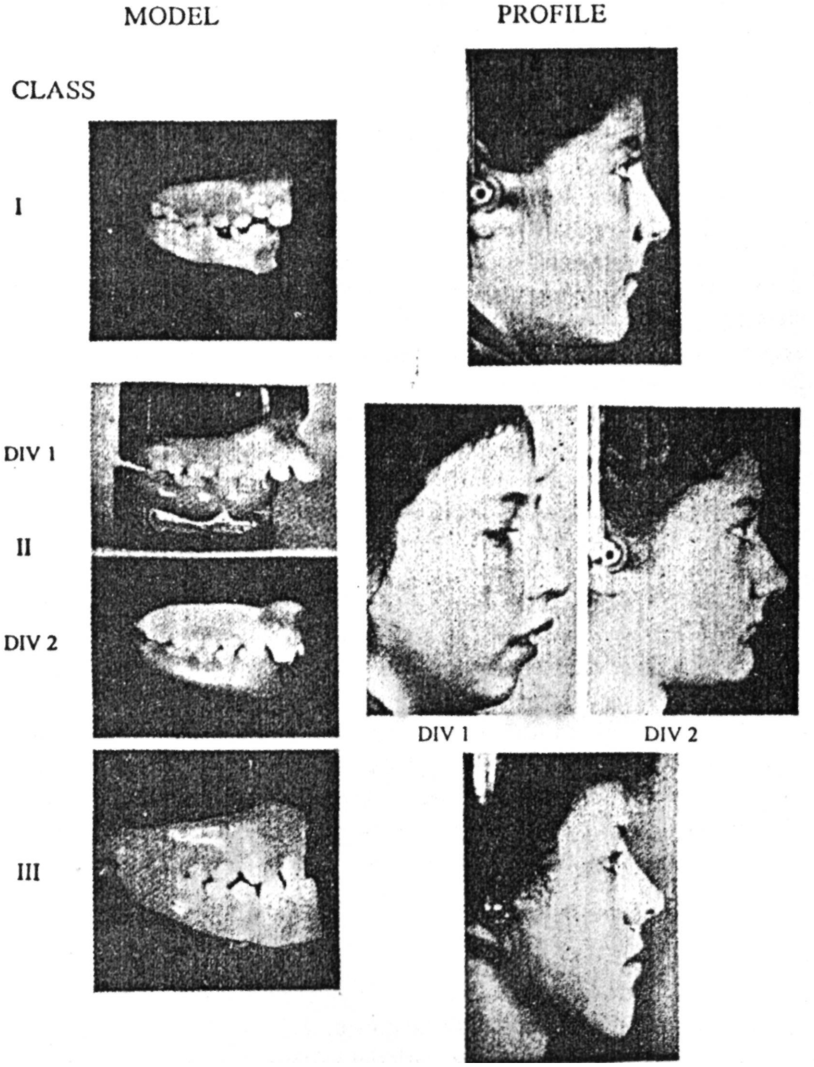


Fig. 44B. Angle's three Classes with relative models and profiles.

degrees of malrelation of the arches may be difficult to detect in the change-over stage from the deciduous to the permanent dentition. Furthermore, local irregularities in the position of individual teeth often accompany Class II dental arch relations. There are two divisions of Class II, each capable of occurring on one side only; a condition described by the suffix 'Unilateral*.

Division I: The upper incisors arc proclincd, such that the ovcrjcl may be as much as 14 mm, the lower incisors frequently meet the palatal mucosa when the jaws are occluded. There is often an accompanying short upper lip with failure in the anterior lip seal (Pig. 44D) wiiich, due to its unfavourable appearance, usually prompts the patient or the parent to seek treatment. Such cases are often accompanied by a deep incisor overbite, an upper arch which is narrow in the canine and premolar region broadening between the molars and giving rise to the typical 'V'-shaped upper arch.

Division 2: The upper central incisors show lingual inclination but may be overlapped by the upper lateral incisors. The upper arch is usually broad while the incisor overbite is deep, both upper and lower incisors being in apparent supra-occlusion. The upper lip is of normal length and contacts the lower lip though there may be a deep mental groove below the latter (Fig. 44B).

These cases are frequently accompanied by prominent malar processes. The depth of the incisor overbite of these cases is increased

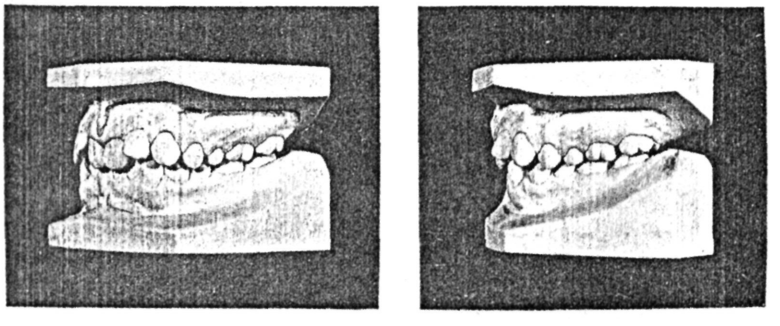


Fig. 45. Example of Angle's Class I molar relationship in which lingual inclination of upper and lower incisors is associated with an appearance resembling that of a Class II Division 2 malocclusion.

by two factors: the distocclusion and the lingual inclination of the upper incisors. Imbrication of the upper incisors is usually present and may assume the characteristic form of overlapping of the distal edges of the

central incisors by the mesial edges of the upper lateral incisors. Both arches have a rather square appearance when compared to those of Division 1; this is due to the lingual inclination of the incisors, In some patients, classification based upon the relationship of the buccal teeth will not agree with that based upon the incisor relationship. This confusion may arise as the result of molar drifting or an abnormal inclination of the incisor teeth. In these cases classification should be based upon the incisor relationship which may be further defined as follows:

Class I. The lower incisal edge occludes with the middle third of the palatal surface of the upper incisor crown.

Class II. The lower incisal edge occludes with the cervical third of the palatal surface of the upper incisor crown or distal to this position.

Class III, The lower incisal edge occludes with the incisal third surface of the palatal surface of the upper incisor crown or mesial to this position.

It should be noted that not all Angle Class II cases fall clearly into one of these two divisions for some present a postnormal occlusion in

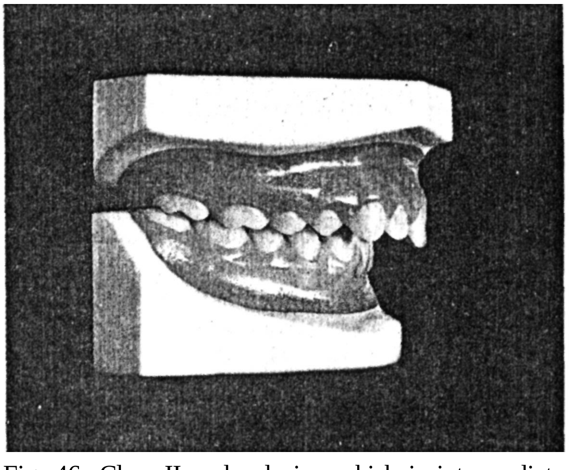


Fig. 46. Class II malocclusion which is intermediate between Angle's Class II Division 1 and Angle's Class II Division 2, because the upper incisors are neither proclincd or rctroclincd, but there is an increased ovcrjct.

which the upper incisors are neither proclined nor retroclined (see Fig. 46). There is therefore an increased incisor overjet which usually allows the overbite also to increase. There may be some crowding of the upper incisors. Being typical of neither Class II Division 1 nor Class II Division

2 malocclusion, such cases may be designated as indefinite Class II malocclusions.

Class III, The lower dental arch is in mesial relation to the upper dental arch. The relation of the posterior teeth may be such that the lower first permanent molar may lie as much as a full premolar width mesial to the upper first permanent molar, though there arc frequently lesser degrees of mesial relationship. The incisors may occlude edge-to-edge, the lower incisors may be in advance of the upper incisors or, rarely, the lower incisors may still present their incisal tips lingual to those of the upper incisors in which case there is an extreme degree of incisor lilting (Fig. 44). Local irregularities in the position of individual teeth may also accompany Class III dental arch relations.

Class III cases may be divided into:

(i) True prenormal cases and

(ii) Pseudo prenormal cases.

There is no sharp line of definition between the two, many cases showing characteristic features of both. The two extreme conditions will be described to illustrate the points of difference:

(i) *True Prenormality.* This always involves an antero-postcrior malrelationship of the dental bases (see Classification of Dental Base Relations, page 75). The mandible is either excessively large or there is lack of forward growth of the maxilla. In many cases there is a combination of both. Therefore, when the teeth are in centric occlusion, the mandibular condyle is within the glenoid fossa and the mandible cannot be retruded further than a millimetre or two. These cases are usually found to be hereditary, other members of the family being similarly affected.

(ii) *Pseudo prenormality.* In this condition the mandible is protruded a little during the final stages of closure in order to avoid a premature contact of incisors or canines. This is most likely to arise in cases where the relationship of the incisors is edge-to-edge, and may be caused by a mildly prenormal relationship of the dental bases (see below) or by premature loss of upper molars. Such a loss may reduce the forward component of growth of the upper alveolar process. As the teeth approach occlusion the condyle is drawn forward a little on to the distal slope of the emincntia articularis, but may return almost to its original position when the teeth are in full occlusion. The incisor overbite is large and the jaws have the appearance of being over-closed when the teeth are approximated. Such pseudo- or postural Class III cases may tend, if left untreated, to become established by a further development of the whole occlusion in Class III relation.

Class III cases of malocclusion are less common in occurrence than those of Class I or Class II. Where the condition is present only on one side it is referred to as 'Unilateral',

CLASSFFICATION OF DENTAL BASE RELATIONS

The terms Skeletal 1, 2 or 3, arc commonly applied to describe dental base relations in the antero-postcrior direction when the jaws are closed and the teeth arc in full occlusion. (See Chapter 12).

Thus *Skeletal* 1 can be taken to indicate a dental base relation which is favourable to the production of a satisfactory occlusion either by normal development or by orthodontic tooth movement. *Skeletal 2* will describe a 'postnormal' relation of the dental bases and *Skeletal* 3 a 'prenormal' relation.

A case may, for example, be described as having a Class II dental arch relation upon a Skeletal 1 base.

It must be emphasized that the diagnosis of a case does not start and finish with a classification which is only a means of placing cases in a category. While it may serve a useful purpose in description, any classification should only be regarded as a convenient starting point in diagnosis.

Therefore, this chapter should be read in conjunction with Chapter 12 (Examination of the Patient) where a description of the clinical features of the varying types of malocclusion will be found and which should assist to a better understanding of the many problems. The reader is also referred to the methods of estimating the relation of the dental bases to one another.

5. Aetiology

Although malocclusion in its many forms is common in a civilized community, the causes of some of these conditions are, at present, only imperfectly understood. There are types of malocclusion which have an obvious cause and are preventable or readily amenable to treatment at the proper time. There are some forms of malocclusion where the cause is more obscure and the result less ready to respond to trcalnicnl unless by prolonged and complicated techniques. Yet others arc believed to be hereditary in origin and beyond prevention. If orthodontic treatment is given in these latter cases, it may only be palliative in nature and applied with the intention of obtaining an aesthetic or functional improvement in the occlusion within the limits set by heredity. Even here, however, the treatment may be more effective if the intervention is timely than if it is delayed until a full malocclusion is established.

The onus is therefore upon the general practitioner to recognize malocclusion sufficiently early for treatment to be undertaken at the optimum age. For this reason some knowledge of the way in which malocclusion arises is essential, even where the origin of the condition is still obscure. This knowledge will also be necessary if the practitioner is to avoid such action as may cause or exacerbate a malocclusion during the course of routine dental treatment. It would seem logical therefore to classify the causes of malocclusion in such a way that the student will know at what stage of development it may first arise. This chapter has accordingly been set out in a manner similar to that used in Chapter 3 where the forces which determine the ultimate position assumed by a tooth are described.

I *Dental Base Abnormalities.*

1. Antero-posterior Malrelationships.
2. Vertical Malrelationships.

3. Lateral Malrelationships.
4. Disproportion of size between Teeth and Basal Bone.
5. Congenital abnormalities.

II *Pre-Eruption Abnormalities*

1. Abnormalities in the position of the developing tooth germ.
2. Missing Teeth.
3. Supernumerary Teeth and Teeth abnormal in form.
4. Prolonged retcniion of Deciduous Teeth.
5. Large Labial Frcnum.
6. Traumatic Injury.

III *Post-Eruption Abnormalities*

1. Muscular Forces:
   (a) Active Muscle Forces—Swallowing.
   (b) Rest position of the Musculature.
   (c) Sucking habits.
   (d) Abnormalities of the Path of Closure.
2. Premature Loss of Deciduous Teeth,
3. Extraction of Permanent Teeth,

I DENTAL BASE ABNORMALITIES

1. *Antero-posterior Malrelationships of the Dental Bases*

The relative position in which a tooth develops depends not only upon its own position within bone but also upon the relationship of that bone to other bones. It has already been shown that the development of the bones which form the upper part of the face and support the maxillary arch of teeth differs fundamentally from that of the mandible. Discrepancies of relationship between the jaws may therefore arise occasionally, since any condition which is selective in its effect may disturb their relationship. Although genetic control is an important factor in guiding the development of the bones of the face, the extent of this control is still in doubt. Clinical experience suggested that heredity and ethnic origin are strong factors in determining the shape of the facial bones. This is supported by the work of Kraus, Wise and Frei, who concluded after analysing radiographs of six sets of triplets that there is a close similarity in the form of individual bones in identical twin pairs, but that there may be variation in the way they are assembled.' It may

'Kraus, B. S., Wise, W. J., Frei, R. H. (1959). *Amer. J. Orthod.* 45: 172

be said, therefore, that antcro-posterior malrelation of the dental bases is often considered genetic in origin although it is not outside the realms of possibility that certain conditions, possibly sub-clinical in nature, may have some selective influence upon mandibular or maxillary growth. Occasionally, however, cases are seen in which an obvious cause of discrepancy can be traced. One example is micrognathia of the mandible arising from physical damage to the condylar head, this may occur as a result of damage to the condyle during development.

2. *Vertical Malrelalionships of the Dental Bases*

Although the teeth and alveolar processes are adaptable within limits and manage to compensate for moderate variations in vertical height of

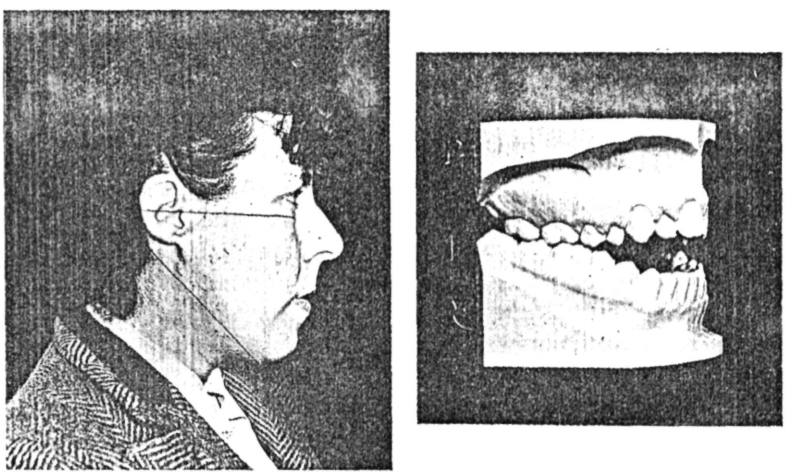


Fig. 47. True open bite of skeletal origin, associated with a large Frankforl mandibular angle.

the lower part of the face, examples arc seen from time to time in which an anterior open bite is associated with an increase of infra-nasal height (vertical distance between the nose and chin). This is known as a true open bite of skeletal origin (Fig. 47).

3. *Lateral Malrelationships of the Dental Bases*

Occasionally cases are seen in which one dental base is disproportionately wide or narrow and is accompanied by a lingual or buccal occlusion ('Cross-bite') of the molars although the axial inclination of the teeth appears correct. Where the upper dental base is

narrow, similar narrowness of the nasal floor may be accompanied by partial nasal obstruction.

4. *Disproportion of Size between Bones and Teeth*

Cases are frequently seen where the dental bases are insufficiently large to accommodate all the teeth in alignment (Fig. 48). The characteristic features arc crowding of the incisors which have had to erupt into limited space between the deciduous canines, and impaction of the third molars. Premature extraction of deciduous canines or molars in these cases, however, allows the incisors to spread themselves distally and become better aligned at the same time transferring the crowding to the permanent canine and premolar regions. Occasionally, spontaneous premature exfoliation of a lower deciduous canine rnay produce a similar result.

The size of the tooth crowns is established at an early stage of development, all but the crowns of the third molars being formed by the age of eight years. Growth of the facial bones, on the other hand, is not completed until the age of twenty years. There is Ihercforc a much longer period over which environmental factors may disturb their growth and cause the bones to fall short of the optimum size set by their genetic potential.

Many have claimed that crowding may be the result of the inheritance of large teeth from one parent and small jaws from the other. It is difficult to reconcile this theory with the comparative rarity of the converse condition, small teeth in large jaws. It is possible, however, that a disproportion of size between teeth and bone may itself be inherited as a characteristic.

It will appear that very little is known of the origins of discrepancies of growth of the jaws and malrclation of their dental bases. Treatment is not materially affected by this lack of knowledge, for, as a general rule, treatment with simple orthodontic appliances can produce little or no change in the basal bones, either in their size or in their mutual relation. It is necessary therefore to accept most dental base discrepancies, and to plan treatment without attempting to alter them.

5. *Congenital Abnormalities: Clefts of Lip and Palate*

A number of physical malformations involving the jaws may arise from defects of development that occur before birth. Many are associated with failure of embryonic processes to fuse, giving rise to clefts of the face or jaws. The most common are clefts of the lip and of the palate, occurring once in every thousand births in Britain.

They may be found together or separately, and vary greatly in their severity. It is not uncommon to find them associated with congenital deformity in other parts of the body. Clefts of the lip may be unilateral or bilateral and usually affect also the alveolar process; those of the palate vary from a bifid uvula to a complete cleft of hard and soft palate. The most severe disturbances are seen where a cleft of hard and soft palate is continuous with bilateral cleft of the lip and alveolar process.

Malocclusions resulting from such causes arc usually extreme, especially where surgical repair has been performed. In the absence of bony support due to the palatal cleft, the buccal segments of the upper arch are pressed upon by the buccinator muscles. They arc caused to assume a lingual inclination due to an upset in the balance of the soft tissue forces (page 46), the molars and the premolars often adopting a lingual relationship to their antagonists in the lower jaw.

II PRE-ERUPTION ABNORMALITIES

1. *Abnormalities in the position of the developing Tooth Germ.*
The developmental position of the teeth is probably determined genetically. This position may be modified by physical pressures. Where the jaws are very small and the tooth germs developing close together, some may become displaced. It is not uncommon for the incisor teeth in a developing dental arch to retain a pattern of irregularity which closely resembles the normal arrangement of the tooth germs (Fig. 48).

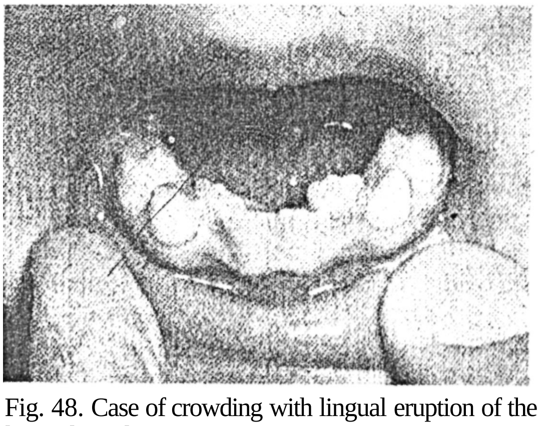


Fig. 48. Case of crowding with lingual eruption of the lower lateral incisors.

In some cases individual teeth develop in an abnormal position without apparent cause. In others an obvious cause is present. For

example, this condition may be associated with the presence of supernumerary teeth, pathological conditions, congenital clefts involving the alveolar bone, or traumatic injury causing displacement of the tooth germ.

Upper canines and incisors are particularly liable to develop in an abnormal position but it may occur with any tooth. A complete transposition may arise especially in the case of upper canines which erupt either mesially to a lateral incisor or even distally to a first premolar (Fig. 49).

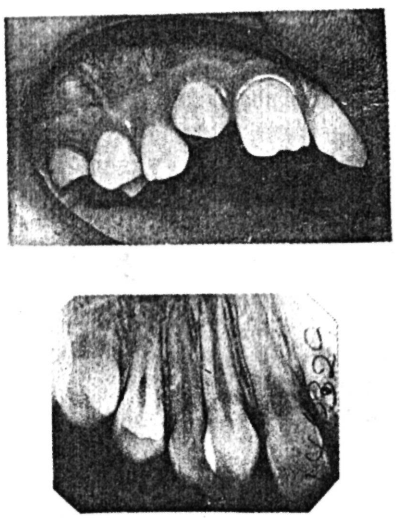


Fig. 49. Transposition of the upper right-canine and lateral incisor.

2. *Missing Teeth* (Partial or Complete Anodontia)

In about 3 per cent of persons the dentition is short of its full complement of teeth because one or more are totally absent.' This is a condition which may appear in succeeding generations of the same family, and more frequently affects the permanent dentition. When a tooth is congenitally absent, the space which it should occupy within the dental arch may close. The degree of closure is dependent upon the support given by the tongue and cheeks to the dental arch and whether there is crowding in other parts of the arch.

' Rose, J. S. (1966), *Dent. Practit.* 17: 107

The teeth which are found most frequently to be absent congenitally are the third molars, the upper lateral incisors and the lower second premolars (see Fig. 86, page 137). The condition is often bilateral. Where a lower second premolar tooth is missing, it is common to find the lower second deciduous molar retained beyond the time when it should have been shed (sec also 'Prolonged Relcnlion of Deciduous Teeth', page 85). As the mesio-distal measurement of the latter tooth is greater than that of a second premolar, an imbrication of the lower permanent teeth mesial to the second deciduous molar may be encouraged. It can be said, of course, that such an anomaly is due to the retained deciduous tooth rather than to the fact that the lower second premolar is missing.

Upper lateral incisors are sometimes missing and this may give rise to a wide space between the upper central incisors and upper canine teeth. More often however, the central incisors move apart (Fig. 50).

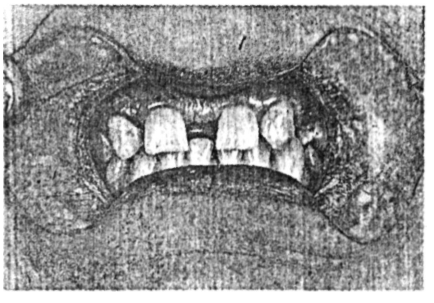


Fig. 50. Large median diastema associated with congenital absence of upper lateral incisors.

While the absence of third molars can seldom be included as a cause of malocclusion, the possibility of such teeth being missing from the arch must be visualized if treatment by extractions is being considered (Chapter 7).

The absence of developing teeth lessens the stimulatory influence for development in the arches and the end result may resemble the effects of loss of teeth by extraction. It may be desirable to maintain, by artificial means, the space within the arch which would normally have been occupied by the teeth which are missing. This will maintain the arch size by preventing the adjacent teeth from encroaching upon the space by tilting and will facilitate the ultimate insertion of a restoration.

It is not unusual to find defects of ectodermal structures such as hair, finger or toe nails and skin associated with the absence of teeth.

3. *Supernumerary Teeth and Teeth Abnormal in Form*

Teeth extra to the normal complement have been found to occur in about 1 percent of the population.[1] Of these only one in three is erupted. Although they may occur in any part of the mouth, the incisor region is their usual site. Extra teeth may resemble normal teeth in form, when they are called supplemental teeth. More frequently, however, they arc conical or multi-cuspcd in form, when they are called supernumerary teeth.

In the deciduous dentition supernumerary teeth are rare, but supplemental lateral incisors are occasionally seen and erupt at the normal time (see Fig. 90, page 141). Supplemental teeth in the permanent dentition are usually found in the lower incisor region, but may also occur in other parts of the mouth. They rarely fail to erupt and cause irregularity and crowding (Fig. 51), The most common site for

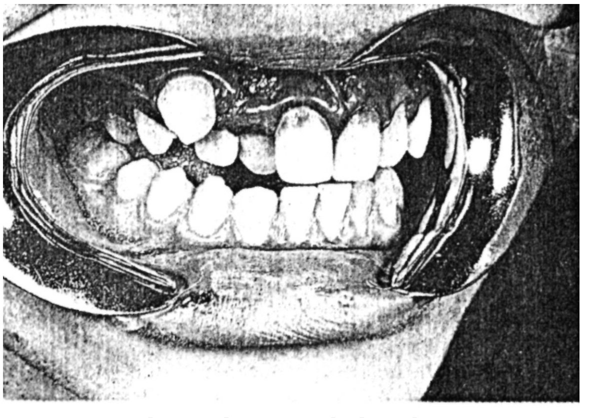


Fig. 51. Supplemental upper right lateral incisor causing irregularity of the permanent dentition.

supernumerary teeth is near the mid-line palatally to the upper incisors (Fig. 52), but they arc also seen frequently in the region of congenital clefts through the alveolar process. Although a conical shape is the most common, other types occur, including a tuberculated form.

[1] Gardiner, J, H, (1961). *Dent. Practit.* 12: 63,

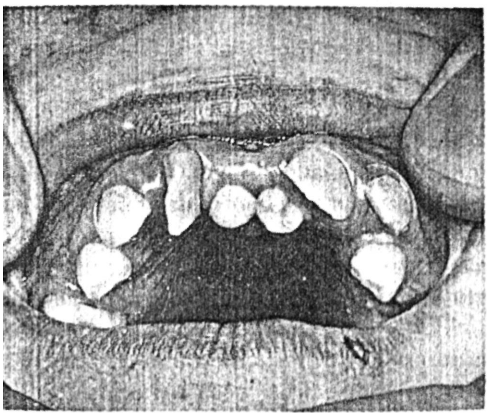


Fig. 52. Example of a mulli-cusped supernumerary tooth alongside a simple conical form.

The presence of more than one supernumerary should always be suspected in this region, and it should be borne in mind that their calcification occasionally begins as late as nine years of age. The presence of supernumerary teeth may be suspected where there are unexplained abnormalities of axial inclination of teeth in the area, local spacing especially between upper central incisors (Fig. 53) or failure of permanent upper centrals to erupt.

Extra teeth arise from a developmental disturbance of the tooth band, the nature of which is very imperfectly understood. Some cases are familial and may have a genetic background. The occasional presence of extra teeth in the same mouth as missing teeth suggests that they are not atavistic manifestations.

The extraction of extra teeth whenever detected is the correct line of treatment although, in the case of supplemental incisors, it may be difficult to decide which tooth to retain. Consideration must be given to the optimum aesthetic and functional result obtainable with the minimum mechano-therapy subsequent to the extraction. Natural forces play a large part in bringing teeth together into close contact after an extra tooth has been removed.

Individual teeth are occasionally found to be of an abnormally large size and unable to erupt into the available space within the dental arch and maintain their correct alignment (Fig. 54). Conversely, abnormally small teeth are occasionally seen. Thus it is not uncommon to find small peg-shaped upper lateral incisors which do not occupy completely the

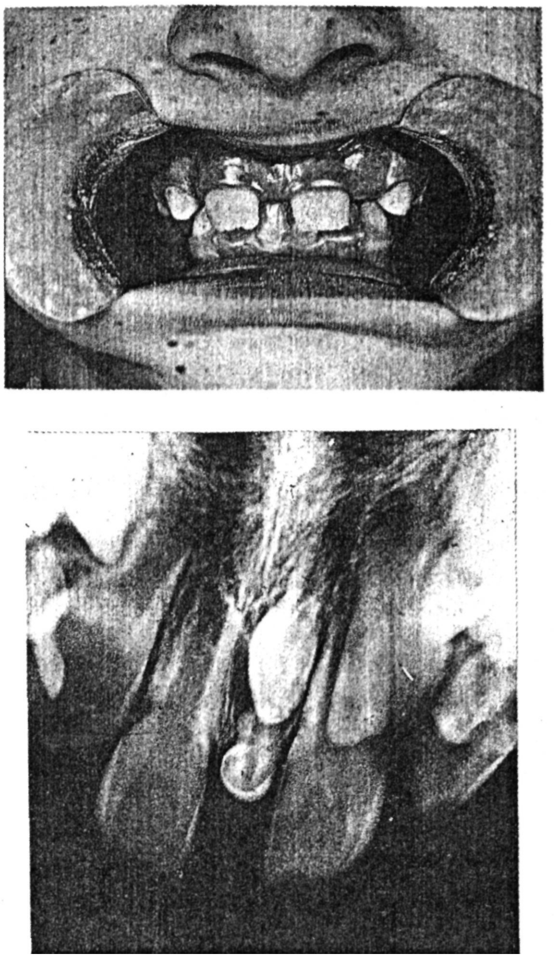


Fig. 53. Wide space between upper central incisors caused by two uneruptcd supernumerary teeth.

space which is available (Fig. 55). Fusion of teeth may be seen occasionally. This may affect two of the permanent dentition, for example, an upper central and lateral incisor. Fusion of a permanent tooth with a supernumerary may occur. Such conditions may adversely affect the development of a normal occlusion (Fig. 56).

4. *Prolonged Retention of Deciduous Teeth*

Occasionally a condition is seen where there is slow development of

the permanent teeth. This is associated as a rule with delayed shedding of the crowns of the deciduous teeth owing to the late resorption of their roots. If the process, though slow, otherwise follows a normal course there is no reason to expect that a malocclusion will develop.

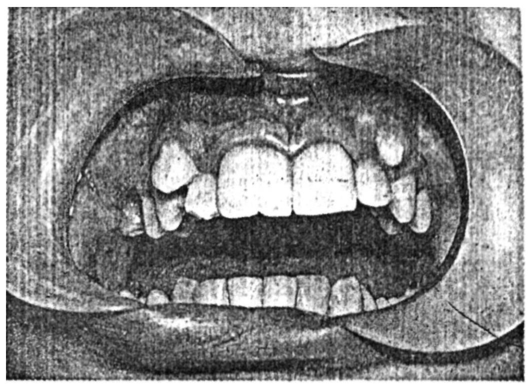


Fig. 54. Example of crowding which is made worse by the presence of unusually large upper right ccnlral incisor.

Fig. 55. Small peg-shaped upper lateral incisors with spacing of the centrals.

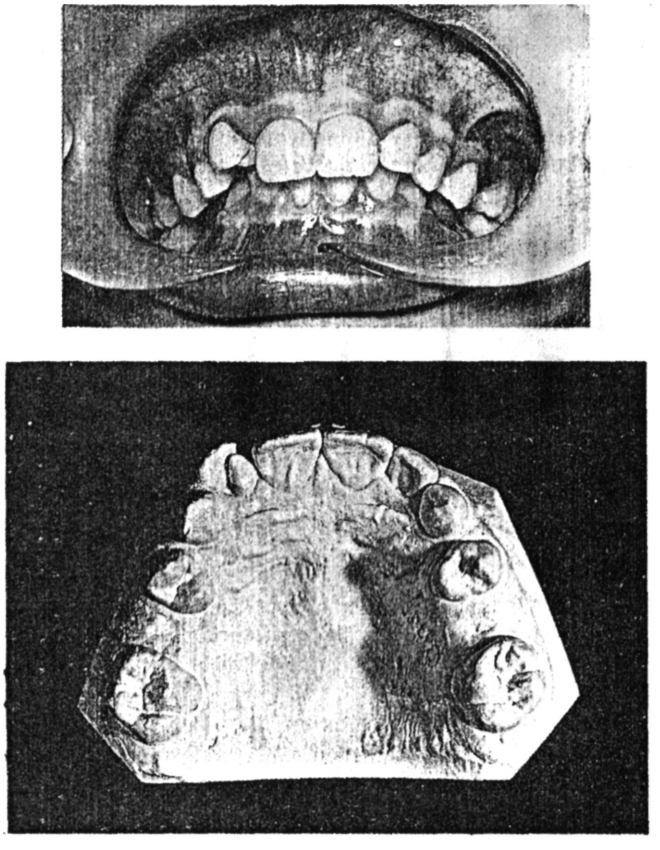


Fig. 56. Malocclusion caused by gemination of the upper right lateral incisor with a supernumerary tooth.

However, very slight resistance will deflect an erupting tooth and this may occur where a deciduous tooth has undergone death of the pulp. Resorption of the roots of such teeth may be delayed or not occur at all and the permanent successor may be deviated from its normal course of eruption and caused to assume a position other than its correct one (Fig. 57).

As has already been discussed in Chapter 2, the first permanent molars are permitted to move slightly forwards subsequent to the normal shedding of the second deciduous molars. This permits the correct intercuspation of the first permanent molars and must not be confused with the even greater degree of forward movement by tilting which is

likely to follow the premature loss of the second deciduous molars (see Fig. 66, page 103). Prolonged retention of the second deciduous molars may inhibit, in this way, the slight adjustment necessary in the permanent molar relationships to allow the correct intercuspation of the latter teeth and thus a malocclusion may be induced.

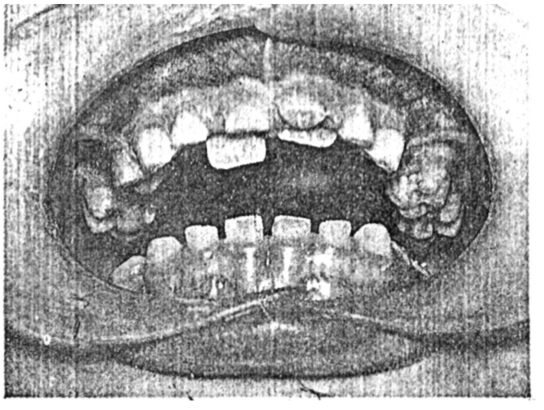


Fig. 57. Lingual eruption of upper permanent central incisors, associated with persistence of deciduous centrals.

The first and second deciduous molars together present a greater mesio-distal measurement than their succeeding premolars. Black has given the average mesio-distal measurement of the upper second deciduous molar as 8.1 mm (0.32 inch), and that of the succeeding upper second premolar as 6.5 mm (0.26 inch), the figures for the lower second deciduous molar and the succeeding premolar being 9.6 mm (0.38 inch) and 7.1 mm (0.28 inch), respectively. But it should also be borne in mind that there is a corresponding *reduction* in space in the canine regions because the *deciduous* upper canine averages 6.78 mm mcsio-distally whereas the *permanent* upper canine averages 7.74 mm In the lower arch the corresponding figures are 5.83 mm. and 6.71 mm, respectively.'

Delayed resorption of the deciduous roots is met with more commonly in the incisor region and may be the cause of a permanent incisor erupting lingually or labially to the arch (Fig. 57). A lower incisor almost invariably assumes a position lingual to the arch in such circumstances

' Moorrees, C. F. A. (1959). *The Dentition of the Growing Child*, Harvard.

(see Fig. 84, page 135), while an upper incisor may be displaced in a lingual or a labial direction.

Canines may be deflected more readily from their normal path of eruption than other teeth because of the greater distance they have to travel before eruption. Where there is ample space present, often because of the absence of permanent lateral incisors, upper permanent canines may erupt mcsially to the deciduous canines which persist.

It is not necessary that there should be prolonged retention of the whole deciduous tooth in order to deflect the permanent successor. Such deflection may result from the presence of roots of deciduous teeth. Where such roots are retained they are a common cause of deflection of the premolars, usually in a buccal direction. Where deviation from the normal path of eruption of the permanent teeth occurs, there may be a resultant contact of the wrong tooth surfaces when these teeth meet their antagonists and thus a malocclusion may be induced.

Retention of a deciduous molar tooth is occasionally caused by an anchylosis between the tooth and the bone at the bifurcation of the roots. When This occurs the deciduous tooth docs not reach its full degree of eruption and docs not keep pace with its neighbours in establishing

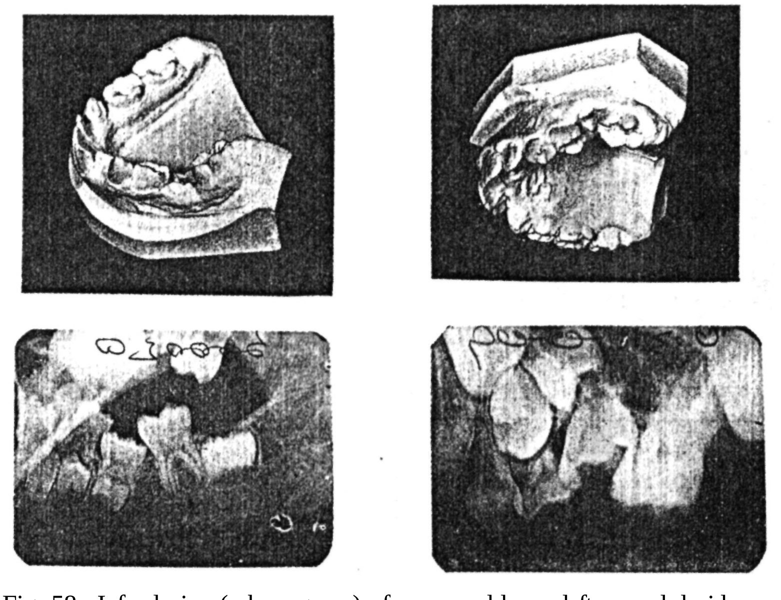


Fig. 58. Infraclusion (submergence) of upper and lower left second deciduous molars.

the vertical height. Thus it is at a lower level than the rest of the teeth in the arch and may indeed appear to sink from sight altogether. The condition often affects deciduous molars to which the inaccurate term 'submerged' is commonly applied (Fig. 58). The pathology is obscure and a permanent successor is not always present. Though difficulty may be experienced on account of the anchylosis, such teeth should be removed whether or not a successor is present. Their presence not only creates malocclusion on account of their greater size, but an area of stagnation is also created with risk of caries in neighbouring teeth and of gingival irritation.

Before a diagnosis of prolonged retention is made, consideration must be given to the age of the patient, the degree of resorption of the root or roots of the deciduous tooth and the state of calcification of the permanent one. This information can be obtained by radiography. It is necessary to be guided by the state of eruption and calcification of the rest of the dentition. There is no rigid timetable for the shedding of deciduous teeth and the eruption of the permanent successors. The chronological age may not conform to the physiological age and the slate of general development must be considered in each individual case. For this purpose the altcnlion of the student is drawn lo the value of the carpal index as a diagnostic aid in the assessment of skeletal development.

5. *Large labial frenum*

The labial frenum has been said to cause spacing between the upper

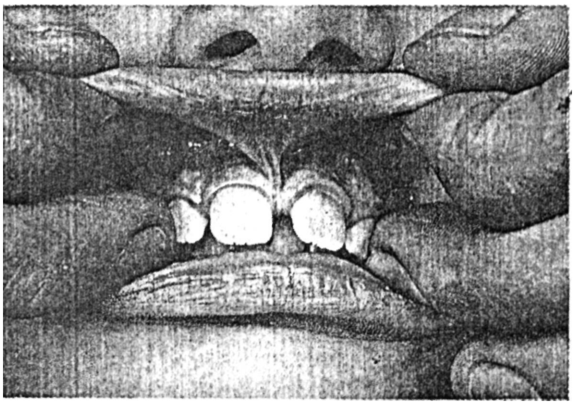


Fig. 59. Well-marked labial frenum associated with spacing of the upper central incisors.

central incisors and its removal has sometimes been advocated (Fig. 59). In the majority of these cases some other cause of the spacing is present, e.g. absent or diminutive lateral incisors, labial inclination of the incisors, unerupted supernumerary teeth, or a racial or family characteristic. In such cases surgical removal of the frenum may offer little advantage. In some cases a large frenum is present without any separation of the central incisors. Cases are occasionally seen where the frenum limits movement of the lip or forms a pendulous fold of loose tissue which appears unsightly, here its removal may be justified. More rarely a well-marked frenum of the tongue may be seen. Although movement of the tongue may be restricted, it is very rare for this to cause any interference with speech or feeding.

6. *Traumatic Injury*

Trauma to deciduous incisors may displace them in the alveolar bone and damage the developing permanent incisors. If permanent teeth are displaced during root development their roots may adopt an abnormal curvature (dilaceration) which may cause failure of eruption into n normal position. (Fig. 70, page 112).

6. Aetiology *(continued)*

III POST-ERUPTION ABNORMALITIES

1. *Muscular Forces*

At the time when a tooth is erupting it is particularly susceptible to the influence of physical pressure. The permanent teeth respond perhaps more readily to pressure than the deciduous because of their greater crown length; this especially applies to the permanent incisors at the time of eruption when their roots are still not fully formed and the tooth attachment is not yet completely established.

It has been shown already in Chapter 3 how the labio-lingual and bucco-lingual positions of the tooth crowns are determined to a large extent by their muscular environment.

This in turn is the result of the interplay of three factors:

(i) The dental base relationship;
(ii) The behaviour of the muscles during activity, particularly during swallowing; and
(iii) The rest position of the musculature in relation to the teeth.

It will be recalled that at rest the tongue lies within the dental arches, its tip lying against the lingual surfaces of the incisors, and that the lips are approximated with ease, the lower lip covering about the incisal third of the upper incisors (see Fig. 31, page 47). The act of swallowing is preceded by expulsion of saliva from the buccal sulci on to the dorsum of the tongue. The teeth are then brought into occlusion and a wave of pressure passes from the tip of the tongue backwards. The labio-lingual relation of the incisors is maintained by the tip of the tongue applied to the lingual surfaces of the lower incisors while at the same time there is pressure from the lower lip against the labial surfaces of the upper incisors. Any interference with these forces may have an adverse effect

upon ihc incisor relationship. The muscle forces acting against the teeth during speech and swallowing, although much larger than those exerted by the soft tissues at rest are probably too short acting to influence arch form in most cases. It seems likely, however, that an adaptive tongue thrust in swallowing often seen with an increased overjet is also associated with a forward resting posture of the tongue and that it is the latter which has the most important influence on arch form.

(a) *Active Muscle Forces—Swallowing*

It has been observed (Rix)[1] that, in some individuals, the oral phase of the act of swallowing is accomplished without bringing the teeth together; this may permit the tongue to escape between the upper and lower teeth. Such behaviour is often accompanied by increased activity of the lip muscles and some contraction of Buccinator muscle. The diminished outward pressure exerted by the tongue on the teeth and the increased inward pressure from the lips and cheeks combine to cause narrowness of the upper arch and a disturbance of incisor position.

The origin of these variations of oro-muscular behaviour is uncertain. There is some evidence to support the view of Ballard[2] that they arc at times inherent in the patient, but many appear to be adaptive, arising from defects of arch relationship.

Variations from typical swallowing behaviour may be divided into two types: those in which there is no upset of the antero-posterior relationship of the incisors, and those in which the upper incisors are made more prominent or dispersed outwards (Rix).

(i) *Normal Antero-posterior Relation of Incisors*

Although these patients may fail to bring their teeth together during swallowing, there is usually no evidence that the tongue escapes anteriorly. Often it may be seen that the tongue appears rather small and its tip is blunt. Forcible parting of the lips may reveal a lateral bulging of the tongue between the upper and lower molars and premolars over their occlusal surfaces. This may be accompanied by contraction of the Orbicularis Oris group of muscles. Lack of support from the tongue may cause some lingual inclination of the incisors which may be increased further by the excessive activity of the Orbicularis Oris muscle (Fig. 60). This is often associated with an increased incisor overbite which exposes the upper incisors to more control from the

[1] Rix. R. E. (1953). *Dent. Rec.* 53: 427.
[2] Ballard, C. F. (1955). *Trans. B.S.S.O.. p.* 118

lower lip. This type of behaviour is not uncommon in Class II, Division 2 cases.

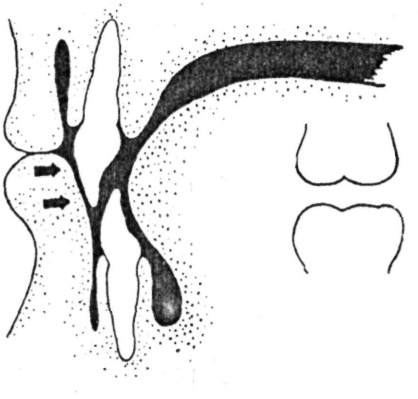


Fig. 60. Diagrammatic sagittal section to show how lingual inclination of upper and lower incisors may be associalcd with an imbalance of muscle forces exerted by the lips and tongue during the act of swallowing.

(ii) *Proclination of Incisors*

A variation from typical swallowing behaviour is seen where there is a forward thrust of the tongue over the lower incisors against the palate and upper incisors (Fig. 61). It is usually accompanied by a scooping

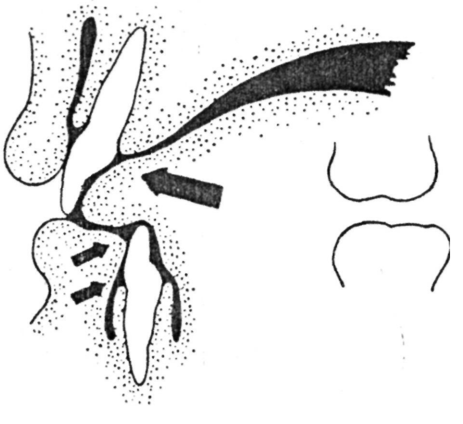


Fig. 61. Diagrammatic sagittal section to show how proclination of upper from lower incisors may be associated with a forward thrust of the tongue against the upper incisors and palate during swallowing. Lingual pressure from the lower lip may, at the same time, cause lingual movement of lower incisors.

action of the lower lip which is drawn inwards and upwards against the lower incisors and the tip of the tongue. The tongue here is often found to have a rather pointed tip. This type of behaviour is associated with an increase in the incisor overjet, due to outward dispersal of the upper incisors and some narrowness of the upper arch. In some cases it is found that the tongue lies between the upper arid lower incisors and

against the lower lip when the tongue is at rest, a condition which may be accompanied by an interdental sigmatism (lisp), and an incomplete incisor overbite. During treatment, the constant assumption of this position increases the difficulties of achieving stable changes in the incisor relationship. Where there is excessive pressure in a lingual direction of the lower lip against the lower incisors, any extractions from the lower arch may facilitate additional collapse lingually on the part of the lower incisors. Very few children with irregular teeth have a speech defect. It seems that the tongue will usually adapt to a variety of dental arch forms to produce normal speech sounds.

(b) *Rest Position of the Musculature*

The effect of muscle behaviour, in determining the positions which the incisor teeth take up, is modified according to the dental base relationship. Variations of skeletal relationship of thejaws were discussed in Chapter 5. It will be appreciated that the presence of a skeletal postnormality may decrease the disturbance produced by dispersing activity of the tongue by placing the upper incisors further from the ir^fluence of the tongue. Nonetheless the lower lip is still active and proclination of the upper incisors may still occur. Conversely, where a skeletal prenormal relationship exists, the upper incisors could be more susceptible to a dispersing tongue behaviour, which in fact might be beneficial in achieving at least an edge-to-edge incisor relation.

Vertical malrelationship of the skeletal bases would also modify the effect of a tongue thrust. An increased vertical distance between the upper and lower jaws (large infra-nasal height) would discourage the occlusion between the upper and lower incisors, favouring an anterior open bite (see Fig. 47, page 78). It also places the tongue and lower lip at a lower level relative to the upper incisors. There is, therefore, greater opportunity for the tongue to pass between the upper and lower incisors, tending to impede their full eruption. Because they are more remote, the upper incisors are more independent of the influence of the lower lip where a large infra-nasal height exists.

An excessively close approximation of the upper and lower jaws (small infra-nasal height) would place the upper incisors very much under the muscular control of the lower lip, which in the presence of a tongue thrust might add to the labial inclination of these incisors.

Excessive activity of the lip musculature may occur as a result of difficulty in approximating the lips at rest (incompetent lips) (Fig. 62). This usually arises from a skeletal discrepancy which causes separation of the lips either antero-posteriorly (skeletally postnormal) or vertically

(increased infra-nasal height), but may occasionally be associated with shortness of the upper lip. In an effort to bring the lips together and create a seal between them, the level of the lower lip is raised by contraction of Mcntalis muscle. Although this activity may cause no interference with the lower incisors, it may, by forcing the lip upwards against the lingual surfaces of the upper incisors, increase an existing

Fig. 62. Case in which a large infra-nasal height makes contraction of Mentalis muscle necessary to approximate the lips ('incompetent lips').

labial inclination (Fig. 63). A similar condition may be seen where the skeletal relationship is good but the upper incisors have become trapped outside the lower lip, preventing its contact with the upper lip. Here the protruding incisors alone prevent easy contact of the lips but become

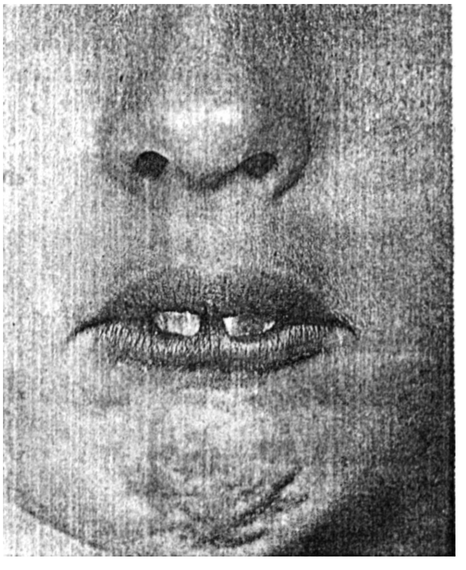


Fig. 63. Contraction of Mentalis muscle causing the lower lip to engage the palatal surfaces of the upper incisors.

more proclined because of the lip activity. This condition of parted lips must in no way be confused with 'mouth breathing', a comparatively uncommon condition affecting only approximately 5 per cent of children with an habitually open mouth.

Finally, it has been known for many years that the size of the tongue plays an important part in determining the size of the dental arches. Absence of the tongue is always associated with very small arches and an over-large tongue, as in Mongolism, produces proclination of the incisors.

(c) *Sucking Habits*

The sucking of thumbs, fingers or dummies is a common phenomenon

in the early years of life. Both Gardiner[1], and Humphreys and Leighton[2] have found an incidence of more than 50 per cent. In the majority of cases the habit is abandoned by the age of four years, and causes little permanent damage. Continuation of the habit past the age at which the permanent incisors erupt may, however, prove detrimental. The more persistent the habit, the greater its contribution to the disturbance of forces operating on the teeth. The thumb is usually inserted in such a position that it causes pressure in a lingual direction against the lower incisors (Fig. 64). There may also be some interference with occlusal movement of incisors causing an anterior open bite. The substitution of

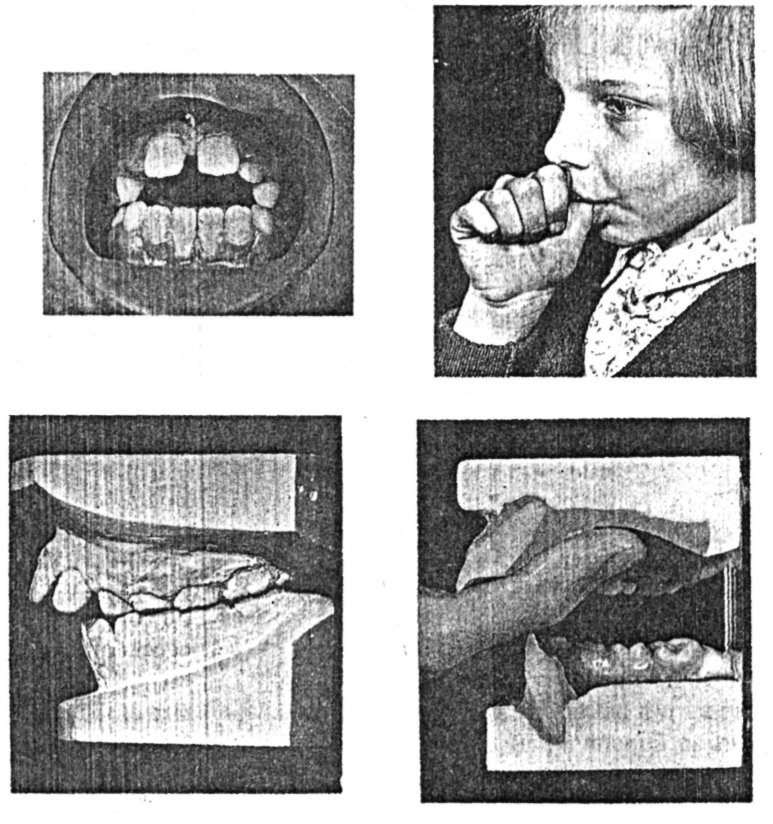


Fig. 64. The effect of thumb sucking.

[1] Gardiner, J. H. (1955). *Trans. B.S.S.O.* p. 144.
[2] Humphreys, H. R, Leighton, B. C. (1950). *Trans. B.S.S.O.*, p. 48.

the thumb for the tongue may reduce the expanding effect on the palate. Because the tongue still remains within the lower arch, a 'crossbite' may develop posteriorly.

A thumb or finger is inserted usually a little to one side and may produce an asymmetrical dispersal of the incisors; a dummy on the other hand is placed centrally and is more likely to be associated with a symmetrical open bile. Persistent sucking habits lrec]ucntly occur in cases where the oro-muscular behaviour or the dental base relation are already unfavourable to the development of good occlusion. In these cases the habit only *contributers* to a condition that is likely to remain even though the habit ceases. However, where the oro-muscular behaviour is favourable an intractable malocclusion is less likely to be produced by the habit and there is every hope of a spontaneous improvement once the habit has ceased. Care should be taken before placing the blame for all prominent incisors upon digit-sucking habits for in one survey one of the authors found that only 14 per cent of all children sucking digits do in fact produce an irregularity of their teeth.'

(d) A*bnornalities of the Mandibular Path of Closure*

The mechanism whereby an erupting tooth may inllucnce the path of closure as it comes into occlusion with its opponent has already been described in Chapter 3. Although minor adjustments in the position the mandible assumes at the moment of maximum intcrcuspation may be tolerated, certain deviations of the path of closure are likely to be harmful and will require treatment. The normal condylar movement during closing from the rest position to centric occlusion is a 'hinge' movement.

Deviations of the mandible on closure may occur in one of four possible directions; to either side laterally, forwards or backwards. Of these the last is the most likely to give rise to symptoms and, being necessarily of a limited degree, may be the most difficult to diagnose. Lateral deviations occur most frequently.

(i) *Lateral path of closure*

A lateral path of closure is almost always associated with narrowness of the upper arch which causes the posterior teeth and canines to occlude in a cusp-to-cusp relationship (see Fig. 40, page 63). There is therefore contact before full intcrcuspation is achieved, guiding the mandible either right or left into a unilateral 'crossbitc' relationship (see Fig. 39, page 62). When seen in the deciduous dentition the narrowness of the

(Gardiner, J. H. (1956). *Dent. Practit.* p. 193).

upper arch is often associated with a persistent sucking habit or with atypical swallowing behaviour. The condition may be perpetuated by

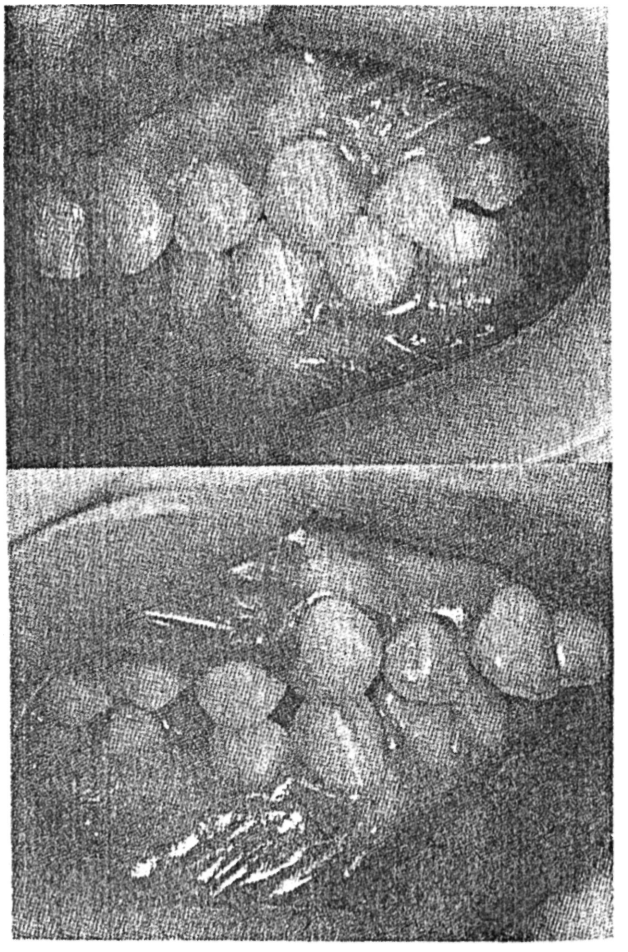


Fig. 65. Case illustrating consequences that may arise from premature loss of a lower deciduous molar.

A The left side is intact and shows a developing normal occlusion.

B Space loss has occurred on the right side following premature extraction of the lower second deciduous molar. Not only has the lower first molar (with a buccal filling) moved mesially, but the teeth mesial to the space appear to have moved distally into a distal relation to the upper teeth.

failure of the deciduous canines to be worn down and later by eruption of the first permanent molars into a comfortable cuspal relation in the acquired position of crossbite occlusion. The mandibular deviation is usually achieved by some forward displacement of one condyle and backward displacement of the other. Occasionally a forward and lateral deviation of the mandible may be caused by a local crossbite such as a lingually inclined upper central or lateral incisor occluding lingual to the lower incisors.

It happens occasionally that the protective ncuro-muscular response to the presence of premature contacts breaks down because no alternalive position of maximalocclusal contact is available. Failure to avoid this contact will lead to a traumatic occlusion involving one or more teeth (see rig. 2, page 4).

While mandibular deviations may arise from faulty intercuspation of upper and lower teeth, it is very important also to remember that a malpositioned tooth or teeth in one arch may induce a malposition of the opposing teeth without a noticeable mandibular deviation.

(ii) *Forward path of closure*

Where there is a very mild skeletal prenormality of the apical bases, it is probable that the eruption of the incisors will bring them into an edge-to-edge relationship. Many of these cases do not have the characteristically large infra-nasal height seen in most Class III cases so that further eruption of the incisors causes them to come into contact prematurely. Since backward movement of the mandible cannot be sufficient to allow the posterior teeth to occlude, the mandible is guided to a more forward position allowing'the lower incisors to become labial to their opponents and in this way the child can approximate the posterior teeth during chewing movements. In the deciduous dentition this may become resolved spontaneously as the overbite decreases, but in the permanent dentition the overbite may be such that the upper incisors become guided lingually, the lower incisors labially and the condition becomes established. This is sometimes referred to as 'pseudo-prenormal occlusion'. A similar condition may arise if early loss of upper deciduous molars permits some collapse of the anterior part of the upper arch. It is possible occasionally for the relationship of the deciduous canines to be instrumental in causing a pseudo-prenormal occlusion which becomes perpetuated when the permanent incisors erupt.

(iii) *Backward path of closure.*

A distal path of closure may be seen rarely in very mild Class II, Division

2, cases where the oro-muscular behaviour has guided the upper incisors into a lingual inclination. There is also usually a small infra-nasal height and an excessive incisor overbite, which contribute to causing a premature contact of the incisors.

It is then possible to bring the posterior teeth into occlusion only by displacing the mandible distally, though necessarily to a limited degree. Painful symptoms in the region of the temporo-mandibular joint may arise later in these cases.

It is important to differentiate these cases from those in which a distal path of closure may appear to occur because the mandible is already *postured forward in the 'rest' position* in order to facilitate closure of the lips. The latter may be of the Class II, Division 1, type of dental arch relation.

2. *Premature Loss of Deciduous Teeth*

As discussed in Chapter 3, upon eruption into the mouth a tooth comes under the influence of its immediate neighbours niesially and distally and of the adjacent musculature labially, lingually and buccally. The incisors arc more exposed to the influence of the musculature whereas the canines, premolars and molars arc also very much under the guidance of the teeth adjacent to them.

It has been shown in Chapter 3 how approximal contact is usually maintained by a tendency of the teeth to move mesially. In the event of a break in the continuity of the arch the teeth distal to the break would be free to move mesially. Those mesial to the break would, at the same time, be deprived of the mesial force arising from the molar region and may therefore *appear* to move distally relative to the other teeth (Fig. 65). This type of collapse may result from any disruption of the continuity of the dental arch, whether by the extraction of teeth or absence of teeth. It may also occur where caries has destroyed the proximal areas of the deciduous molars. The degree of collapse varies with the site of the extraction, the age at which it is performed and, most important of all, the degree of crowding already present. Another very important factor is the balance of muscular force which will be dealt with later. If the space which is available for the deciduous teeth is sufficiently generous, proximal tooth contact is slight or absent. In these circumstances there may be little or no mesial resultant of occlusal forces to cause the teeth distal to the space to move mesially into it. This is often apparent in the lower arch in Class III cases.

Where there is already a tendency to crowding and a lack of space for all the teeth, the collapse will be greater and more rapid. There

would have been insufficient space for all the teeth in any case and the extraction merely emphasizes an existing condition, facilitating a redistribution of the crowding.

Seipel' has suggested that the loss of space following premature extraction of deciduous molars is most rapid immediately after this extraction, when preventive measures should be taken if space loss is to be avoided.

The approximation of the teeth adjacent to the site of extraction collapses the arch and will cause the succcssional tooth cither to be excluded from the arch or to become impacted (Fig, 66). The collapse

Fig. 66. Mesial inclination of lower first permanent molar following premature extraction of the lower second deciduous molar, causing impaction of the second premolar.

of the arch usually involves more than just the adjacent teeth and may upset the relationship of all the opposing teeth of one or both sides. It is important also to remember that the dental arches are largely dependent upon one another. A diminution in over-all size of the lower arch will often affect the size or shape of the upper.

It has been observed by Clinch[2] that early loss of upper deciduous molars is followed by a greater degree of mesial movement of the upper permanent molars than that of the lower permanent molars which occurs following a similar loss from the lower arch. In the lower arch a collapse in the incisor region is more likely to occur. These differences probably arise from the high position of development of the upper molars and the greater restriction of the lower incisor region by the lower lip.

' Seipel, C. M. Prevention of Malocclusion, *Trans. Eur. Orthod Soc.* 1947/48; 203-18.

[2] Clinch, L. M (1958). *Dent. Practit.* 9: 109.

The age at which a deciduous tooth is lost is of some importance. The longer the time interval between extraction of a deciduous tooth and the eruption of its successor, the longer there is for a collapse to occur. When a deciduous molar is lost before the eruption of the first permanent molar, the latter is more likely to move mesially before eruption and assume a normal axial inclination but in a mesial position. Extraction after the first permanent molar has erupted often allows mesial inclination of this tooth (Fig. 66).

By and large the premature loss of a second deciduous molar will have its greatest effect upon the position of the permanent molars, whereas the loss of other deciduous teeth may also affect the incisor region, particularly in the lower arch. Where the loss is from one side alone, this will cause an asymmetrical collapse and, especially in the lower arch, often results in a shift of the centre line towards the affected side. This sequel is seen at its worst where a deciduous canine has been extracted or shed spontaneously at an early age. The exfoliation of one lower deciduous canine at the time of eruption of the lateral incisor is not uncommon in cases of crowding. This may hasten collapse towards the side of loss. In these cases it may be decided that permanent teeth will have to be extracted later to obviate crowding and therefore consideration may be given to the extraction of a similar deciduous tooth from the opposite side, and even from the opposite arch in order to prevent asymmetry and a discrepancy of arch relationship (see Chapter 8).

3. *Extraction of Permanent Teeth*

The extraction of permanent teeth has a similar effect upon the dental arches to that of their deciduous counterparts. Although this is usually undesirable, it is often turned to advantage in the treatment of malocclusion by following up the extractions with tooth movemnt controlled by mechanical appliances (sec Chapter 8).

Permanent molar teeth. Their susceptibility to caries renders the first permanent molars particularly liable to require extraction at an early age. The early loss of an upper first molar, if it occurs after the second permanent molar has erupted into occlusion, may permit only a little mesial movement of the latter. If, however, the extraction of the upper first permanent molar occurs *before* the upper second permanent molar has erupted, the latter can move mesially very rapidly and even occupy the site of the upper first permanent molar with the minimum of rotation. In the case of the lower first permanent molar, however, it is not uncommon for its loss to be followed by mesial inclination of the second

molar together with collapse of the anterior part of the arch. The tilted lower second molar may then engage the distal aspect of the upper first molar encouraging the upper tooth to move forward. In Class I and II cases this may be mitigated to some extent by extracting the upper first molar as well as the lower. A further sequel that may follow the early loss of the lower first permanent molar (i.e. at eight years of age or even earlier) is the distal migration of the lower second premolar (Fig. 67). This is very likely to occur where the premolar develops in such a position that the distal root of the second deciduous molar is absorbed

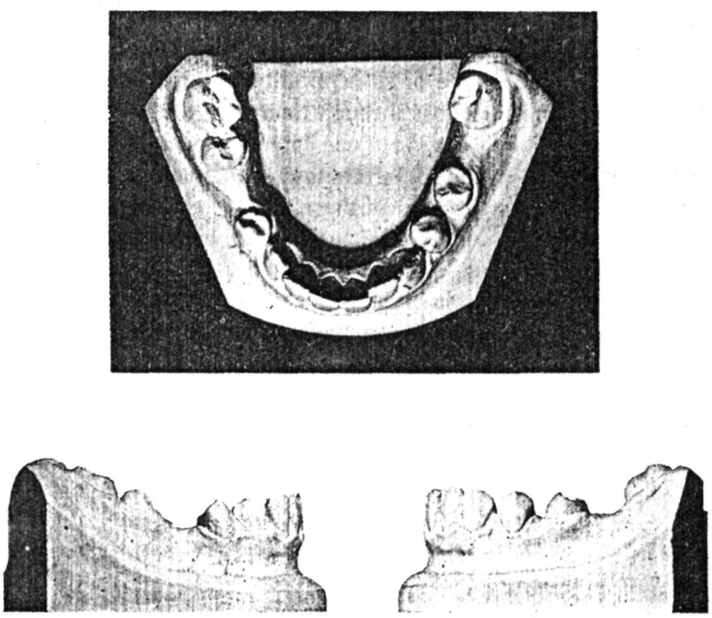


Fig. 67. Distal migralion of the lower right second premolar following loss of the first permanent molar. The firstl molar on the right was extracted at 8 years 4 months whereas that on the left was not extracted until 10 years 11 months,

prematurely, or where the deciduous molar has been extracted. This may be overcome by delaying the extraction of the permanent molar until the premolar has erupted.

Permanent incisor teeth. The presence of permanent teeth has a guiding influence upon the course of eruption of their immediate neighbours. Thus the loss of a central or a lateral incisor will result in the space being partially or completely closed by the encroachment of the tooth

immediately distal, with a resultant collapse of the anterior part of the dental arch. In certain circumstances where treatment is contra-indicated it may be advantageous to allow this to occur, although in the case of loss of the central incisor the aesthetic result is seldom pleasing and it is preferable to maintain the space for a subsequent restoration.

The loss of a lower incisor is often followed by a collapse of the anterior part of the lower arch and, as Chapman ' has pointed out, imbrication of the upper incisor teeth will follow, the size of the lower arch having a considerable influence in maintaining that of the upper. The exception is those few cases where, due to excessive tongue action, the anterior part of the lower arch is held forward.

Permanent canine teeth. The early loss of these teeth is rare. They do not possess the same degree of susceptibility to caries as affects other permanent teeth and their loss through trauma in the young patient is very seldom seen. The extraction of one upper canine tooth may produce a change externally in the facial contour, but this is not always so. Otherwise the effect of the loss of these teeth is similar to that of the incisors. Occasionally an upper canine is so badly misplaced that alignment within the arch is not possible and extraction of the canine becomes inevitable. In these circumstances the loss of the canine will not materially affect the asymmetry which is already present, (sec Fig. 78, page 121).

Premolar teeth. While the extraction of premolar teeth is often undertaken as part of orthodontic treatment (see page 120), it is seldom that such a procedure can be adopted without subsequent mechano-therapy in order to obtain occlusal balance. The loss of premolar teeth, if left untreated, results in a loss of correct occlusal relations due to the drifting of the adjacent teeth. Where a premolar tooth is lost under circumstances such as neglected caries it may be advisablp, if the relationships of the teeth are otherwise correct, to extract the opposing tooth and to maintain the position of the teeth mesial to those which have been extracted while controlling the forward movement of the posterior teeth by mechano-therapy.

' Chapman, C. (1950). Tooth Extraction as an Orthodontic Measure. *Int. Dent. Joum.* 1: 101-30

7. Therapeutic Extractions and other Surgical Procedures

In the foregoing chapter reference was made to the fact that some cases of malocclusion require, as part of their treatment, the extraction of permanent teeth. The extent to which this is practised varies from one operator to another. The necessity for extraction of permanent teeth may also vary from one country to another as ethnic characteristics may have an important bearing. In the United Kingdom it has been found that extractions are frequently required as part of treatment. The decision as to where and when to extract can only be made with accuracy after considerable experience has been acquired. There are, however, some general principles which will offer guidance.

Most extractions are performed as part of a general plan of treatment which also involves the use of appliances. The age of the patient and the nature of the malocclusion may be important factors in deciding whether or not to employ extractions. The duration of orthodontic treatment, an important psychological factor, should always be as short as possible and may influence the age at which extractions arc performed. By careful timing of extractions it is often possible to facilitate spontaneous migration of adjacent teeth as they erupt. This is of advantage in that less tilting occurs. The use of appliances to prevent undesirable tooth migrations may usually be required. It must be emphasized that only very rarely can a case be treated by extraction alone as untoward movement of other teeth can so readily occur.

Before extractions are considered, an exhaustive study of the case must be made by a clinical and radiographic examination of the patient, paying particular attention to caries or heavily filled or traumatized teeth which might subsequently give rise to symptoms. Radiographs should be scrutinized to ensure the presence of all teeth. Where doubt

exists in the mind of the operator as to whether the extraction of one or more teeth should form a part of the treatment, the advice of an orthodontic specialist should be sought.

A. REASONS FOR EXTRACTING TEETH AS PART OF ORTHODONTIC TREATMENT

There are several factors which justify the extraction of teeth as part of orthodontic treatment and these may serve as guiding principles:

1. Disproportion between tooth and arch size.
2. Malrelation between arches.
3. Adverse position of root apices.
4. Abnormal form and size of individual teeth.
5. Preservation of symmetry.
6. Extreme jaw relations.
7. Late treatment.

1. *Disproportion of size*

(a) Disproportion in size between the alveolar processes and the teeth may give rise to crowding not only of the tooth crowns but also of their roots. The prevalence of this crowding appears to be higher in the people of Great Britain than in other populations.[1]

(b) Although rare, cases are seen where a local deficiency of outward growth of the dental base is accompanied by convergence of the apices of the teeth in that area. This is seen in the upper molar region and the upper and lower incisor regions. In the former case the molars are inclined distally and the canines mesially. In the latter, the incisor and canine crowns are inclined away from the mid-line (see Fig. 75, page 118). This, of course, is not to be confused with the transient 'ugly duckling' stage in the eruption of the upper lateral incisors (iee page 36, Chapter 2). Where there is dento alveolar disproportion, molars and premolars tend to drift forwards following the premature loss of deciduous molars, thus reducing the space available for the eruption of premolars and canines. In these circumstances it may be best to extract a tooth in the crowded segment rather than attempt distal movement of the molars which have drifted forwards, (see Fig. 69, page 111).

2. *The Effect of Antero-posterior Relationship of the Dental Arches on the Selection of Teeth for Extraction*

Since the extraction of teeth impairs the forward component of development of the alveolar processes and dental arches, it is possible

[1] Gardiner, J. H. (1974), *Br. J. Orthod.*, 1: 69

to select teeth for extraction in such a way that the aesthetic appearance and functional efficiency may be improved in some Angle Class II and Class III cases which are otherwise unsuited for prolonged appliance therapy.

(a) *Angle Class I.* In these cases the antero-posterior relationship of the dental arches is correct. It is therefore unwise to discourage forward development of the alveolar bone in one jaw more than in the other. Extractions which have to be pcrfonncd in Class I cases, unless of teeth completely displaced from the arch, are usually better to be symmetrical, the same tooth usually being removed from each quadrant of the mouth. The selection of the teeth is governed by factors to be discussed later in this Chapter.

(b) *Angle Class II.* In some of these cases the upper dental arch may appear relatively further forward than the lower dental arch. Where such a condition has been diagnosed it may be desirable to discourage forward development of the upper arch more than the lower. If the malocclusion is severe, and the root apices of the lower teeth are in correct relationship to one another, extraction of a premolar tooth from either side of the upper arch will cause a relative impairment of the forward development of the upper arch and allow the upper anterior teeth to be moved palatally with appliances, thus improving the upper and lower incisor relationships. The upper first premolars are usually the teeth of choice (Fig. 68) though some orthodontists favour the removal of the second premolars. In Class II cases treated by this method

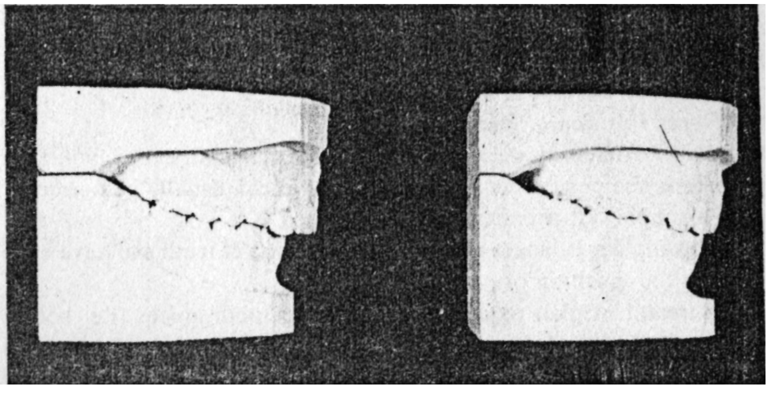


Fig. 68. Class 11 division (i) case treated by extraction of upper first premolars. The upper canines and then the upper incisors were retracted with simple appliances. Lower second molars were extracted later.

the posterior teeth retain their apparent postnormal relationship, which is functionally satisfactory, and the method is often suitable for patients who are not likely to respond to extensive appliance therapy.

If extractions from the lower arch of a Class II case are necessitated by extreme caries, it is almost always essential to extract teeth from the upper arch lest the postnormality be increased, but normally extractions are to be avoided from the lower arch in a Class II malocclusion unless dictated by the orthodontic treatment plan in any particular case.

(c) *Angle Class III.* Similar principles guide the decision to extract teeth from prcnormal cases. When the treatment of Class III cases is complete, the upper incisors may be inclined labially to an abnormal extent and may only be prevented from assuming a lingual relationship to the lower incisors by the degree of overbite. Because of (he effect upon the forward development of the upper dental arch, extraction of upper teeth should be avoided in most Class III cases. If such extractions are inevitable, consideration should be given to the reduction in numbers of the lower teeth in order to compensate. However, should the lower teeth be already spaced there is no point in extracting from the lower arch as compensation Will not occur.

It has been found that extraction of lower teeth from Class III cases is not followed by the same degree of antero-posterior collapse of the lower arch as appears in Class I and Class II cases; especially is this so where the malocclusion is accompanied by excessive forward development of the mandible. For this reason, if extractions from the lower arch are considered necessary in Class III cases, they should be performed as early as possible in order that the maximum interference with the forward development of the dental arch is obtained. If extractions are delayed until a late age it is difficult to obtain any change in the form of the dental arch.

3. *Adverse Position of Root Apices*

Providing sufficient space exists, and the root of a tooth has a favourable inclination, the position of a displaced crown can usually be corrected using a simple orthodontic appliance.

Most simple appliances merely tilt the crowns of teeth and have little effect on the position of root apices.

If a treatment plan requires movement of tooth apices (i.e. bodily movement of teeth as opposed to tilting), then a Fixed Appliance will be required and treatment will be best undertaken by a specialist orthodontist.

Sometimes displacement of crown or root may be so severe that extraction may be preferable to a prolonged attempt at correction.

4. *Abnormal Form and Size of Individual Teeth*

Variation of tooth shape and size is very wide among the population. In the majority of cases there is sufficient uniformity within one dentition for satisfactory occlusion to be possible. Occasionally it happens,

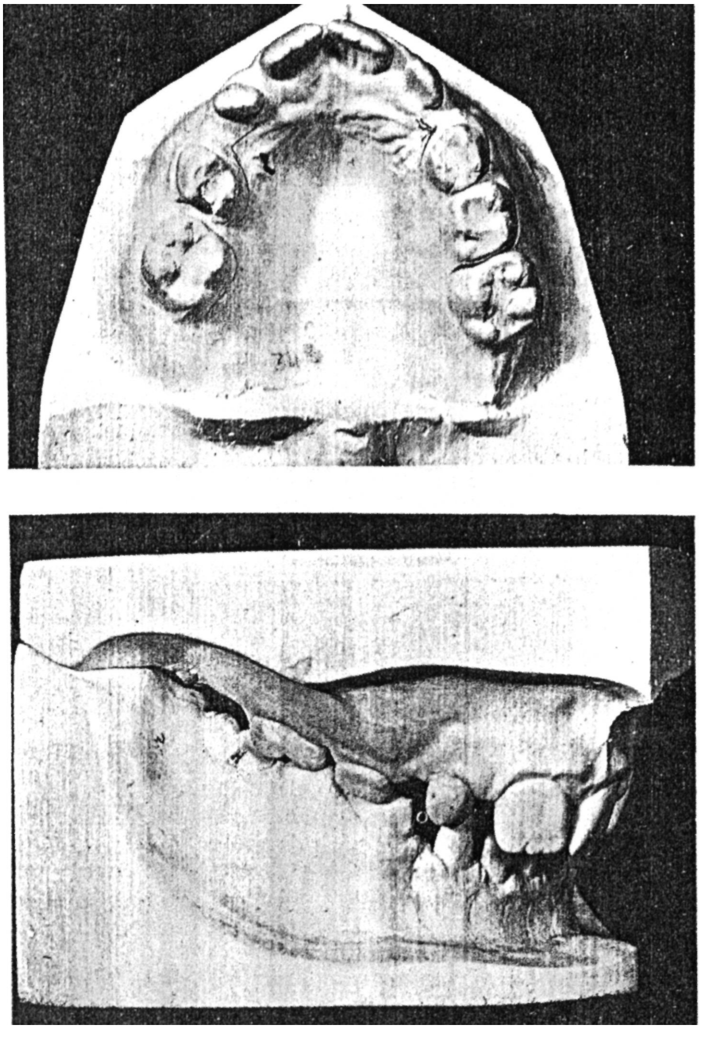


Fig. 69. Case in which the upper right first permanent molar has moved bodily in a mesial direction by rather more than a premolar width. Treatment of this case will require the extraction of a premolar as well as appliance therapy.

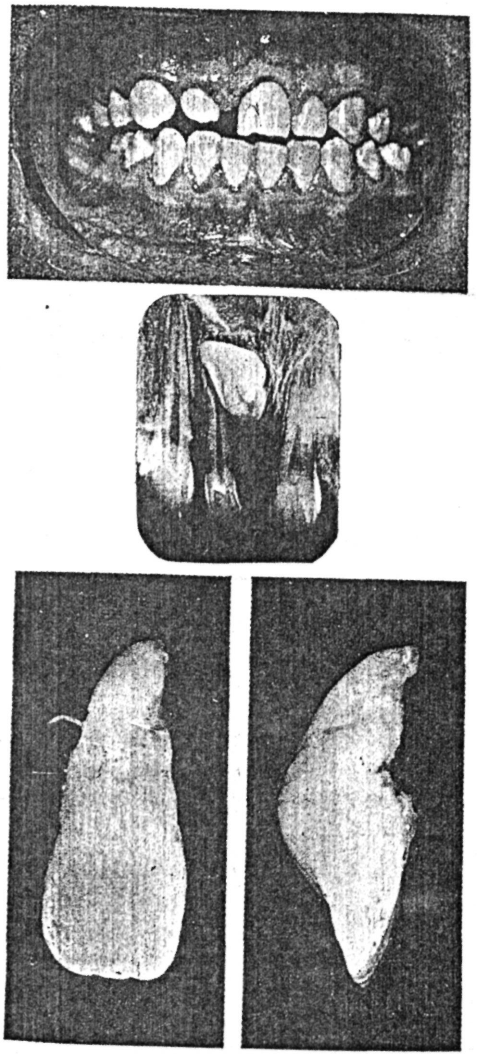


Fig. 70. Dilaceration of upper right central incisor following early traumatic injury. Extraction of the tooth was necessary.

however, that individual teeth are so atypical in size or form that occlusion cannot be satisfactory. This is most likely to occur in the upper incisor region (see Fig. 54, page 86). Unless an acceptable shape can be restored by means of a crown or by stoning away an offending cusp, it may be necessary to extract the tooth. Where the crown is diminutive, and the cervical margin of the tooth large enough, it may be possible to fit a crown. Should the tooth be very deformed or exceptionally large (see Fig. 54, page 86), its extraction is almost inevitable. Similarly, deformities of the tooth root (Fig. 70), usually caused by previous traumatic injury (dilaccration), often render extraction necessary for, even where the tooth has not been displaced traumatically, its eruption is likely to be impaired by the root deformity.

5. *Preservation of Symmetry*

In Chapter 3 the normal forward movement of the teeth to maintain approximal contact was discussed. It was explained that pressure caused by growth and eruption is guided round the arch by the lips to the mid-line where the forces from each side are equal and opposite and therefore balance one another. If a tooth is extracted from one side of the dental arch only, the forward movement of the teeth mesial to the space is impaired and therefore pressure from that side is deficient. The pressure from the other side is normal, however, and the inequality of pressure may cause the incisors to be inclined towards the side from which the tooth was removed, especially where the tooth was lost at an early age.

Where teeth are congenitally missing from one arch, the other arch being intact (the arch relations being normal and the muscular forces of the tongue, lips and cheeks adequate), it may be advisable to balance by the symmetrical extraction of similar teeth from the opposite arch. On the other hand, if the opposing arch is of good shape and the teeth well aligned, it may be preferable to replace the missing tooth by an artificial restoration.

Similarly, where pathological conditions necessitate the extraction of a tooth from an arch, further extractions may be justified to preserve symmetry or to maintain the relative proportion in arch size.

6. *Extreme Abnormalities of Jaw Relationship*

In rare cases teeth may require extraction as a part of surgical correction of the jaws. Even where teeth have been extracted there are limits beyond which it is not possible to correct the malocclusion solely by the use of orthodontic appliances. The more extreme deformities involving basal bone are likely to require surgical treatment for their correction. These

include cases where the condylar growth has been arrested at an early age, cases of extreme prenormality and also cleft palate conditions. It is likely that extractions, together with appliance therapy to adjust the occlusion of individual teeth, will be required in addition to the surgery.

7. *Late Treatment*

In those cases where treatment for a malocclusion has not been sought until a late age (fifteen years and over) extraction of one or more teeth may well reduce the duration of treatment and overcome a possible lack of co-operation on the part of the patient to a long course of treatment.

B. CHOICE OF TEETH FOR EXTRACTION

There may be little alternative where pathological conditions render extraction necessary. On the other hand, defects in tooth structure may determine the choice. It is only possible to offer certain guiding principles to aid this decision as each case must be treated on its own merits.

Orthodontic treatment may include the extraction of any tooth in the arch, but certain teeth should be retained where possible. The extraction of a permanent incisor or canine tooth for orthodontic reasons is usually to be avoided unless there is severe displacement of the root apex (Fig. 71). One exception to this rule will be discussed. The choice of tooth to be extracted usually lies between the premolars and the molars,

(a) (i) *Upper Incisors:* Where imbrication exists in the upper incisor

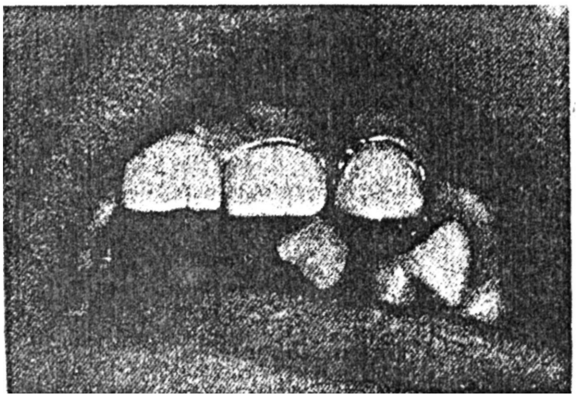


Fig. 71. Case where unfavourable position of the apex of the upper left lateral incisor may make its extraction necessary.

region, combined with a mesial displacement of the root apices of the upper permanent canines to a marked degree, the extraction of an upper lateral incisor may occasionally be considered (Fig. 71). While this treatment may not be frequent or the result entirely desirable, it may be necessary to overcome a worse condition. By rounding the tips of the canines these teeth can be made to simulate incisors (Fig. 72). A

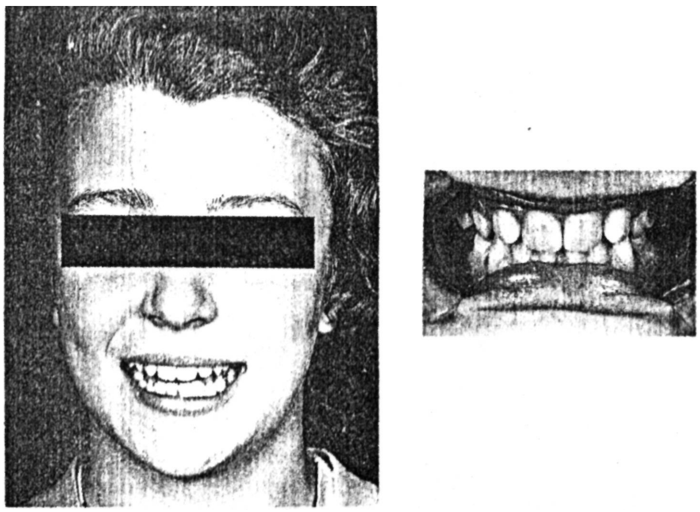


Fig. 72. A case where early extraction of upper lateral incisors has allowed the canines to erupt adjacent to the centrals; they have been shaped with a stone to resemble lateral incisors.

disadvantage, however, lies in the occasional well-marked palattl ridge of the upper canine which normally fits into the embrasure between the lower canine and the first premolar. This ridge when it occludes with lower incisors, causes cither labial inclination of the upper canine or lingual inclination of the lower incisors. On account of the close proximity of the pulp, the ridge can only be ground to a slight degree.

Traumatic injury is a common phenomenon among young children. Although it is usual to make every effort to conserve damaged incisors, extraction of a central incisor will be unavoidable from a proportion of them. Should this occur before eruption of the lateral incisor, this tooth may be allowed to erupt mesially into the position of the central with a view to its being crowned later to resemble a central incisor. The mesial migration of the lateral is most complete where some crowding is already

present and the central has been lost soon after its eruption (Fig. 73). Should the central be lost at a later stage from a case with no crowding, it may be preferable to maintain the space and restore the central artificially. Congenital absence of one upper lateral incisor is often

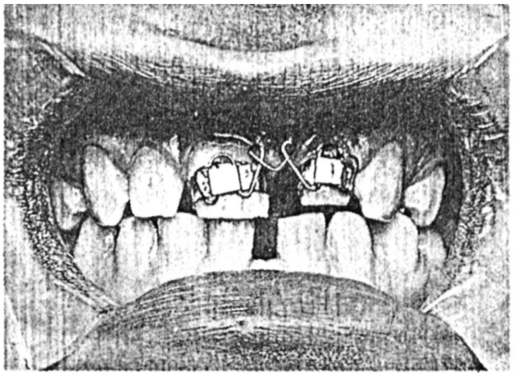


Fig. 73. A patient of thirteen years who had lost his upper left central incisor in an accident. Thc-appliance is about to be used for space closure.

accompanied by development of a diminutive lateral on the opposite side. Extraction of this tooth before eruption of the canine will preserve symmetry by allowing both canines to erupt into positions adjacent to the central incisors.

(a) (ii) *Lower incisors:* The extraction of a lower incisor often permits collapse of the lower arch and a narrowing of the inter-canine measurement, the exception being those cases with an over-active tongue. Even where imbrication of the lower incisors exists, and the remaining three lower incisors are aligned following the removal of the fourth incisor, a collapse and narrowing is likely to follow with a return to the imbricated condition although now only three incisors remain (Fig. 74). This disconcerting occurrence is usually accompanied by an increase in the incisor overbite with retroclination of the lower incisors.

Deprived of the support of the lower arch, the upper arch also undergoes anterior collapse with narrowing of its inter-canine width and proclination or imbrication of the upper incisors. As a general rule, therefore, the removal of a lower incisor from an imbricated arch is to be avoided. Occasionally, however, a condition is seen where the root apices of the lower permanent canines and incisors are not in normal position but are closely approximated (Fig. 75), the crowns being inclined fanwise in a distal direction. In such cases there is invariably a

disproportion between the size of the teeth and the dental base together with possibly a degree of postnormal occlusion. The lower incisors appear to be over-erupted, the occlusal plane curving sharply upward in the lower incisor region.

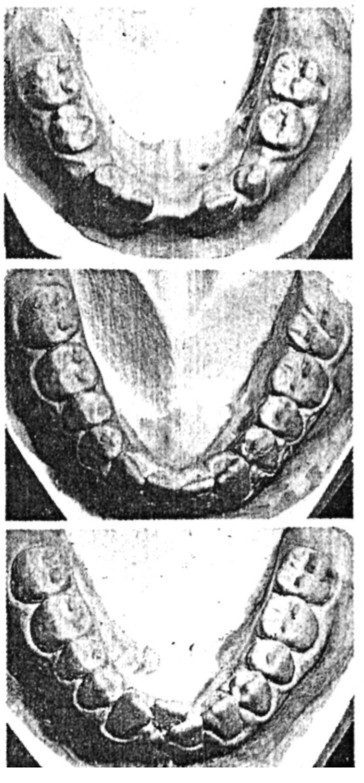


Fig. 74. Models of a boy who accidentally knocked out both lower central incisors at the age of eight years. The serie.s sh()w.s how the space was closed satisfactorily but continued to collapse producing further crowding in this area.

Before a diagnosis can be made it is necessary to have radiographic evidence of the position of the root apices and even then the diagnosis may be difficult before the physiological age of nine years for, up till this age, a similar appearance may be quite normal, being due to the presence of the developing canines near to the incisor roots (see Fig. 175, page 253). Where the condition is established beyond doubt, the extraction of a lower central incisor tooth may be justified, though the choice of incisor largely depends upon the positions which the incisors have adopted. Subsequent to the extraction, the movement of the

remaining lower incisor teeth must be carefully controlled to prevent collapse of the arch before the incisors are aligned (Fig. 76). The incisor overbite may be reduced by the use of a simple bite plate which appears to depress the lower incisors. Such treatment for this condition of the lower incisors is almost always accompanied by the extraction of two

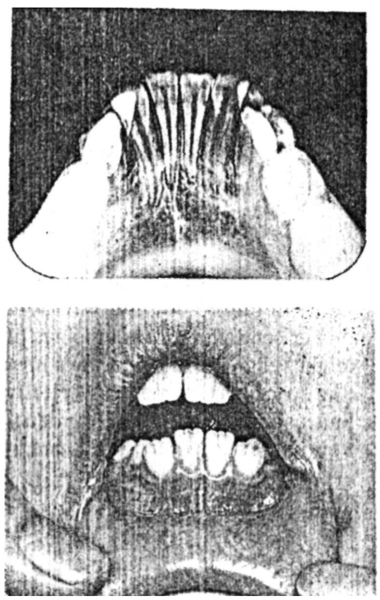


Fig. 75. Case in which the root apices of the lower incisors are approximated.

upper teeth, usually the first premolars, with subsequent retraction of the upper canines and incisors. Although the resulting occlusion of the premolars and the molars is not entirely satisfactory, this treatment has the advantage of reducing the incisor overbite and correcting (he axial inclination of the lower incisors and canines without impairing their alignment.

(b) *Canines:* As a general rule the extraction of canines for orthodontic purposes is to be avoided. However, their comparatively remote developmental position renders them susceptible to severe misplacements. Upper canines may stray into the palate or they may erupt into another abnormal position or fail to erupt at all. This may be manifested at times by transposition between the canine and lateral incisor or first premolar (see Fig. 49, page 81). Although the latter transposition may be acceptable, the former is unlikely to present a satisfactory appearance and extraction of the lateral may be necessary.

Where the apex of' the canine as well as the crown is displaced, so that the tooth is completely out of an otherwise symmetrical arch, it is often necessary to extract the tooth itself. (Fig. 78, page 121). Where, however, a space exists between the lateral incisor and the first premolar and the latter tooth is rotated mesio-buccally, so that its lingual cusp is visible (sec Fig. 79, page 123), the result may not be so pleasing. It has been thought that if an upper canine were to be extracted, a flattening of the

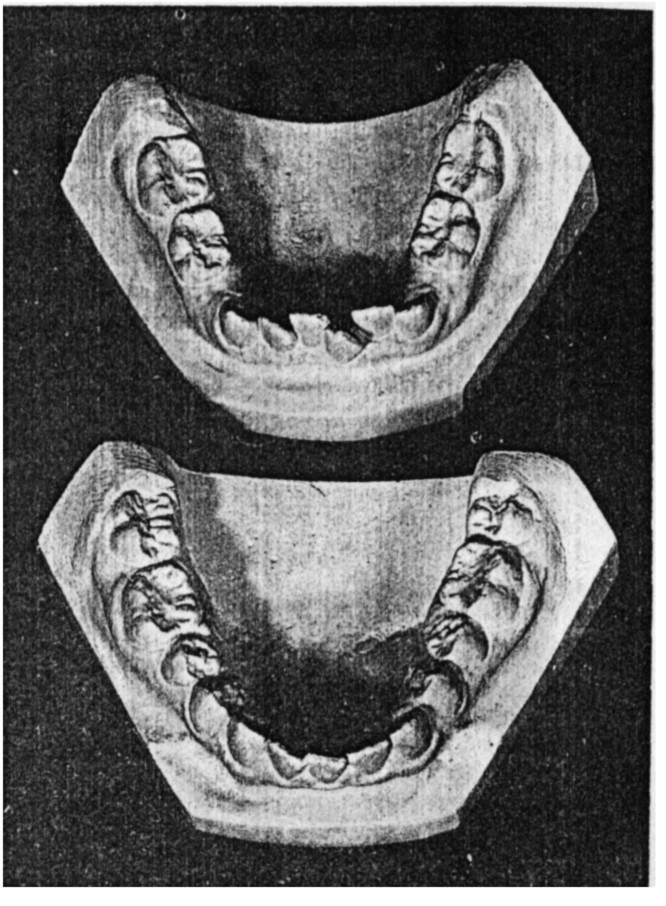


Fig. 76. Models of a case from which one lower central incisor has been extracted. It was necessary to use a lower fixed appliance to align the remaining incisors. The case had been out of retention for about four years.

facial contour in that region would follow. Observation over many years indicates that this may not be so.

Occasionally it is found that one of the deciduous canines has been shed naturally though its fellow on the other side of the arch is still present. This may cause inclination of the incisors towards the side from which the canine is lost. In order to restore symmetry it is necessary to extract the remaining deciduous canine.

In a Class II case the lower deciduous canines are sometimies shed prematurely. If, in such a case, the upper deciduous canines are retained they should be extracted also. Otherwise the discouragement to forward development of the incisor segment of the lower arch may facilitate an increase in the incisor overjet. Conversely, the lower deciduous canines should be extracted where a similar condition occurs in the upper arch in a Class III case.

(c) *Premolars:* Irregularity in the alignment of the dental arch by 'crowding' of the teeth occurs usually in one of two sites, either in the premolar region or in the incisor region. The former is commonly the sequel to the premature extraction of deciduous molars and the latter to a disproportion of size between the apical base and the teeth. If the second deciduous molar is lost prematurely, and before eruption of the first permanent molar, the latter frequently moves bodily forward so that its root apices are in an abnormal position. In such cases the

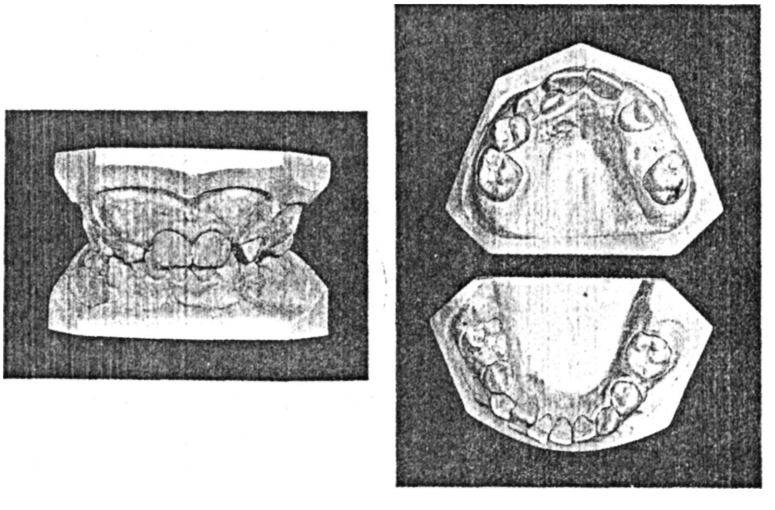


Fig. 77. Case of crowding in addition to which there has been mesial movement of the permanent molars after early loss of deciduous molars.

extraction of either the first permanent molar or a premolar may be justified (Fig. 77).

Where a disproportion exists between the dental base and the teeth, the root apices of the teeth may all be in an abnormal position and the crowding will be manifested especially in the incisor region of each dental arch. It must be remembered that the deciduous incisors may normally undergo spacing but, if a disproportion exists, the spacing will certainly not be present. The permanent incisors therefore attempt to erupt into whatever space is available between the deciduous canines and Ihcy will become malaligned. The premolars arc more assured of sufficient space because they are smaller than the deciduous molars. The third molars frequently become impacted. The extraction of first premolars in such cases may assist in making space available in the incisor region and may also assist in accommodating the permanent molars (see Fig. 81, pages 126, 127).

Before extracting a first premolar it is important to establish the presence of the second premolar radiographically as these may be congcnilally absent (sec Fig. 86, page 137). Where a decision to extract first premolars is made, the best results follow the extraction of these teeth before the eruption of the permanent canines. This is discussed on pages 126-8. If the permanent canines have already erupted, it will be necessary to have clinical and radiographic evidence of the position of their root apices. If the root apex of the canine is displaced mesially (Fig. 78), further distal inclination of this tooth by treatment to occupy

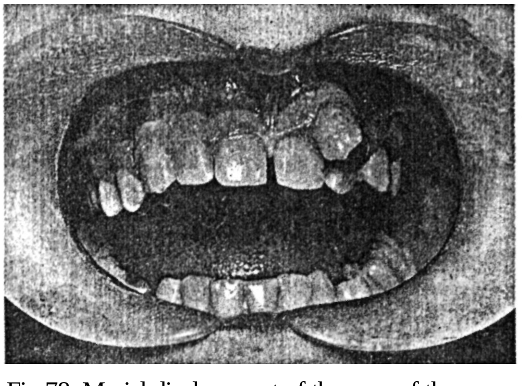


Fig 78. Mesial displacement of the apex of the upper left canine. The difficulty involved in correction of this, displacement make it advisable to extract the canine.

the premolar space may emphasize its abnormal inclination. In such cases consideration may be given to the possibility of removing the canine itself or a lateral incisor instead of the first premolar (see Fig. 71, page 114). Where the position of an upper canine is such that it is completely excluded from an otherwise perfect arch, and contra-indications to treatment exist (e.g. the age of the patient), it may be advisable to remove the canine rather than a first premolar. In some cases it may be an advantage to extract the first premolars before these erupt (see page 129).

The extraction of second premolars provides rather less space to the incisor region since a greater proportion of that made available is lost to the molars. This is'of advantage where only a small amount of space is required anteriorly. It should be borne in mind, however, that retraction of the first premolar by tilting may leave a poor contact between this tooth and the first molar. Extraction of second premolars may also be indicated where they are excluded palatally or lingually from the arch and the alignment of other teeth is satisfactory. Should this be accompanied by a rotation of the first premolar, however, it may be advisable to extract the tooth whose rotation is particularly difficult to correct (Fig. 79).

(d) *Molars:*

First Permanent Molars. As these teeth are particularly susceptible to caries, their early loss is unfortunately common. This frequently complicates orthodontic treatment (see Chapter 6, page 104). The extraction of a first permanent molar may be justified if there has been bodily mesial displacement of this tooth following the very early loss of the second deciduous molars and it shows evidence of caries in an otherwise caries-free mouth. Such an extraction should be undertaken before the eruption of the second premolars so that the latter may be influenced to erupt into correct position. The upper second permanent molars move forward more readily than do the lower second permanent molars (see page 16) since the former develop high in the bone at a considerable distance from their final position whereas the lower molars develop nearer and there may be some temporary increase in the incisor overbite. Wilkinson has advocated the extraction of the four first permanent molars between the ages of 8 1/2 and 9 1/2 years in selected cases on account of their susceptibility to caries. He believed that this provides additional space for third molars and the resulting relief from overcrowding favours the preservation from caries of the remaining teeth (Fig. 80, page 124). There are some centra-indications to the

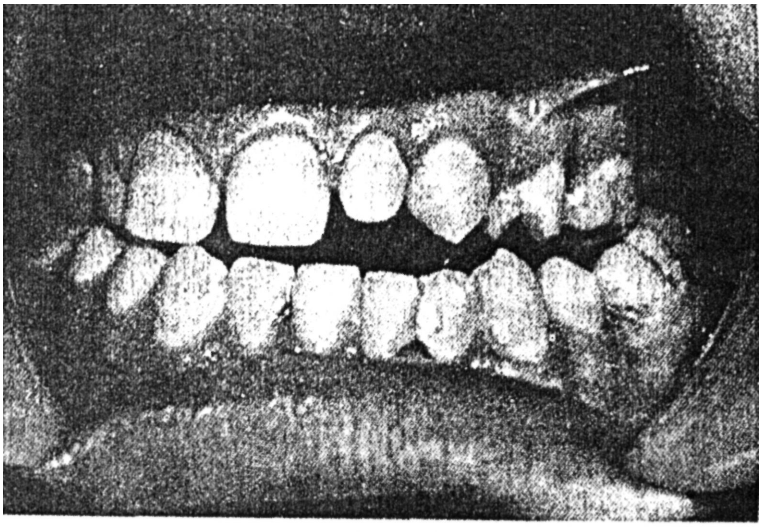


Fig. 79. Crowding of the upper left premolar region manifested by palatal inclination of the second premolar and rotation of the first premolar. The, unattractive appearance and difficulties of rotating teeth make it advisable to extract the first premolar rather than the second premolar.

extraction of first molars which may make the indiscriminate application of this philosophy inadvisable.

The extraction of the four first permanent molars offers only limited space in relieving crowding of the incisor teeth. There are further objections to the routine removal of the four first pennanent molars, viz.: the second premolars and the second permanent molars frequently rotate as they erupt following the loss of the first permanent molar. Furthermore, depending on the age at which the first permanent molars are removed, the second permanent molars may erupt partly into the

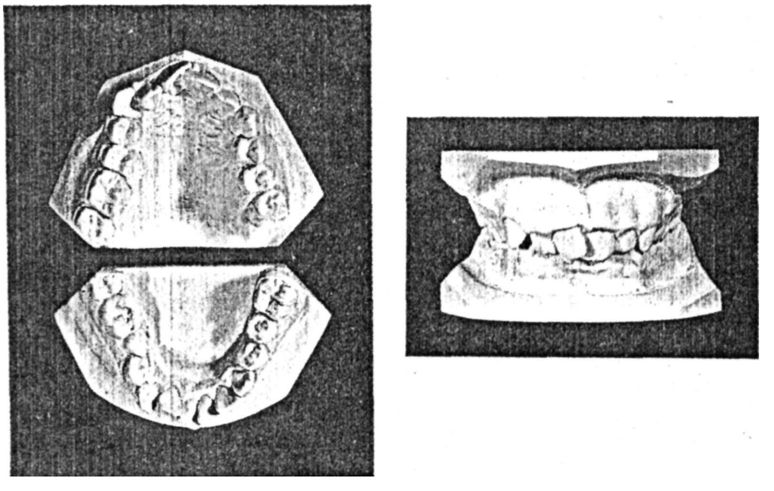


Fig. 80. Case of moderate crowding from which upper and lower left first permanent molars were removed at nine years nine months, only from the left side, those on the right being inadvertently left in situ. Much of the crowding on the left side has been relieved.

space of the first molar and, in so doing, frequently undergo mesial tilting or fail altogether to contact the second premolar. The resulting interdental space will favour the accumulation of food debris and the ultimate onset of periodontal disease. Removal of the first permanent molars also deprives the operator of adequate anchorage for tooth movement by orthodontic appliances and may be detrimental to subsequent treatment. A controlled follow-up of 100 cases where the first permanent molars had been extracted, showed less than 10 per cent to have an acceptable occlusion as the result.'

'Hallett, G. E. M. and Burke, P. H. (1961). *Trans. Eur. orthod. Soc,* p. 238.

In mixed dentition cases where an open bile of skeletal origin limits occlusion to the first molars only, it may be tempting to close the open bite by extracting those first molars. It has been found, however, that subsequent eruption of the second molars usually restores the original bite condition, and no improvement of this aspect of the case will have been gained.

Excellent results can be obtained, however, where the first permanent molars arc extracted *in selected cases* at a carefully chosen age, which is usually between 8 1/2 and 10 years, but considerable experience is necessary to determine suitable cases.

In a Class II case it is sometimes found necessary to extract one or both of the upper first permanent molars either because of their condition or because the relief of crowding is better treated by distal movement of the premolars and the canine. Care is needed here to avoid loss of space by untoward mesial movement of the second permanent molar. This may be overcome by delaying the upper extraction until the second molar has erupted, or perhaps by the immediate distal movement of the second premolar. It will then be possible to hold the second molars back until distal movement of premolars and canines is completed.

Second permanent molars. As the general direction of growth and development of the alveolar process and the teeth is occlusally, outwards and forwards, the teeth are moving forwards during the periods of active growth. For this reason the extraction of a second permanent molar may only provide space for the third molar. Loss of the second permanent molars may facilitate, however, the stability of a treated case where there is a mild disproportion between the size of the dental arch and that of the dental base which otherwise might tend to cause relapse. It is only here that extraction from the lower arch in Class II cases can be considered justifiable.

It has been shown by Rix and others that the loss of a lower second molar at fourteen years may allow spontaneous distal movement of the first molar in cases where the lower second premolar has become vertically impacted. This docs not occur where the second premolar is inclined lingually, and cannot be expected in the upper arch without recourse to an appliance.

Third permanent molars. The extraction of these teeth will have little effect upon the relationship of the remaining teeth in most cases. They are frequently removed on account of lack of space in the jaw causing their impaction against the second molars or because of their displacement in the bone.

SERIAL EXTRACTIONS

Where there is a disproportion in size between the dental arch and the dental base to the extent that the teeth are unable to find sufficient accommodation in perfect alignment, it frequently occurs that both the deciduous central and lateral incisors arc shed when the permanent central incisors erupt. Later, the deciduous canines are shed when the permanent lateral incisors erupt. The permanent incisors have thus erupted into good alignment at the expense of the space reserved for the permanent canines.

The observation of this phenomenon suggests the possibility of planned serial extraction in cases where an insufficient apical base **is** diagnosed at an early age (Fig. 81). Such a diagnosis, however, requires

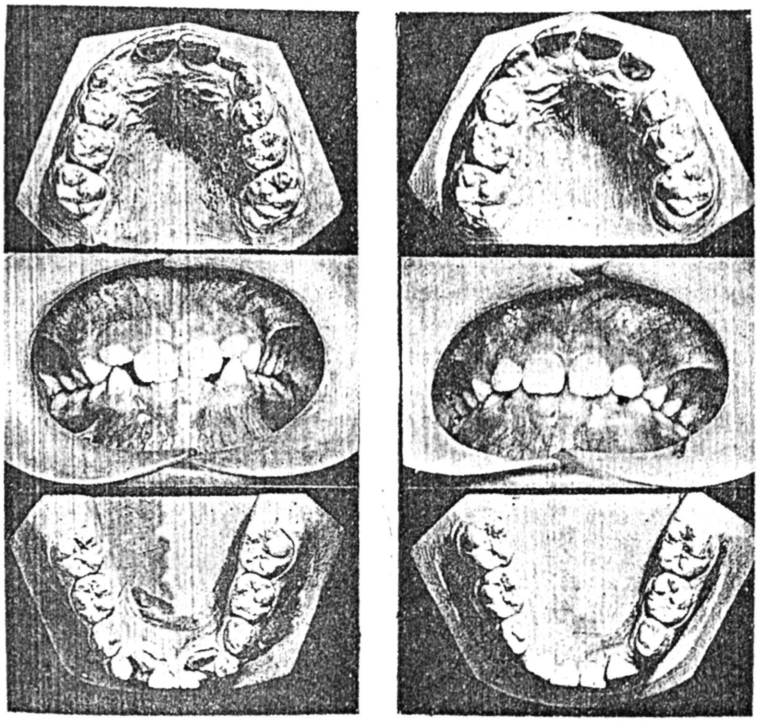
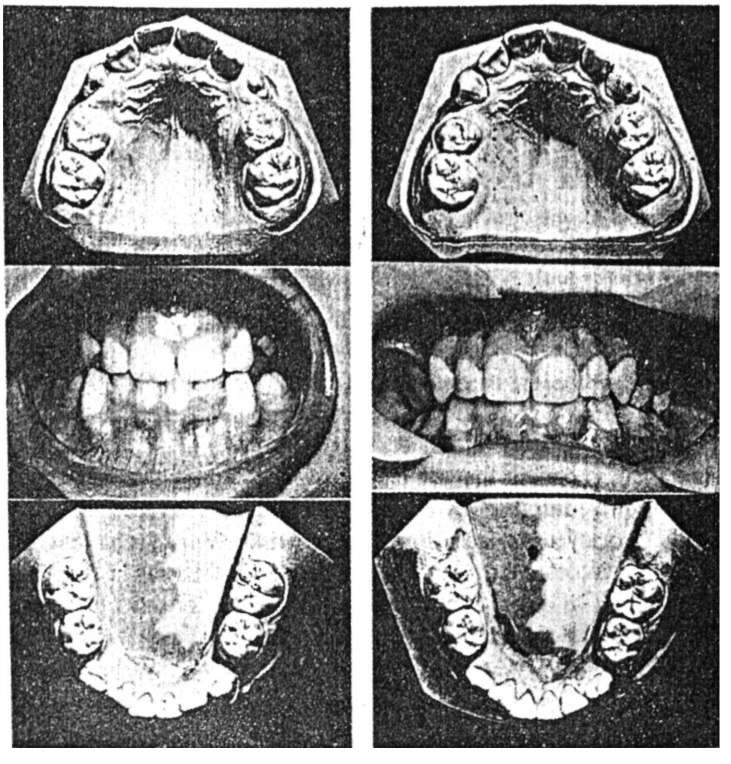


Fig. 81. Serial models of a case in which planned extractions have been carried out. The models were taken at 7 1/2 years, 8 1/2 years, 9 3/4 years and 10 1/2 years of age.

considerable clinical experience and it is advisable to seek the opinion of an experienced orthodontist before embarking upon this treatment. It must always be borne in mind that this method merely transfers the crowding from the incisor region to the canine or premolar regions: thus it *must be followed eventually by the extraction of permanent teeth.*

The deciduous lateral incisors can be extracted soon after the appearance of the permanent central incisors, thus permitting these teeth to be guided into correct alignment by the natural forces of occlusion as they erupt. At this stage the teeth are particularly responsive to the inlluence of guiding forces. The deciduous canines are extracted soon after the appearance of the permanent lateral incisors, again permitting the correct alignment of the latter within the arch. From this stage onwards it is necessary to ascertain periodically the relationship of the unerupted canines and the premolars. This relationship can be seen radiographically and is of particular importance as it may be necessary



to extract first or second premolars before the eruption of the canines. Alternatively, the first permanent molars may have to be extracted if they are very carious.

The first deciduous molars may be extracted shortly before the time of eruption of the first premolars in order to hasten their eruption. Extraction of the second deciduous molar in this way does not appear to have the same effect on the speed of eruption of the second premolar. Indeed, such a procedure may on occasions actually delay the appearance of the second premolar. Furthermore, if a second deciduous molar is lost early, a space-maintaining appliance may be advisable to obviate the mesial tilting of the first permanent molar.

Very frequently the lower canine erupts before the lower first premolar and it may be necessary to extract the latter tooth before it has actually erupted. If the first premolar erupts before the canines it may be extracted shortly before the eruption of the latter which will then erupt into the space. It may be desirable to adopt appliance therapy to complete the movement of the canines.

If the case is not seen until the malalignment of the incisors is apparent, serial extractions may be instituted at the appropriate stage but the results are frequently not so satisfactory, more appliance therapy being frequently required.

Indications for Serial Extractions

Great care should be exercised in the selection of cases for treatment by serial extractions. This procedure offers the best results when it is applied to cases of moderate crowding, and the patient is likely to be under observation for several years. Since the treatment aims at the eventual extraction of all first premolars it is essential that all permanent teeth should be developing, in good position and of good quality. Absence of lower second premolars and extensive caries of first permanent molars are contra-indications which occur commonly. Should crowding be severe, there is danger that the early loss of deciduous teeth may allow more forward migration of first molars than is desirable; this would make necessary the extraction of more than four permanent teeth. Although it is designed specifically for the treatment of crowding in Class I cases, it is possible, where the oro-muscular behaviour is favourable, to apply it to the upper arch alone in some Class II cases.

SURGICAL TREATMENT

The surgical treatment of pathological conditions, in so far as it restores

normal growth, development and function, may be a necessary adjunct to orthodontic treatment.

Examples of conditions which require surgical intervention are uncrupted supernumerary teeth, misplaced unerupted teeth, congenital clefts, extreme degrees of prenormaiity or postnormalily and, very occasionally, a persistent labial frcnum. Orthodontic treatment may also be required following the removal of cysts of the jaw or repair to congenital deformities. Most of these conditions warrant the seeking of specialist assistance. The treatment of misplaced unerupted teeth and a persistent labial frcnum may, however, be in the province of the general practitioner.

Extra teeth

As mentioned on pages 83-4 extra teeth in the upper anterior region can result in the delayed eruption and displacement of the upper incisors. In these cases correction of the incisor irregularity cannot be achieved until the extra tooth has been removed. This should be undertaken as soon after the normal time for incisor eruption as possible, and may require the reflection of a flap and surgical removal.

Pre-emption extractions

As an alternative to serial extractions in a case where it is particularly desired not to subject the child to' a series of extraction sessions, it is possible to remove not only the deciduous canines and first deciduous molars but also the unerupted first premolars at the same time. In this way the unerupted permanent canines move distally in the alveolar process as they erupt, and this may reduce or render unnecessary the subsequent wearing of appliances (Fig. 82). The conditions which limit the choice of case for this procedure arc exactly the same as those for serial extractions.

Persistent Labial Frenum

Up to the age of nine years, a space often occurs between the upper central incisors due to the attachment of the labial frenum not only to the labial surface of the alveolar bone but also to the palatal surface. The subsequent downward growth of the alveolar border normally leaves the frenum attached to the labial surface only. By the age of nine years the upper lateral incisors have erupted and the upper canines are moving from a position near the apices of the incisors towards the occlusal plane. Relief from pressure in the region of the apices and the change in

the attachment of the frcnum pcnnits the incisors to be approximated. Occasionally, however, the palatal attachment of the frenum persists and perpetuates the space between the central incisors (see Fig. 59, page 90). The differential diagnosis of this condition of spacing between the upper central incisors is important (page 230). In addition to the normal appearance described above, such spacing may be due to the presence of a supernumerary tooth or teeth situated in or near the mid-line (see Fig. 53, page 85). Where such additional tooth bodies arc present the apices of the upper central incisors may be separated and the axes of the teeth appear to be parallel or even converge towards the crowns whereas, in the case of the persistent labial frenum, the axes of the upper central incisors may appear to diverge, i.e. the crowns are inclined distally. Unerupted supernumerary teeth may be identified radiographically (page 242), while, in the case of the persistent frcnum.

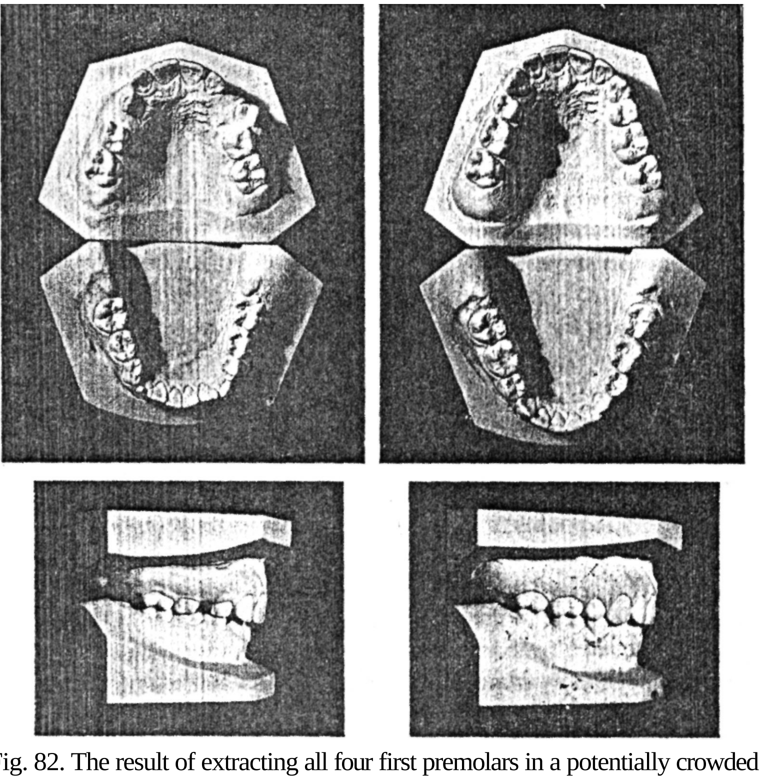


Fig. 82. The result of extracting all four first premolars in a potentially crowded dentition. In this case the extractions were carried out at nine years and no appliances were required.

the apex of the alveolar crest between the upper central incisors will appear truncated or even concave.

It should be borne in mind that spacing between the upper centrals may also be a manifestation of general spacing. This may happen to be concentrated between the central incisors and may occur where upper teeth arc cither congenitally absent (e.g. lateral incisors) or have been extracted. It is also seen occasionally where teeth are disproportionately small or where the upper incisors are inclined labially, for instance in digit-sucking. It happens occasionally that marked spacing of the upper central incisors appears in several members of a family or race with no obvious local cause.

Although spacing between upper central incisors is usually due to some other cause there remain a few cases where the frcnum seems to be the sole cause of spacing. Occasionally a patient will complain of a large, fleshy frenum, the appearance of which is aesthetically unpleasing. In other cases the frenum may be the cause of ulceration and damage to the gingival margin around the central incisors.This is particularly likely to occur in the case of a lower labial frenum. In all these cases it may be necessary to remove the frenum entirely. A local anaesthetic may be used and is preferable to general anaesthesia on account of the better haemorrhage control. The labial portion of the frenum is secured in a pair of 'Spencer Wells' forceps and the tissue snipped away labial to and above the beaks of the forceps. Using these to hold the frenum taut, the dissection is continued between the incisors to the palatal surface about one millimetre labial to the incisive papilla. The bone is curetted thoroughly to remove any remaining strands of fibrous tissue. A transverse suture may be required labially in the loose tissue. To prevent the blood clot organizing into a fibrous band in the median interdental papilla, and to ensure post-operative comfort, the wound may be dried and packed with a suitable paste which can be made up with zinc oxide powder and sterile cotton wool moistened with oil of cloves. This should be removed within five days or, if one of the non-eugenol periodontal packs is used, it can be left in place for a longer period.

The Misplaced Unerupted Upper Canine

Failure of a canine to erupt usually occurs where the tooth is not in correct position. Where possible it is desirable to encourage its eruption into the dental arch. This is possible only when the apex of the root is in a favourable position, both mesio-distally and bucco-lingually. The best position is above and a little mesially to that of the first premolar. Where the inclination of the canine is fairly steep to the occlusal plane and the

crown is not impacted against the root of another tooth it may be enough merely to provide manoeuvring space. However, if the normal time for its eruption has passed, surgical exposure may be necessary. Provided that the tooth is in a favourable position near to the surface, its crown is freely exposed by resection of muco-periosteum and overlying bone. Patency of the wound is maintained by means of an obtundent packing, usually of zinc oxide, oil of cloves and cotton wool, or one of the non-eugenol periodontal packs.

If the crown is lying deeply or is impacted, its eruption can only be achieved by exerting traction from an orthodontic appliance. To achieve this the tooth is surgically exposed and some form of attachment for a spring fixed to the tooth crown. This may take the form of a metal cap and hook, or more usually now a bonded bracket. The hook is used for the attachment of a spring from a fixed orthodontic appliance. This treatment is usually undertaken only by an orthodontic specialist. Other forms of treatment which may be considered necessary by the specialist are transplantation or repositioning of an unerupted tooth.

It is found necessary in some cases to accept the absence of the canine from the arch, either because its misplacement is too great or because prolonged appliance therapy is contra-indicated. If the canine is likely to; cause interference with other teeth it should be removed surgically. Where it is lying in a position remote from other teeth it may be left *in situ.* The patient should be informed of its presence.

Mandibular Resection

In cases of extreme disproportion of mandibular size (see Fig. 5, page 8) orthodontic treatment alone is unlikely to be of much avail. Should it be felt to be justified, the patient may be referred to an oral surgeon for resection of the mandible. It is often necessary to combine this with orthodontic treatment to produce a more pleasing appearance.

8. Interceptive Measures

Involving as it does the frequent use of appliances, orthodontic treatment is popularly regarded as 'springs', 'plates' and 'braces'. There is, however, much in orthodontic treatment that depends not so much upon appliances as on interceptive measures and therapeutic extractions, in addition to the clinical experience and knowledge of the operator.

In general practice children can be seen from a very early age over many years and, although an inherited malocclusion may not be preventable, there is much that can be done to correct a developing malocclusion or at least to alleviate some of the sequelae. This chapter, therefore, should be of interest to those already in the school service or general practice or who are about to enter a family-type practice where children are treated.

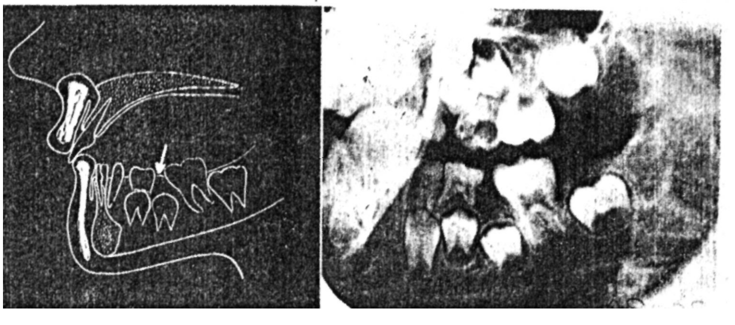


Fig. 83. Mesial inclination of the lower first permanent molar following premature extraction of the lower second deciduous molar, causing impaction of the second premolar.

(A) CARE OF THE DECIDUOUS DENTITION

The deciduous molars play an important part in guiding the permanent posterior teeth into occlusion (Chapter 3) and, as mentioned in Chapter 6, the premature loss of the lower deciduous molars may permit a shortening of the lower arch antero-posteriorly (Fig. 83). This is more likely to happen in those arches where the development of the jaws and the action of the soft tissues surrounding the dentition do not favour ideal development (sec page 93). In such cases, consideration should be given to the need for extracting the three corresponding teeth in the other quadrants so that any asymmetry or arch malrelation could be avoided. Where, on the other hand, arch development is good such spaces may well remain patent following the premature loss of one or more deciduous molars.

Space Maintainers. There is now considerable doubt about the value of space-maintaining appliances especially in those mouths where overcrowding may occur in any case and subsequent extractions and appliances are likely to be required. There arc, however, a few instances where space maintainers would be of value, such as a space-maintainer in the form of an immediate denture where an upper permanent central incisor has been lost and it is planned to keep the space for a more permanent restoration later. Possibly another situation where a posterior space-maintainer might be used is to ensure subsequently a good incisor relation in a Class III malocclusion where upper deciduous molars have been extracted.

Occasionally one lower deciduous canine might shed spontaneously, leading to an asymmetry of the lower incisors. As crowding is usually present in such cases, the extraction of the other deciduous canine in the same arch should be considered together with those in the opposing arch if the relationship between the arches is normal.

Oral Hygiene, As caries in the deciduous teeth may occur as early as twelve months of age, it is important that preventive measures should be taken in good time. The mother should be instructed to brush the infant's teeth and gums each night with a special soft texture infant's brush as soon as the incisors have erupted. From the age of two years the child may be encouraged to take part in brushing the teeth after each meal. It will be necessary, however, for the mother to supervise the brushing herself for several years to make sure this is accomplished thoroughly. Just as important as brushing is the supervision of diet. The ratio of

carbohydrates in the diet should be kept as low as possible and their consumption at the end of each meal discouraged. Parents should be warned particularly of the damage caused by dummies or 'Dormer' feeders used with syrupy compounds and by sweets consumed between meals.

Conservation. Regular dental supervision should begin from about 2 years of age in order to intercept caries in its early stages and to familiarise the child with the dental chair. The use of fluoride both topically and by ingestion is increasing and is possibly the most effective measure for preventing caries yet known.

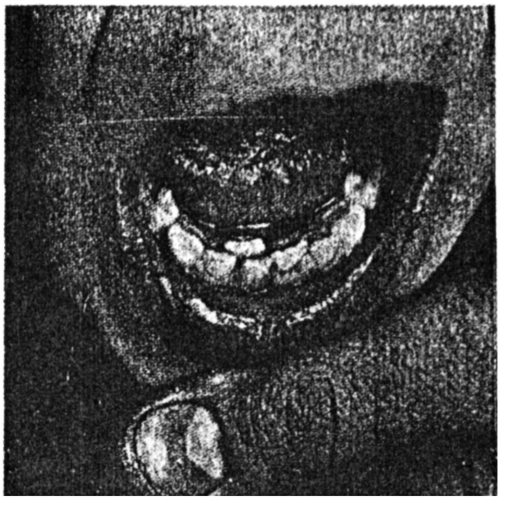


Fig. 84. Lingual eruption of the lower right permanent central incisor, associated with persistence of the deciduous central.

Retained deciduous teeth. In contrast to the premature loss of deciduous teeth, a deciduous tooth may remain too long in position, resorption proceeding on one side of the root only, so that an erupting permanent tooth is deflected from its normal path of eruption (see page 85). Due to their development on the lingual aspect of the deciduous predecessors the permanent incisors have a tendency to erupt lingually if the deciduous incisors are not shed in time. This occurs fairly frequently in the mandible (Fig. 84). If the persistent deciduous incisor is extracted, the pressure of the tongue brings the erupting permanent incisor into its correct position

providing sufficient space develops. When this occurs in the upper arch, the upper permanent incisor may be caused to erupt in a lingual position and even in lingual occlusion with the lower incisors (Fig. 85).

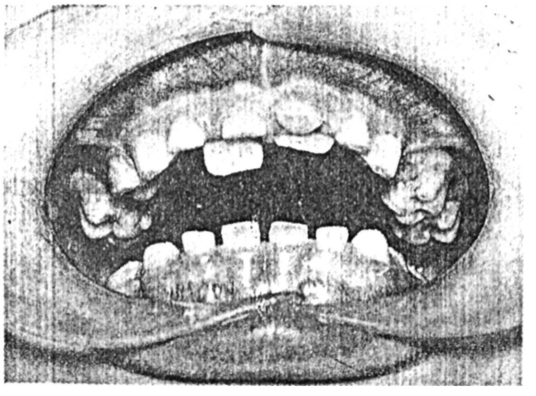


Fig. 85. Lingual.eruption of the upper permanent central incisor, associated with persistence of the deciduous central incisors.

If the upper incisor has fully erupted into lingual occlusion to the lower incisors, treatment with an appliance is indicated (see pages 172-3).

The deciduous teeth may persist too long and obstruct entirely the eruption of their successors (see Fig. 58, page 89). In such a case, provided radiographic examination confirms the presence of their successors, the persistent deciduous teeth may be extracted immediately. Where a premolar successor is absent (Fig. 86) and therapeutic extractions arc not indicated for other reasons (see Chapter 5), the deciduous molar should be preserved if at all possible. If this is impossible, and the arches are in normal occlusion, the space should be maintained until the tooth can be replaced artificially.

Cuspal interference. This happens frequently if minor malocclusions of individual deciduous teeth are associated with deviations of the mandibular path of closure. Frequently these deviations are corrected spontaneously as attrition wears down the cusps, allowing some form of movement of the lower arch relative to the upper (see page 52). At times, however, these changes are prevented by the failure of normal attrition to occur. It is often possible to remove the interference by carefully stoning the offending cusps. This may not be possible in other cases, particularly where a crossbite or prenormal occlusion is associated with

supraclusion of the deciduous canines which may even require to be extracted for this reason.

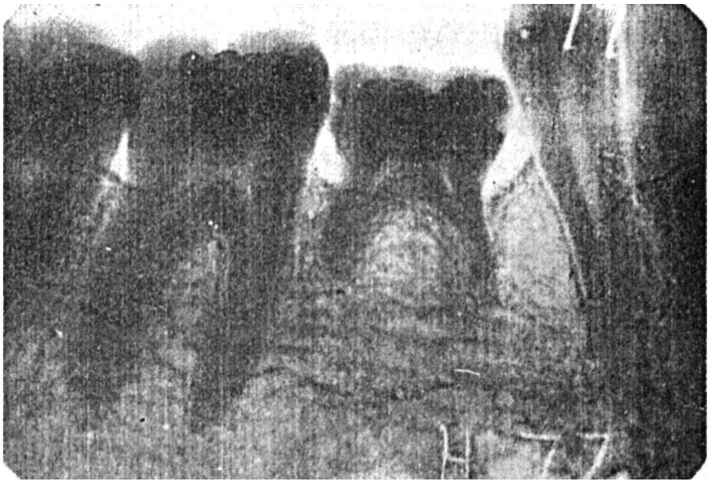


Fig. 86. Congenital absence of a lower second premolar and lack of crowding may make it desirable to conserve the deciduous tooth for as long as possible.

Supplemental deciduous teeth. Extra teeth (Fig. 87) may occur in the deciduous as well as the permanent dentition (see pages 83-5) and, if

Fig. 87. Supplemental upper right deciduous lateral incisor, causing crowding of the upper incisors and an increase of the ovcrjet.

they are causing a malocclusion, the usual treatment is to extract them. Since the defect may at times be repeated in the permanent dentition, a radiographic examination should be carried out in these cases so that provision can be made for the removal of the supernumerary teeth before the affected permanent teeth are due to erupt.

Crowding. If the erupting permanent incisors arc imbricated, it may occasionally be permissible to extract a deciduous lateral or canine. This subject is discussed fully in Chapter 7.under 'Serial extractions', page 126 and on page 129 under 'Prc-cruption extractions'.

Median Diastema. This, together with spacing between all the upper incisors, is not uncommon in the deciduous dentition and need cause no concern until the child reaches nine to eleven years of age (see pages 28-35).

(B) CARE OF THE PERMANENT TEETH

Oral hygiene and regular dental attention to both tcclh and gingivae is also of great importance in the permanent dentition. Early and unbalanced loss of even one permanent tooth can lead not only to malocclusion but also to traumatic occlusion and future periodontal lesions. In an unpublished survey of 112 dental students at nineteen years of age, it was found by Professor F. C. Wilkinson that 50 per cent had lost one or more first permanent molars with consequent malocclusion. Of those students who had retained all the first permanent molars, malocclusion was evident in 39 per cent; whereas 77 per cent of those who had lost one lower first permanent molar, and 71 per cent of those who had lost both lower first permanent molars, showed malocclusion. In all cases 'malocclusion' was taken to be any occlusal abnormality which would lead to traumatic occlusion and damage to the periodontal tissues.

The loss of one permanent tooth from either side of either arch, but more especially from the lower arch, may cause the collapse of that arch and malocclusion in the opposing arch, as shown in Fig. 88 (and described fully in Chapter 6 (page 104) and 7 (page 122). Thus, if a permanent tooth is to be extracted, it is of great importance that the occlusion between the arches is studied. If the arch relationship is neutral and no mesial drift of teeth has occurred following previous extractions, a compensating tooth may be removed from the opposing arch (Fig. 89) or a replacement unit inserted into the space resulting from the proposed extraction. Removing a second tooth from the opposing arch may seem

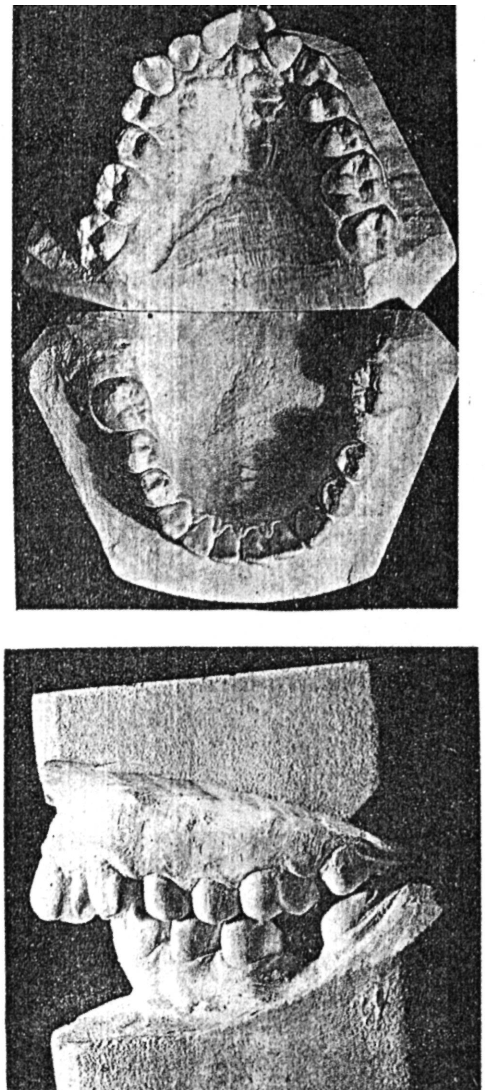


Fig. 88. Unbalanced loss of the lower first permanent molars.

heroic treatment to the parents but the sight of models such as those in Fig. 88 usually convinces them of the soundness of this action.

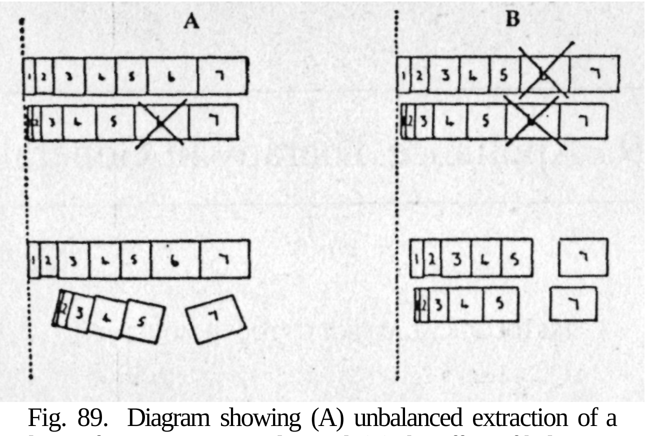


Fig. 89. Diagram showing (A) unbalanced extraction of a lower first permanent molar, and (B) the effect of balancing the extraction by removing the opposing tooth.

Supernumerary teeth. The incidence of extra teeth in the permanent dentition is in the order of 0.3 per cent erupted and 0.7 per cent unerupted.[1] Naturally these cannot be prevented but undue disturbance to the developing dentition may be obviated if they are removed as early as possible without endangering the adjacent teeth (see page 129).

Undue delay in the eruption of a permanent tooth should be investigated radiographically as it may have been occasioned by the presence of an unerupted supernumerary tooth (Fig. 90). Similarly, before correcting any rotated tooth, a radiographic examination should be made in case the rotation has been brought about by an unerupted extra tooth. A space between upper central incisors is produced not infrequently by unerupted supernumerary teeth as shown in Fig. 53, page 85. In the case of supplemental teeth (Fig. 51, page 83) treatment is usually aimed at removing the tooth in the least favourable position.

Missing teeth. Unless a full radiographic examination of the mouth has been made, the congenital absence of a permanent tooth may not be suspected until a deciduous tooth is found to be retained longer than the others (Fig. 86, page 137), or the eruption of the permanent tooth delayed. The treatment of such cases depends on several factors and is discussed in Chapter 5.

[1] Gardiner, J. H. (1961), *Dent. Practnrdent. Rec.* **12:** 63.

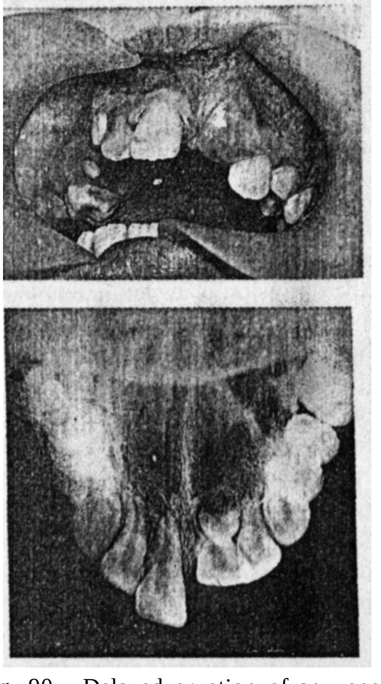


Fig. 90. Delayed eruption of an upper central incisor in a girl of ten years due to an uncruptcd supernumerary tooth.

Median Diastema. A space between the upper permanent central incisors has been commonly attributed to the labial frenum many of which have been unjustifiably resected. There arc, however, many causes of such mid-line spaces:'

1. As a transitory condition whilst awaiting the eruption of the permanent upper lateral incisors or canines.
2. Familial or ethnic characteristics.
3. Absence of upper teeth especially lateral incisors (see Fig. 50, page 82).
4. Extraction of teeth, especially upper first prcrnolars in large arches.
5. Small teeth in relation to the size of the arch.
6. Labially inclined incisors resulting from a sucking habit (see Fig. 64, page 98).

' Gardiner. J. H. (1967)., *Dent. Praclnr dent. Rec.* 17: 87.

7. An unerupted supernumerary tooth or an odontomc in the mid-line between the roots of the upper central incisors (see Fig. 53, page 85).
8. A large 'fleshy' frenum where there are no nearby spaces in the upper arch and which on stretching produces blanching of the anterior palatal tissues (see Fig, 59, page 90).

(C) SUCKING HABITS

Our knowledge regarding the reasons why children adopt the various habits which affect the occlusion is as yet incomplete, but we do know that only about 14 per cent of all children who suck digits eventually produce a malocclusion directly attributable to this habit (see Fig. 64, page 98).

In the past the importance of sucking habits in the aetiology of malocclusion has been over-emphasized and it is now generally agreed that a sucking habit by itself is unlikely to produce an Angle's Class II (i) malocclusion and certainly not a post normal skeletal relation; nevertheless such a case may be aggravated by digit-sucking which may also interfere with the progress of treatment. So often, however, a child with a prominence of the upper arch finds it comfortable to indulge in digit-sucking. Any open bite in the incisor region brought about by digit-sucking may well be perpetuated by the action of the tongue in thrusting forwards when swallowing.

It is usually necessary only to reassure the parent and to defer any action until orthodontic therapy commences when the presence of a layer of plastic material over the palate or the wire of a fixed appliance almost invariably discourages the child from indulging further in the habit.

9. Appliance Therapy in General

HISTOLOGICAL ASPECT OF TOOTH MOVEMENT

It is assumed that the reader is already familiar with the histology of the normal dental tissues.

Bone is a living tissue which, as has been seen in Chaplcr 3, reacts to pressure or tension in a certain defined manner. Wherever pressure is applied to the surface of bone there is resorption of bone. Wherever there is tension or traction upon the surface of bone, bone deposition occurs.

When a tooth moves, either due to the application of an orthodontic force, a pathological condition or traumatic cuspal contacts (or even during the normal eruptive stages), there is bone resorption on the side of pressure and new bone formation on the side of tension or traction. This is due to the fact that the periodontal tissues react to force and compensate by active cell proliferation producing the necessary alterations in the architecture of the alveolar bone to accommodate the tooth in the new position, thereby neutralizing the force applied.Therefore tooth movement is necessarily accompanied by marked histological changes in the surrounding bone. In fact, unless the tooth movement was traumatic or pathological, no movement could occur without these histological changes.

It is important to note that under these circumstances the vitality of the tissues is of great significance, since only vital tissues can produce the necessary active cell changes and response to the force applied. It is easier to produce tooth movements in a young individual whose cells are in their active phase of growth and readily adaptable to changes whereas in older individuals the cellular response is more sluggish.

The cellular response also depends upon the intensity and duration of

the force applied. If the force is mild, it may act as a mild traumatic stimulant which initiates cell activity and consequent changes in bone permitting the tooth to move. On the other hand, a severe force will lead to necrosis of the periodontal membrane, due to the fact that the blood vessels arc occluded by being compressed by the tooth against the

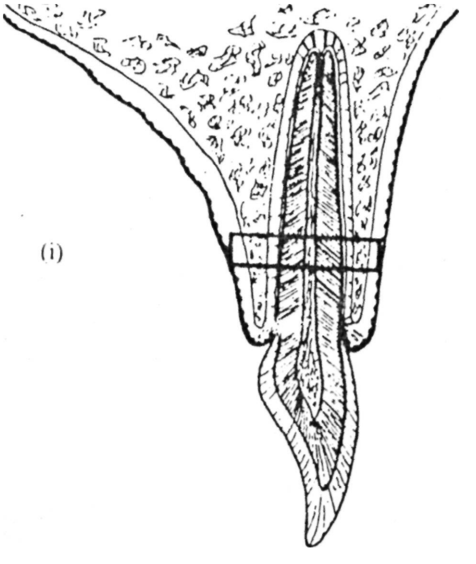


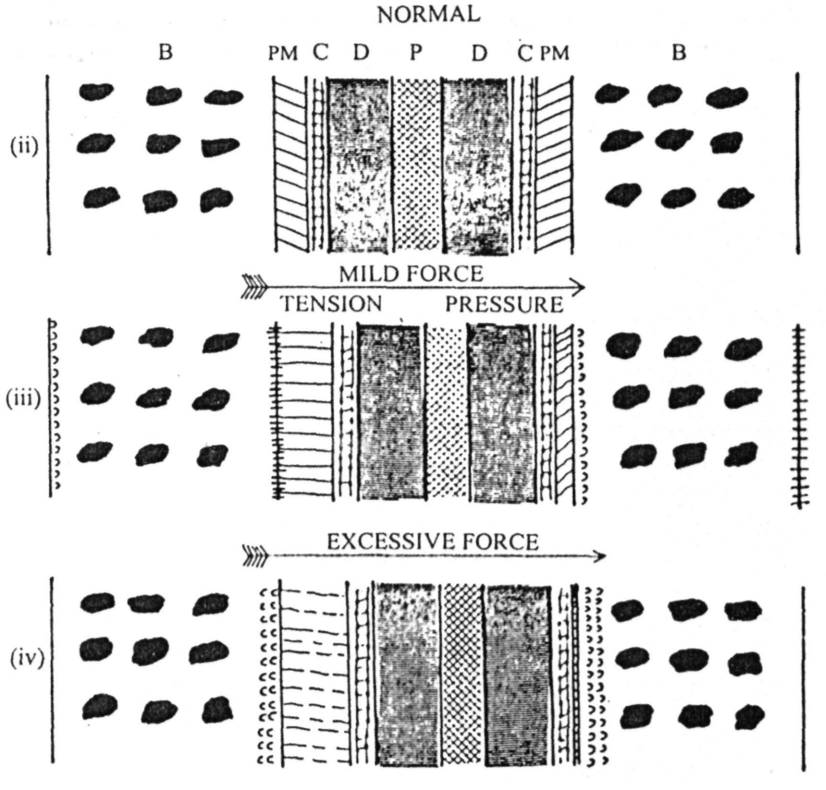
Fig. 91. (i) Sagittal section of tooth to show source of diagrammatic sections in (ii), (ill) and (iv).

alveolar process, and pathological changes ensue. The normal intracapillary blood pressure is approximately 20 to 26 grammes per sq cm and it is important that an orthodontic force applied to a tooth should not exceed this pressure. The distance over which a tooth may be moved using this pressure is approximately 1 mm per month.

CHANGES FOLLOWING THE APPLICATION OF MILD FORCE

(A) *Changes on the Side of Pressure*

(i) In the periodontal membrane: The periodontal membrane is initially compressed to about one-third of its thickness. An increase of the capillary blood supply especially near the alveolar crest precedes mobilisation of



(ii) Diagrammatic section to show normal structure of bone, periodontal membrane and tooth,
(iii)Diagrammatic representation of the effects of mild force on the supporting structures of a tooth. B—bone, C—cementum, P—pulp, PM—periodontal membrane, D—dentine,
(iv) Diagrammatic representation of the effects of severe forces on the supporting structures of a tooth. Note that there is no new bone deposited.

fibroblasts, osteoblasts, cemcntoblasls and osteoclasts. It is believed that osteoblasts form new bone while osteoclasts are responsible for the elimination of bone. This initial response on the part of the membrane is followed by changes in the adjacent bone (Fig. 91).

(ii) In the bone: After several days the presence of large multi-nucleated cells, the osteoclasts, will be noticed.These are associated with absorption of bone, particularly along the wall of the socket, where they may be seen in crescent-shaped excavations known as Howship's lacunae. After

several weeks both osteoblasts and osteoclasts arc present in the cancellous bone where the internal structure is being reorientated by absorption and apposition. Instead of lying in a generally vertical direction, the trabecular pattern of the bone will become orientated in a predominantly horizontal direction. This process will be slowly reversed as soon as tooth movement ceases.

Thus it is noticed that the initial response to the application of a mild force is an osteoclastic and an osteoblastic activity, the former giving way to the pressure and allowing the tooth to move and the latter helping to provide the necessary support to the tooth as it moves (fig. 91 (iii)).

(D) *Changes on the Side of Tension or Traction*

(i) In the periodontal membrane: The membrane is stretched and the space between the alveolar process and the tooth is widened. There is again an increase in vascularity and cell activity (Fig. 91 (iii)).

(ii) In the bone: The layer of the lamina dura immediately next to the periodontal membrane shows changes in response to this traction and bundle bone is laid down parallel to the direction of the force applied. The Osteoblasts lie farther out towards the cancellous bone. In the cancellous bone towards the lamina dura there is a laying down of bundle bone along the surfaces of the trabeculae while, in the outer cortical layer, there is osteoclastic activity removing bone from the outer parts where it is no longer needed; the supporting structure being moved closer to the moving tooth (Fig. 91).

Thus it will be seen that a mild orthodontic force sets up a slight inflammatory reaction in the periodontal membrane and the alveolar bone, leading to osteoblastic and osteoclastic cell activity with absorption of bone on the side of pressure within the membrane (i.e. on the side towards which the tooth is being moved), and compensatory deposition of bone on the side of traction within the membrane (i.e. the side away from which the tooth is being moved). At the same time as these structural changes are taking place in the bone immediately surrounding the tooth, there is a compensating alteration of bone structure elsewhere to maintain the thickness of the alveolar bone plates. For example, if the tooth is being moved in a lingual direction, (Fig. 92) there is a compensatory absorption of bone on the outer surface of the labial alveolar bone plate and also a compensatory apposition on the outer surface of the lingual alveolar bone plate. These compensatory structural alterations maintain the thickness of the supporting alveolar process even though the tooth may be moved over a distance several times greater than the thickness of the alveolar bone plates,

Most orthodontic movements of teeth by simple apparatus are tipping or tilling in nature and the fulcrum probably lies at the junction of the coronal two-thirds and apical third of the root (Fig. 92). Thus the extent to which these histological changes occur in the supporting structures in

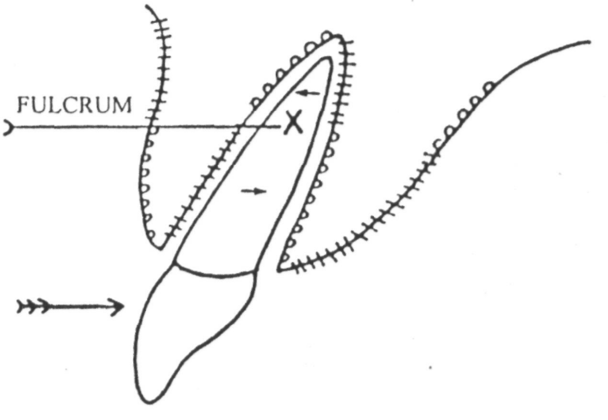


Fig. 92. The position of the fulcrum during the 'tipping' of a tooth by simple orthodontic treatment.

absorption apposition

such tooth movements varies at different levels of the root. The changes are greatest at the alveolar crest and become progressively less towards the point of the fulcrum on the apical side of which the changes may be reversed.

In the treatment of infra-clusion, where a tooth is being brought to the proper occlusal level, the tissue changes show a deposition of new bone at the gingival crests and at the apex. The treatment of supra-clusion, where a tooth has to be depressed by mechanical apparatus, may be the most hazardous since there is a greater chance of damaging the periodontal membrane and causing necrosis of the pulp of the tooth due to compression of the apical blood vessels.

Rotation of a tooth may also be a hazardous process if it is required over more than 45° owing to the fact that osteoblastic activity may not keep pace with osteoclastic activity and the supporting bone may not be developed to such an extent as to support the tooth in a stable position. The rotation of teeth should be accomplished very slowly and it may be advisable to rotate the tooth beyond the correct position to allow for the slight relapse which frequently follows such tooth movements. Also the corrected tooth should be retained in its final position for at least six months.

(c) *Changes in other tissues associated with Tooth Movement*

(i) Cementum: Owing to the stimulation and increased cellular activity within the periodontal membrane, resulting from the application of even the very slight forces required for orthodontic tooth movement, bays of osteoclastic resorption may appear in the cementum next to the periodontal membrane. If the pressure has not been loo great, these areas are repaired by cemcntoblasts when the tooth is rested, i.e. cither after the movement has been completed or during the process of treatment,

(ii) Dentine: Occasionally cases are seen where the ccmcntal resorption has been followed by resorption of the dentine even tiiough the pressure has not been excessive. Such areas of resorption are not repaired by dentine but arc filled in by the action of cemcntoblasts with a resulting inostosis. Such responses vary with individuals and the cause of the variation is not known.

(iii) Pulp: With mild force there may be a slight degree of hyperaemia of the pulp. If extreme force is applied the pulp may show signs of degeneration and partial or complete necrosis.

(iv) 'Basal' areas of the jaws: It is believed that changes in the .shape or size of the maxilla or mandible achieved by orthodontic appliances are limited in general to the alveolar process.

In the treatment of postnormal or prenormal occlusion the changes in arch relationship are attributed to an alteration of the axial inclination of the teeth in each jaw plus a possible degree of bodily movement of the teeth within the alveolar processes. There *may* also be changes in the position of the condyle within the glenoid fossa, which may also be accompanied by changes in the morphology of the joint,

(v) GingivalTissues:Although the gingival tissues do eventually become adjusted to the new position of a tooth, these changes are more sluggish than those in the bone. It is frequently found after rapid movement that the gingival tissues tend to pile up on the side towards which the tooth is moving. It is advisable not to cause irritation to this tissue by allowing the appliance to impinge upon it. Until such time as these tissues are completely adapted to the new tooth position, their elasticity is likely to cause some degree of relapse. This is of particular importance where a tooth has been rotated.

(vi) Temporomandibular joint: Changes in the occlusion of the teeth may bring about changes in the region of the temporomandibular joint. Breitner' has shown evidence in monkeys indicating areas of bone

' Breitner, C. (1942). 'Further Investigations of Bone Changes Resulting from Experimental Orthodontic Treatment'. Abstract. *Year Book of Dentistry*.

resorption and deposition within the glenoid fossa and on the articular eminence on the one hand, and around the condylar head of the mandible on the other. Other authorities hold that such changes are not of a permanent nature and that resolution of these changes will follow cessation of treatment. Still others hold that treatment involving a change in arch relationships permits additional growth of the ascending rami of the mandible in the region of the condyle in the young patient. Considerable research has yet to be carried out before our knowledge is complete concerning the changes in the region of the temporomandibular joint following upon alterations in the occlusion of the tcclh.

CHANGES FOLLOWING THE APPLICATION OF EXTREME FORCE

The reader cannot be advised too strongly against the use of pressures which exceed that of intra-capillary blood pressure in his attempts to move teeth with orthodontic appliances. As has already been stated, the optimum pressure which should be used is approximately 20 to 26 grammes per sq cm of root surface wilh a rate of movement not exceeding 1 mm per month.

An extreme force leads to a crushing of the periodontal membrane to such an extent as to compress the capillaries and to allow the root of the tooth to come into very close contact with the lamina dura on the side of pressure. On the side of traction, the over-stretched fibres of the periodontal membrane lead to an ischaemia of the membrane. Resulting from this, the lamina dura may at first show little evidence of change on either the side of pressure or the side of traction but there is an increased osteoclastic activity in the cancellous bone next to it. Later the lamina dura also shows osteoclastic resorption. By this time the periodontal membrane, and possibly the pulp, may show evidence of hyaline degeneration and the alveolus is enlarged by disintegration of the lamina dura and cancellous bone without the presence of osteoblastic activity. The tooth therefore loses its support and loosens within its socket. There is accompanying pain and hyperaemia of the gingivae. The hyaline changes of the periodontal membrane are slow to be reversed, a rest period of at least six weeks being needed for restoration of the cellular elements of the periodontal membrane to normal.

The use of extreme force may also cause excessive tipping of the tooth, the fulcrum moving to a point nearer to the coronal portion. In such circumstances the tooth may come into actual contact with the crest of the alveolar process. The failure of the cellular response to excessive pressure delays tooth movement, the tooth merely becomes

more mobile. Although it is becoming too great to elicit any cellular activity in the periodontal membranes of the teeth to be moved, an excessive force may well prove ideal for the larger number of anchor teeth. There is therefore a very real danger that the anchor teeth will move, while those intended for movement remain stationary.

APPLIANCES IN GENERAL

Orthodontic appliances may be defined as: *Appliances by means of which mild pressure may be applied to a tooth or group of teeth in a predetermined direction.*

It is upon the response of bone to pressure or tension described above that the use of active orthodontic appliances is founded. The pressure may be generated by the appliance or by the natural forces of occlusion, described in Chapter 3, which may be harnessed and applied to the teeth through the medium of the appliance. These appliances may be divided therefore as follows:

MECHANICAL APPLIANCES

A mechanical appliance exerts on the alveolar bone, through the medium of the teeth, pressure in a predetermined direction, by means of screws, springs or elastics: these are incorporated in the appliance.

The pressure exerted may be

(i) intermittent, achieved by the use of screws, or
(ii) continuous, achieved by the use of springs or elastics.

The mechanical appliances may be further divided into:

(a) Removable appliances (i.e. removable by the patient).
(b) Fixed appliances; these are attached to bands or rings of metal, which are closely adapted and cemented to the teeth.

Occasionally a combination of a fixed and a removable appliance is used, a part only of the appliance being removable by the patient.

FUNCTIONAL APPLIANCES

A functional appliance harnesses natural forces which it transmits to the teeth and alveolar bone in a predetermined direction. Usually the natural forces used are derived from muscle activity. These appliances may also be used to guide the behaviour of the muscles by obstructing undesired muscle activity. They are described more fully in the next chapter.

THE COMPONENT PARTS OF MECHANICAL APPLIANCES

Removable Appliances

A removable appliance consists of a plastic base secured in the mouth by means of cribs, and from this firm base forces arc applied to misplaced teeth by means of screws, springs or elastics.

(a) *Cribs.* An active orthodontic appliance is a vehicle through which forces may be applied to the teeth. In order to achieve this it is necessary that the appliance should engage not only the lingual or palatal surfaces of the Icelh, but of certain teeth also the buccal and interdental surfaces. For this purpose cribs (Figs. 125, 126, pages 187-8) arc constructed of loops of wire fashioned to engage the teeth buccally. One or both ends of the wire may be inserted in the plastic base. Cribs may also be used, as arc clasps in prosthetic appliances, to obtain adequate fixation in the mouth. Their use for this purpose is secondary to that described above. Fixation refers to attachment of the appliance to the teeth, and should not be confused with 'anchorage' which refers to the site of delivery from which mechanical forces are exerted. Cribs may be made from 0.7 mm (0.028 in) hard drawn round stainless steel wire.

(b) *Labial or facial bows.* A labial bow is an evenly curved, rigid and symmetrical arch of round wire which engages the labial surfaces of the teeth. There are two types, the short labial bow which passes over the interdental contact points distal to the canines, and the long vestibular bow which is soldered to the buccal arms of molar cribs. Each labial bow should carry U-loops, symmetrically, for adjustment of its length. In the case of the short bow the U-loops are placed labially to the canines, and in that of the long or vestibular bow they are placed buccally to the second premolars. These bows can be made of 0.7 mm.-0.9 mm (0.028-0.036 in) hard drawn round stainless steel wire.

Labial bows are used for the following purposes:

(i) To limit labial movement of the incisors,
(ii) to reinforce anchorage (see page 154).
(iii) To exert pressure in a lingual direction on the incisors when incorporated into an expansion appliance (see page 182).
(iv) to carry auxiliary springs.

(c) *Bite planes and inclined planes.* A bile plane may be built up of plastic material on the acrylic base palatally to the upper incisors, to engage the incisal edges of the lower incisor and canine teeth. This is a flat horizontal plane used to prevent the upper and lower molars, and premolars from occluding. An inclined plane may be built up in the same situation to have the additional effect of encouraging a forward

posture of the mandible combined with reinforcement of the anchorage (see page 153), in which case the inclined plane will engage the lingual surfaces of the lower incisor and canine teeth (see Fig. 95, page 154). The angle at which the inclined plane is constructed will vary with the individual requirements but will be approximately 60 degrees to the occlusal plane. Where the thickness of the inclined plane issufficient to prevent occlusion of the molars and premolars, it may be called an inclined bite plane.

Half capping, an extension of the plastic base to cover the occlusal surfaces of the molars and premolars, is used to disengage the incisors, and to reinforce the anchorage. Full capping is a similar extension to cover not only the occlusal surfaces but also the buccal surfaces of the molars and premolars; it may be used not only to disengage these teeth when a contraction appliance is used but also aids fixation of the appliance in the mouth.

Fixed Appliances

Molar bands are used as the basis of most fixed appliances. To these may be attached either a rigid bow wire which lies lingually or facially to the teeth, or a spring bow. The former may carry auxiliary springs to engage individual teeth or groups of teeth, or may carry hooks to which elastic rubber bands are attached. Teeth to be moved may be subjected to pressure or tension. Further details of fixed appliances will be given in Chapter 11.

ANCHORAGE

Anchorage is the site of delivery from which a force is exerted.

Because action and reaction of a force are equal and opposite it is necessary that the anchorage should offer more resistance to the force than does the part to be moved (Fig. 93). If the anchorage is not to move at all, the ratio of the resistance of the two parts must be very high. The resistance of a tooth to a given force is proportional to the surface area of alveolar bone to which it transmits the force (i.e. to the surface area of its roots), and dependent upon the direction of force relative to the axes of the roots. For example, great resistance is offered by the molars to a force exerted upon them in a distal direction; this is due to (i) the fact that the general direction of growth is outwards, occlusally and forwards, and (ii) to the distal inclination of the roots (Fig. 94). Similarly, greater resistance is offered to a force which is disposed equally over the whole length of the root of a tooth (i.e. a force which causes bodily

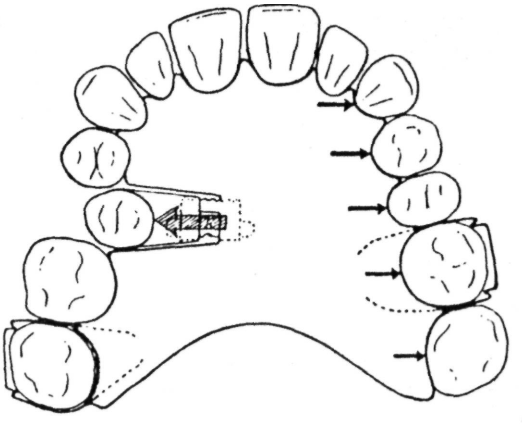


Fig. 93. Diagram of a simple screw appliance to illustrate the direction of action and reaction when force is exerted. This is an example of simple anchorage.

movement of the tooth) than one which permits the tooth to till. Anchorage may be offivc types: reciprocal anchorage, simple anchorage, reinforced anchorage, intermaxillary anchorage, and extra-oral anchorage.

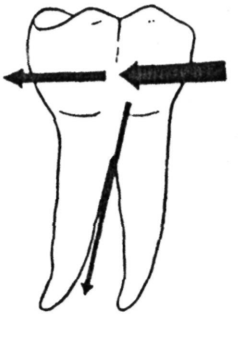


Fig. 94. Drawing to illustrate the dispersal of force when applied to a lower molar in a distal direction.

Reciprocal Anchorage

The anchorage is said to be reciprocal in those cases where it is designed that two teeth or two groups of teeth shall move to an equal extent in opposite directions. It is necessary that each group should offer equal resistance lest movement be unequal.

Simple Anchorage

Simple anchorage is obtained by engaging, with the apphancc, a greater number of teeth than are to be moved within the same dental arch (Fig. 93). The ratio of surface area of the roots of the anchor teeth to that of the teeth to be moved is sufficiently high to ensure adequate stability of the anchorage, bearing in mind the direction of force. The ratio of surface area of the roots should usually be at least two to one.

Reinforced Anchorage

It happens frequently that the stability of simple anchorage is insufficient to withstand the reaction of the movable part. This is particularly so when the upper molars are to be moved distally. The anchorage may then be augmented or stablized in one of several ways:

(a) The mandible may be used to reinforce the anchorage by engaging the lower incisors and canines with a plane built up on the palatal aspect of an upper removable appliance. The plane faces downwards and forwards at an angle of 60 degrees to the occlusal plane and engages the lower incisors and canines when the jaws arc approximated, guiding the mandible forwards (Fig. 95). The effect of this is to stretch the muscles which normally retract the mandible (the posterior fibres of the

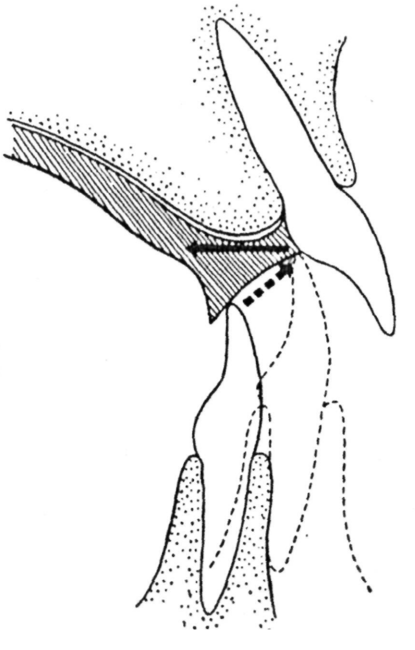


Fig. 95. Diagram to illustrate how an inclined plane reinforces the anchorage by the backward thrust from the lower incisors when the mandible is guided forward during occlusion.

Temporalis muscle, the anterior belly of the Digastric muscle and the Geniohyoid muscle); the tonus of these muscles is thereby increased, and they exert a backward pull on the appliance through the mandible.

Where an inclined plane is used, care should be taken to avoid interference with the tooth movement by unfavourable intercuspation of molars and premolars. Should this occur it may be overcome by using an inclined bite plane which is built up sufficiently to prevent cuspal contact. In other cases where intercuspation of premokrs and molars is favourable it may be used to stabilize the anchorage. Occasionally further reinforcement may be obtained by extending an inclined bile plane over the incisal edges.This is known as a Sved-type plate and has the advantage of splinting the incisors to prevent them from being inclined labially (Fig. 96, 97). They can only move bodily forwards with the appliance. The increased resistance teeth offer to bodily movement has already been discussed.

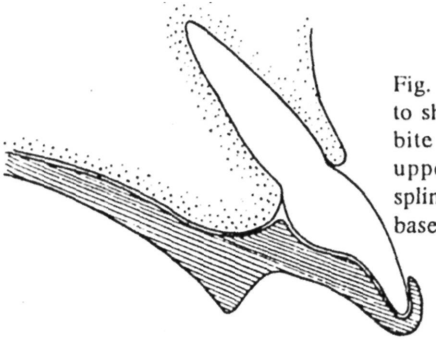


Fig. 96. Diagrammatic sagittal section to show the contour of a Sved-type of bite plane. Labial inclination of the upper incisors is prevented by the splinting of their crowns by the acrylic base.

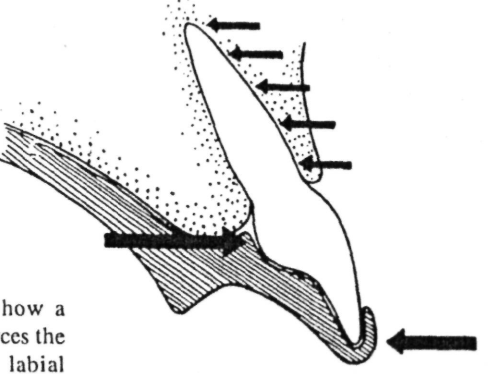


Fig. 97. Diagram to show how a Sved-type of bite plane reinforces the resistance of the incisors to labial displacement.

A rigid labial bow may be constructed to engage the labial surfaces of the incisors at the junction of the cervical two-thirds and the incisal one-third of each crown (Fig. 98). The ends of the bow usually pass distally to the canines to be inserted into the plastic base of the appliance. Provided it is quite rigid this bow will splint the incisors in much the

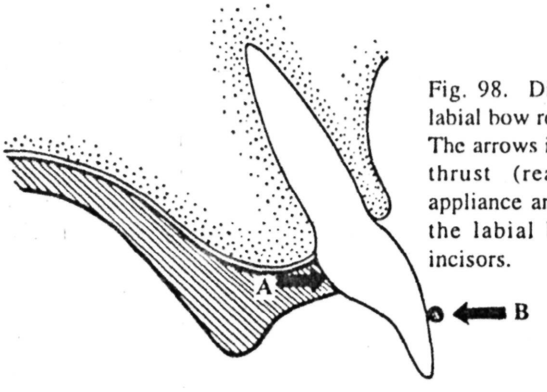


Fig. 98. Diagram to show how a labial bow reinforces the anchorage. The arrows indicate (A) the forward thrust (reaction) through the appliance and (B) the resistance to the labial bow to tilting of the incisors.

same way as the Sved plate, and interfere with their inclination labially. The interference may be made more complete by fitting the bow accurately into the contour of the labial surfaces of the incisors. This is known as a Titted labial bow'.

(b) The anchorage may be reinforced in the case of a fixed appliance by designing the appliance so that only bodily movement (i.e. movement of the crown and root to an equal extent) of the anchor teeth can occur, and tilting is prevented. One method of accomplishing this is to pass a bow wire through horizontal tubes on bands attached to adjacent teeth.

(c) In correcting the antero-posterior relationship of the upper and lower dental arches it is necessary to reinforce the anchorage to such an extent that the opposing jaw is used as anchorage. In these cases there is some movement in each arch, but the movement is not equal. This is known as intermaxillary anchorage (see Fig. 112, page 178) and is in fact a form of reinforced anchorage.

(d) If it is desired that one arch be restrained from forward growth, or moved backwards without any movement of the other, then anchorage must be sought outside the mouth. The use of a headcap of cotton webbing with an extension to the nape of the neck is a convenient form of extra-oral anchorage. From this headcap elastic bands may extend to a chin cap, or to extra-oral bars from an upper fixed appliance (Fig. 99). This is known as occipital traction. Elastics and a cervical collar may be used

to exert horizontal traction on the facial extensions of an upper appliance. This is known as cervical traction.

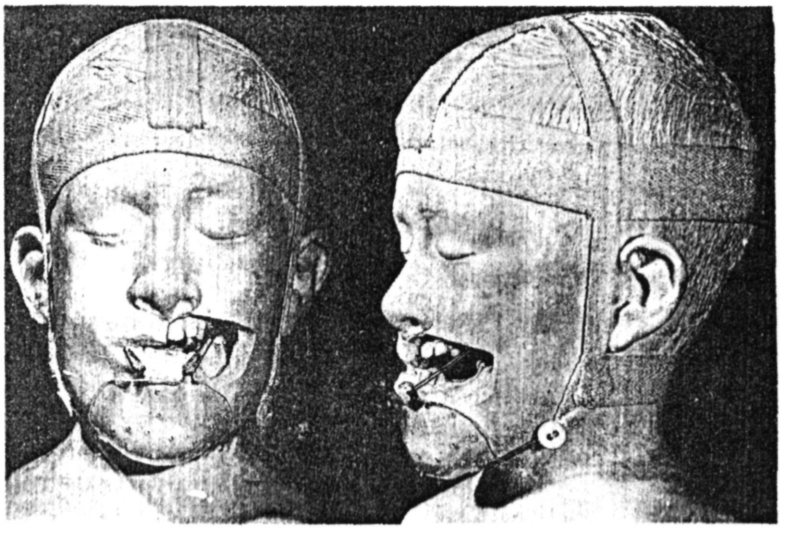


Fig. 99. Manikin showing head and chin cap with clastic traction. This is an example of extra-oral anchorage.

METHODS OF DELIVERING PRESSURE TO TEETH

Tooth movement may be stimulated by means of mechanical pressure. The rate of movement, however, is not proportional to the degree of force used. Excessive force causes pathological changes to occur in the cementum, bone and periodontal membrane (see page 149). It may be a contributory cau.sc of periodontal disease in later life. The force used may be intermittent or continuous.

(a) *Intermittent force.* Intermittent force is generated by means of screws or by the guidance of muscle activity, as in the case of the functional appliances. The screw exerts what is virtually an irresistible force and tilts the tooth across its socket. It is important to avoid damage to the attachment of the tooth by limiting the pitch of the screw, so that the tooth cannot be impacted on the crest of the alveolar bone. The periodontal membrane of a child is about 0.25 mm (0.01 in) thick. Manufactured screws are designed to open 0.18-0.20 mm (0.007-0.008 in) at each adjustment (that is, one-quarter turn), thus allowing a margin

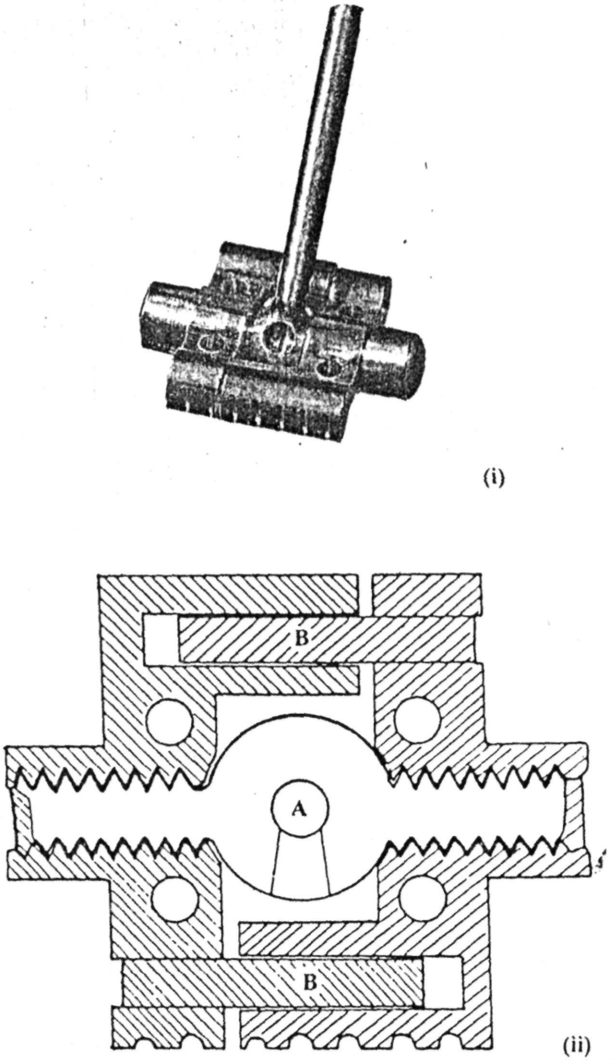


fig. 100. i Expansion screw as supplied by the manufacturer.
ii Diagrammatic section to show the internal structure.
A Centre boss of screw.
B Guide pin.

of 0.05-0.07 mm (0.002-0.003 in). The periodontal membrane of an adult, however, is not so thick, being about 0.15 mm (0.006 in); it is therefore necessary, when treating older children and adults, to limit each adjustment to a half of that given by the manufacturers. Most of the manufactured screws are basically of a similar design. A typical screw consists of an oblong body which is divided symmetrically into two parts (Fig. 100). Each half is tapped centrally to receive one end of a double-ended screw. Holes are drilled transversely through the centre boss of the screw for the insertion of a key. There are four of these holes, so thai the screw is turned one-quarter revolution at each adjustment, giving 0.18 mm (0.007 in) linear movement. One end of the screw has a left-hand thread; thus turning of the screw withdraws it from both sides simultaneously. Near the side of each half is a guiding pin, parallel to the centre screw. Each guide pin is received into a hole drilled on the opposing half (Fig. 100). The surface of the body is suitably serrated to obtain fixation in the plastic base material.

(b) *Continuous force.* Continuous force is generated by means of springs or elastic bands. In order to avoid damage of the periodontal

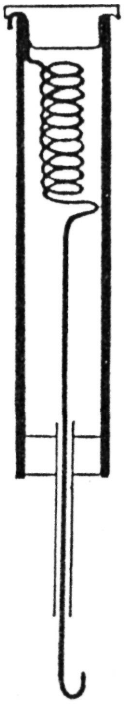


Fig. 101. Spring tension gauge which may be constructed from simple materials used in the surgery.

membrane the force should be limited to that of capillary blood pressure, that is 20-26 grammes per sq cm (20-30 mm of mercury); this is equivalent to about one-half to one ounce per tooth. The force exerted may be measured with the aid of a small spring tension gauge (Fig. 101). This gauge may be made in the laboratory and calibrated by hanging various weights upon it. The force exerted by an clastic may be measured by suspending various weights on it to estimate the weight required to stretch it to a given length,

(i) Springs.

Using a given calibre of wire, the longer a spring the more gentle its action and the greater the range over which it operates. As has been explained, gentleness is of the utmost importance when moving teeth. It is also important that springs should maintain the same direction of force throughout the tooth movement. McKeag has shown that where a straight piece of spring wire is held in a vice at one end and pressure applied to the free end so that it moves 1 cm to the right, it will bend in the form of an arc (Fig. 102). The diagrams show that the tangent to the distal end of the wire in the first case makes a much larger angle with the original

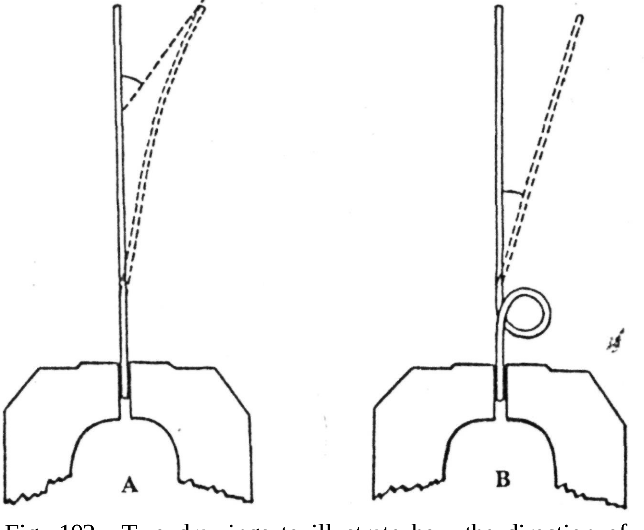


Fig. 102. Two drawings to illustrate how the direction of application of force by a spring is more stable when a coil (helical loop) is incorporated at the root of the spring.

A. When the end of the wire is moved 1 cm to the right, the spring curves evenly.

B. Wire with coil loop, moved 1 cm to the right curves largely at its root.

passive direction than it does in the second case. There is thus a greater change of direction of force during movement of the wire. The coil at the root of the spring has a double purpose:

(i) By increasing the length of wire, without it being cumbersome, to distribute stress and prevent distortion.

(ii) To maintain more nearly the direction of movement.

Owing to the limit on length imposed by the size of the mouth, springs are often recurved upon themselves; this provides two points of adjustment and enables the spring to maintain a constant direction of movement. It also prevents any change in the point of application of force on the tooth, and therefore eliminates one cause of undesirable rotations (Fig. 103).

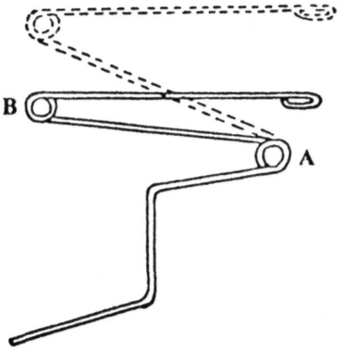


Fig. 103. Z-spring with two sites of adjustment A and B. By this means the direction of the application of force can be maintained.

Orthodontic springs are made of round wire. The mechanical principles governing their behaviour are the same as for springs made of flat material such as metal strip. The spring is activated by increasing the curvature of its long axis. Provided the curvature has not been increased sufficiently to cause distortion or permanent bending, the resilience of the metal will re-establish the original curvature when it is released. As a general rule all springs are so constructed that, when passive, the curvature is less than when active, the curvature being increased temporarily to activate them. Thus they open out to operate, as does the mainspring of a clock. This minimizes the amount of distortion needed to construct the spring, thereby reducing the amount of fatigue caused when shaping the wire.

(ii) Elastic traction.

Elastic bands may be used to apply traction to an individual tooth by means of a hook attached to a band or a metal cap (Fig. 104). Elastic traction may also be used in the form of semi-transparent elastic bands in the retraction of prominent incisors where aesthetics is an important

consideration (Fig. 105). Yet another use of elastic traction is in the form of inter-maxillary anchorage and extra-oral anchorage (see page 175) and as 'cross elastics' in the reduction of a crossbite (see Fig. 192, page 272).

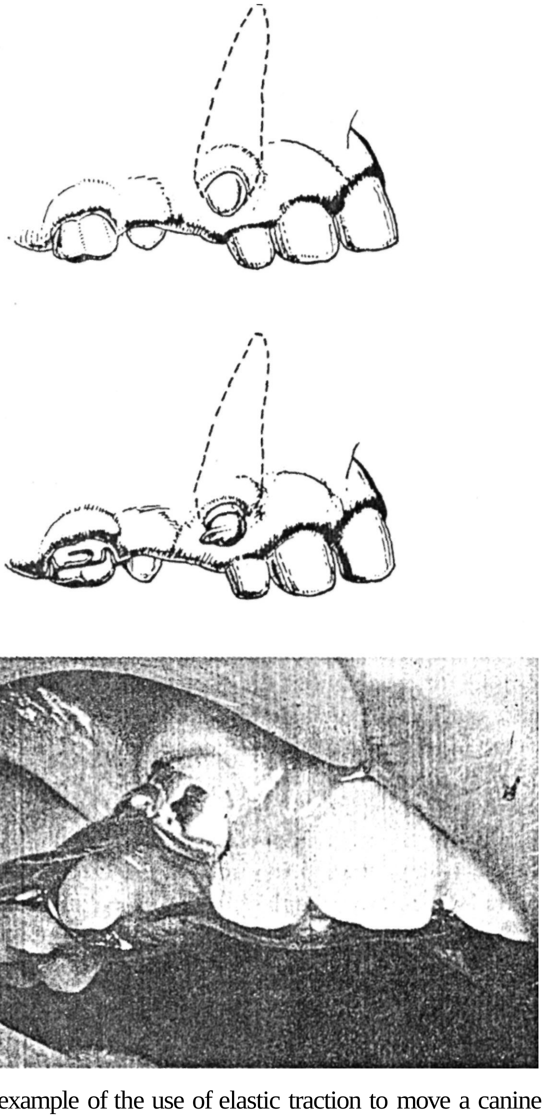


Fig. 104. An example of the use of elastic traction to move a canine distally. This is especially useful when the patient has a shallow labial sulcus, and the canine is only partially erupted.

RELATIVE ADVANTAGES OF FIXED AND REMOVABLE APPLIANCES

Removable Appliances

These appliances may be left without supervision for longer periods with reasonable safety. They may be removed by the patient if anything amiss should befall the appliance or the patient. They are less easily

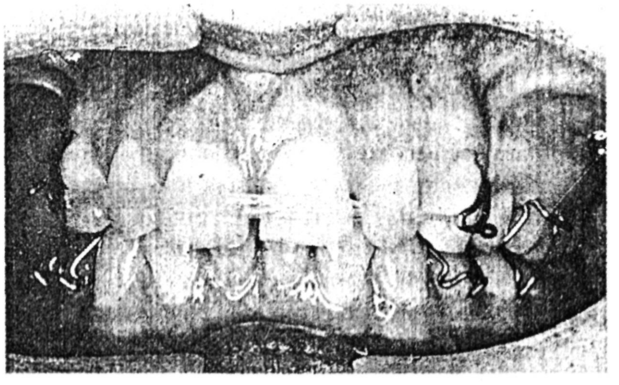


Fig. 105, Rctraclion of prominent incisors with semi-transparent clastic bands. This is useful in those cases where aesthetics has to be considered.

damaged, but arc not suitable when the co-operation of the patient is doubtful. Cleanliness is less of a problem than with fixed appliances. They may be made entirely by a technician and so economize on surgery time. Special equipment other than that of the average dental laboratory is not necessary. It is easy to replace a removable appliance using a minimum of surgery lime.

Fixed Appliances

Fixation is more secure and force may be applied with a high degree of gentleness and precision, but considerable experience is required on the part of the operator before they can be used with safety. The appliance is not bulky and cannot be removed by the patient. Any tooth movement may be accomplished, including bodily tooth movement and rotation or tilting of the root of a tooth, the only limit being the physiological tolerance of the tissues. Repairs may be effected at the chairside.

DESIGNING AN APPLIANCE

All orthodontic appliances should be designed at the chairside, with both study models and the patient present. Only in this way is it possible to ensure that the appliance will not interfere with normal occlusion, function or growth changes such as eruption of teeth, and that no untoward movements will be stimulated. It must be remembered that the mouth and dental arches, to which the appliance is to be fitted, will themselves be undergoing developmental changes while it is being worn. These changes must be anticipated when the appliance is designed. Care should also be taken to avoid any obstruction to the movement intended (i.e. intercuspal locking may often impede tooth movement). Careful observation should be made lest the normal forces of growth interfere with the appliance or become diverted to abnormal channels by the appliance (i.e., the alignment of the incisors may be prevented by an appliance which maintains what would otherwise be temporary imbrication of these teeth). Erupting teeth may cause displacement of the appliance. Where all the premolars and molars arc covered by half capping, except the erupting second molars, which arc thereby pcrmilicd to over-erupt, an open-bite may result. The details of design should be written down at this time—this eliminates any possibility of mistakes due to the limits of the human memory. For this purpose a standard formula of abbreviations may be used. If a technician is to construct the appliance, not only should directions for the design be given but also the purpose of the appliance. In deciding the type of appliance the circumstances of the patient should be borne in mind. Such factors as the degree of co-operation and frequency of visits may affect this decision.

MATERIALS USED IN THE CONSTRUCTION OF APPLIANCES

The plastic base of a removable appliance is usually made of acrylic resin.

The manufactured screws are made of nickel-silver and sometimes stainless steel is used for the spindle (Fig. 100, page 158). The nickel-silver, if unplated, may tarnish in the mouth, but little harm results.

Springs, Bows and Cribs

Metal in some form or another is used in the construction of nearly every appliance. It is used in removable appliances for making cribs, clasps, labial bows and springs. Fixed appliances are made entirely of metal. The metal used should have the following properties:

(i) Resistance to chemical action of the fluids of the mouth.

(ii) sufficient strength to withstand the forces that are to be imposed upon it.
(iii) Resilience; this is particularly so of the metal used in the construction of springs,
(iv) Ease of manipulation.
(v) Commercial production; it should be capable of being produced in the form of wire or thin tape at moderate cost.

Platinized gold, an alloy of gold and platinum, fulfils all these requircmcnls. It has the advantage of retaining its properties after being heated. It is easy to manipulate and can be soldered without difficulty. Stainless steel fulfils all of the requirements except that it loses its properties when healed. This difficulty has been largely overcome in several ways. As it is the metal most widely used, its properties will be described in some detail.

Stainless steel was discovered by Brearley of Sheffield. He found that the addition of chromium to steel rendered it resistant to etching with acids and to corrosion. The Austenitic steels, of which one is used for the manufature of orthodontic wire, contain 16-19 per cent of chromium and 8-10 per cent of nickel and arc thus sometimes referred to as '18-8' stainless steel. They do not respond to heat treatment, but their resistance to corrosion is sufficient for their use in the mouth. The stainless properties of the steel are due to its chromium content, there being a very thin film of chromium oxide on the surface of the metal. If the temperature of the metal is maintained at 500-600°C. for any length of time, carbides of chromium and iron are formed; this is known as weld decay, and destroys the properties of the steel. These Austenitic steels, unlike the carbon steels and the Martensitic stainless steels, cannot be hardened by heat treatment; on the contrary heat only softens the metal. They may only be hardened by working them; wire may be hardened by being drawn through a draw plate. It is therefore not possible to harden the steel after soldering.

Stainless steel is supplied for orthodontic use in the form of round wire of diameters varying from 0.10 mm (0.004 in) to 2.0 mm (0.08 in), and tape from 0.10 mm (0.004 in) to 0.15 mm (0.006 in) thick by 2.5 mm (0.1 in) to 7.0 mm (0.28 in) wide. It is also supplied as lengths of round tube of internal diameters varying between 0.5 mm (0.02 in) and 1.10 mm (0.04 in), usually in the hardened form. The tape is always soft, but the wire may be soft or hard drawn. The soft wire is used only for ligatures or for making small hooks. The hard wire is used for making springs, cribs, labial bows and all fixed appliances. The manipulation of the hard wire to fabricate cribs, bows and springs requires skill derived

from much practice. Since the metal has already been work-hardened when it is supplied, it is important that manipulation should be reduced to a minimum. Excessive working causes further hardening and fatigue and will ultimately result in fracture of the metal. In order to reduce manipulation to a minimum, it has been found advisable to curve the wire only and not to bend it sharply where avoidable. To accomplish this the wire is gripped in the pliers and is drawn around the round beak with the thumb and forefinger (see page 189). The wire should not be held in the fingers and bent with the pliers as this will produce sharp bends in the wire. These sharp bends have several disadvantages; they cause fatigue at the site of the bend, they are difficult to straighten out if wrongly placed, they irritate the soft tissues and favour the collection of food debris.

SOLDERING

Solder is a fusible alloy used to unite, by heating, metals and alloys which are less fusible. In order to achieve union it is necessary not only to clean the parts to be soldered of oxide, but also to prevent oxidation of the metal during heating. For this purpose a flux is used; this is usually a reducing agent, which absorbs the metallicoxides as they are formed. Although borax was at one time used as a flux for soldering stainless steel, it was found to be very unreliable. More recently, fluoride fluxes have been introduced and these have achieved much more success. They are made up of approximately equal parts of boric acid and potassium fluoride. Their introduction has enabled orthodontists to solder stainless steel as a routine procedure in constructing appliances.

Although the joint can be made to function quite satisfactorily, examination of a section of the metal will show that the solder and steel have not fused; a clear-cut line of separation is always presenty. The union is maintained by the close adaptation of the solder to the surface of the steel.

The solder most widely used in orthodontics is an alloy of silver (61 per cent), copper and zinc. It is supplied either in the form of sheets or of wire; the latter is more convenient for orthodontic purposes.

As a source of heat a small gas-compressed air burner giving a narrow flame is usually preferable because of the loss 'of resilience of the steel when it is heated. This creates some difficulty when solder is used as the means of attachment for stainless steel springs. It may be overcome by fusing the solder on the supporting heavy gauge bow, and dabbing the lightly fluxed spring wire into the molten solder after the source of heat has been removed.

Technique for Soldering

Soldering, as a process in the conslruclion of orthodontic appliances, may be accomplished in two ways:

(a) By free-hand soldering.

(b) By soldering the parts assembled on a plaster cast.

(a) *Free-hand soldering.* Each of the parts to be soldered is cleaned and painted with flux; then each in turn is heated in the gas air flame until the flux is fused, and is then wiped with solder. The parts are then brought together and heated to fuse the two portions of solder. The flux may be removed by boiling in alum solution. This technique is used in the construction of some fixed appliances,

(b) *Soldering on a plaster cast.* The parts to be soldered, already bent to shape, arc cleaned and assembled in position on the model. It may be necessary to use a little oxyphosphate cement to attach them securely to the model. It is essential that the parts to be soldered should be closely applied to each other. If the model is to be used for the processing of acrylic resin it should be protected with wet asbestos; this is cut so that it covers the model around the part to be soldered. It may be necessary to use a separate model for soldering in some cases. The flux is applied to the parts to be united and these are heated until the flux is fused, then solder is applied to the joint. This is cleaned by plunging it into cold water and then chipping off the flux. The joint should be buffed with nothing more abrasive than a lambswool mop and whiting. Pumice and a brush should be avoided lest the sheath of solder be opened to release the wire it invests.

WELDING

Welding is the fusion of two pieces of a similar metal under pressure without the introduction of a third material. The metal must be softened by heat as well as being compressed to achieve this.

Principle

The resistance offered by stainless steel to an electric current of high amperage generates enough heat to soften it.

Current

The usual mains supply of electricity is passed through a transformer to increase the amperage at the expense of the voltage. The current may be varied on most machines used for this purpose. The secondary circuit of the transformer is connected to two copper-alloy electrodes.

Pressure

The copper alloy electrodes may be approximated under pressure on the parts to be welded by releasing a powerful coil spring. The pressure maintains close apposition of the steel and compresses it when it is softened, causing the parts to fuse together.

Electrodes

The electrodes are made of an alloy which has the same conductivity as copper without its disadvantage of adhering to the steel after welding. The shape of each electrode is designed to concentrate the current sufficiently to cause a rapid rise of temperature. They are also shaped in such a way that the part to be welded is held securely. They are made of sufficient calibre to conduct away the heat rapidly, before it destroys the properties of the steel around the welded spot.

Timing

Most welding machines have incorporated in them a time switch for adjusting the duration of the passage of the current, as timing is an important factor in welding. If the temperature is maintained between 450°C and 850°C for more than one-tenth of a second, weld decay due to precipitation of carbides may occur, destroying the properties of the metal. It is important that, after welding, the heat should be dissipated as rapidly as possible, through the alloy electrodes, which are good conductors of heat, so that this temperature range is passed quickly. Although steel is a poor conductor of heat, if the heating is prolonged it will spread beyond the area of the spot weld. Recently, electronic control of the timing device has been introduced and is capable of producing a discharge of current for only one-thousandth of a second. This method of welding is very much superior to the mechanically controlled method. Spot welding may be used as a method of fusing:

(i) Stainless steel strip for making bands.
(ii) Securing attachments to the bands.
(iii) Attaching springs to a rigid bow wire, or to bands.

It is used more in the construction of fixed appliances than removable appliances.

10. Removable and Functional Appliances

The term 'removable' is used to indicate an appliance which is intended to be removed for cleaning by the patient in contrast to the 'fixed' appliance which is usually cemented to the teeth. It is necessary for the removable appliance to have a high degree of stability and anchorage otherwise the pressures used to move teeth may react to dislodge the appliance. Furthermore, since it has to be handled by the patient, it is important that the removable appliance should be of reasonably strong construction.

Removable appliances may incorporate screws, elastic bands or springs to exert the necessary orthodontic pressures upon teeth to be moved; otherwise they may be inert in themselves and so constructed as to harness the muscle forces of the wearer to produce the necessary orthodontic pressures.

The use of screws in removable appliances is popular because screws can combine strength with limitation of force within physiological limits when they are properly handled by the patient. When springs are used, not only are they designed to produce the necessary tooth movements but also to be protected from damage either by mastication or by handling.

Although removable appliances arc perfectly adequate to produce the majority of orthodontic tooth movements, it is difficult to attain the delicacy and gentleness of pressure of the fixed appliance. Nonetheless the removable appliance, correctly used, can be considered adequate to accomplish most of the tooth movements that might be required in the average general practice,

A selection of removable appliances in common use now follows, though this list is by no means comprehensive.

REMOVABLE APPLIANCES IN WHICH SCREWS ARE INCORPORATED

The screws in these appliances are usually of the type (described on page 157). It is intended that they should be adjusted at intervals by the patient and with the key supplied for the purpose. They are therefore of particular value where the patient lives at a distance and visits for regular adjustment to the appliance arc not practical. Nevertheless, they must be supervised at intervals because, should the fit of the appliance become less satisfactory, further adjustments to the screw will almost certainly worsen matters until the appliance may become unwearablc. When this occurs, relapse to the original position of the teeth will follow and the patient may return after a long interval with the appliance in his or her hand and the malocclusion as bad as ever. To obviate this the wearer of a removable appliance incorporating a screw must be impressed with the absolute necessity to report back *at once* should any misfit of the appliance occur and warned of the consequences if this advice is not heeded.

Removable appliances incorporating screws may be divided into three types according to the desired action of the screw,

(A) *Expansion appliance with screw* incorporating reciprocal anchorage and used to widen a dental arch by tilting or tipping the molars and premolars in a buccal direction (see Fig. 106A, page 171).

(B) *Appliance with screw to move individual teeth or small groups of teeth in a buccal or a labial direction. (Fig. 107, page 174).*

(C) *Appliance with screw to move individual teeth or small groups of teeth in a distal or mesial direction (Schwarz appliance)* (see Fig. 109. page 176).

(A) *The Expansion Appliance with screw*

(Note: This may be used to increase the width of either dental arch, *providing* the narrowness is due to the palatal or lingual inclination of the molars and premolars. If the narrow dental arch is associated with molars and premolars which are not palatally or lingually inclined but are upright upon their apical base, the expansion appliance will produce a buccal inclination of these teeth. Since the appliance will not influence the size of the apical base, relapse of the tooth movement must follow on cessation of the treatment. Thus the use of the expansion appliance is strictly limited and failure to realize this fact can only result in disappointment). The simplest form of this appliance can be seen diagrammatically in Fig. 106A, page 171. It is made up of two modified arrow head cribs and a plastic base which has been divided down the

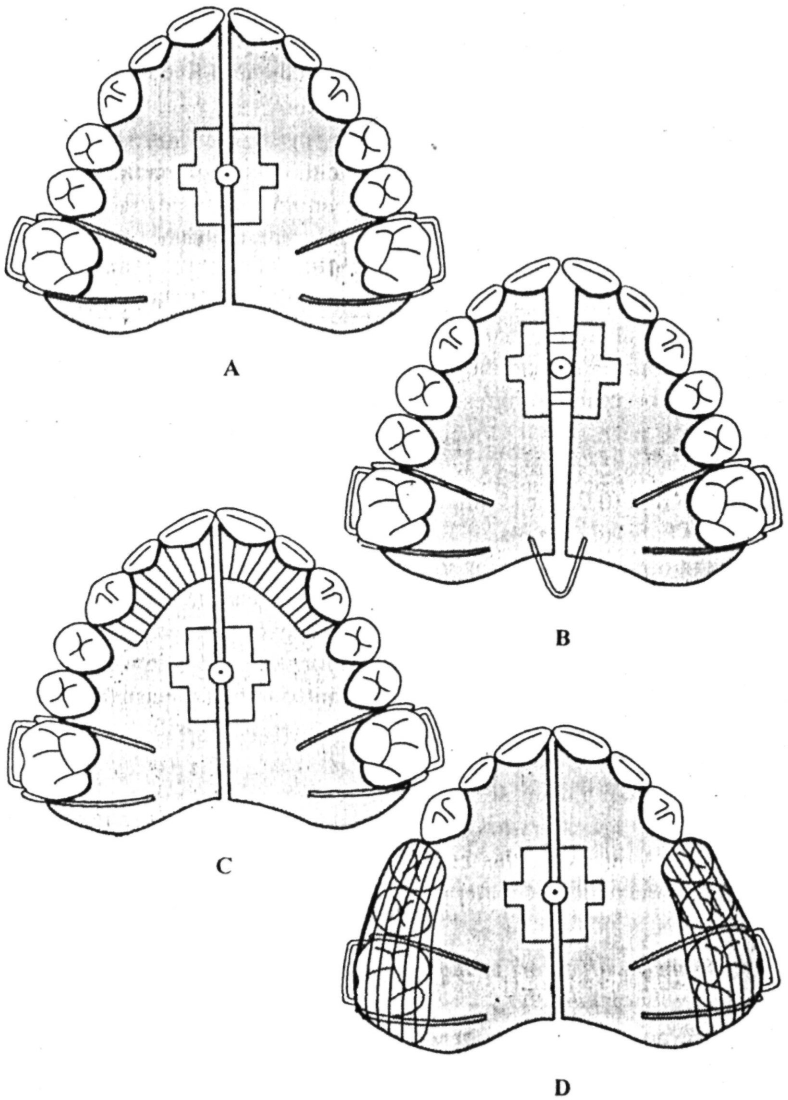


Fig. 106. Diagrams representing various types of lateral expansion appliance.
A Simple upper expansion appliance.
B Appliance to expand the arch anteriorly more than posteriorly.
C Appliance with flat anterior bite plane to disengage molars and premolars.
D Appliance with posterior half capping, to disengage the incisors.

middle, the two halves being united by a screw. When used in the upper arch the screw is placed in the mid-line with its axis set transversely. If used in the lower arch, the screw is placed in the mid-line lingual to the alveolar process of the incisor teeth.

The tooth movement achieved by this form of expansion appliance is symmetrical and of the same degree in the molar and premolar regions. Since malocclusions necessitating an equal expansion across the premolars to that across the molars are very rare, the use of this simple form of expansion appliance is equally rare.

However, it is not uncommon to find that, as part of a malocclusion, the upper dental arch appears V-shaped as a result of a greater degree of palatal tipping of the canines and premolars than of the molars, the narrowness becoming progressively less towards the last molar. It may therefore be necessary to widen the anterior part of the upper arch of teeth with a lesser degree of widening across the molars. In this case a loop of 0.7 mm (0.028 in) stainless steel wire unites the posterior borders of the two halves of the plastic base (Fig. 106B, page 171). According to the size of this loop, widening of the posterior part of the appliance can be limited or prevented altogether. If the screw can be accommodated near to the anterior part of the appliance it may be opened by the usual amount at each adjustment (one quarter turn). If the screw is placed further back, each adjustment should be limited to half the usual amount (one-eighth turn), as the anterior part of the appliance will widen more relative to the distal part.

The expansion plate is sometimes used where there is a crossbite. In such cases it is necessary to disengage the upper and lower teeth which are so related, otherwise the teeth in the opposing arch may be induced to move by the action of the appliance (Fig. 106 C, D).

(B) *Appliance with screw to move individual teeth or small groups of teeth buccally or labially*

The narrowness of the upper dental arch is not always symmetrical, the lingual inclination being sometimes confined to teeth on one side only. In order to move these teeth buccally or labially it is necessary to ensure that the anchorage is adequate and not reciprocal. It is certainly not possible to secure suffipient anchorage within one arch to move all the premolars and molars on one side of that arch at the same time. The teeth may therefore be moved in two groups with separate appliances. The teeth not being moved can then contribute to the anchorage.

(i) Appliance with screw to move one or two molars buccally: together with adequate cribbing, this appliance has a short labial bow (Fig 107 A).

The screw is placed transversely to the mid-line of the palate opposite the teeth to be moved. A flat-anterior bite plane disengages the posterior teeth. The plastic base should be trimmed away from the fitting surface over the mucosa, palatal or lingual to the teeth, to prevent the appliance from being driven into the soft tissues during expansion (Fig. 108B).

(ii) Appliance with screw to move premolars buccally: this appliance is similar to (i) but in cutting the plastic base it is important that the part to be moved should be slightly wedge-shaped with its base towards the teeth to be moved. (Fig. 107B).

(iii) Appliance with screw to move upper incisors labially: cases in which it is desired to produce this tooth movement are of two types; either they are cases in which the upper incisors engage the lingual surface of the lower incisors or they are cases of Class II, Division 2. In the former, it is advisable to disengage the incisors in order to correct a lingual occlusion. The usual method for accomplishing this is to extend the plastic base of the palate over the occlusal surfaces of the posterior teeth (Fig. 107C). This appliance carries modified arrowhead (Adam's) cribs (see page 190) on the first permanent molars, together with cribs on other teeth as thought necessary. The screw is set with its axis lying antero-posteriorly about a centimetre palatal to the upper incisors. It is important that the axis of the screw should lie parallel to the occlusal plane. The plastic base may be cut so that either two or four incisors arc engaged by the moving segment of the appliance. In using this appliance it must be remembered that, as the incisors move labially, they do so by tilting. Consequently the fit of the . appliance behind the incisors becomes progressively less good. Where progress seems to halt after an inadequate amount of incisor movement has been achieved, it can often be stimulated by closing the screw and packing the resulting space behind the incisors with cold cure acrylic resin.

(c) *Appliance with screw to move individual teeth or small groups of teeth in a distal or mesial direction (Schwarz appliance)*

In attempting such tooth movement it is more important than ever to ensure that anchorage is adequate, otherwise the reciprocal action of the screw will produce opposite movements of the remaining teeth. Therefore

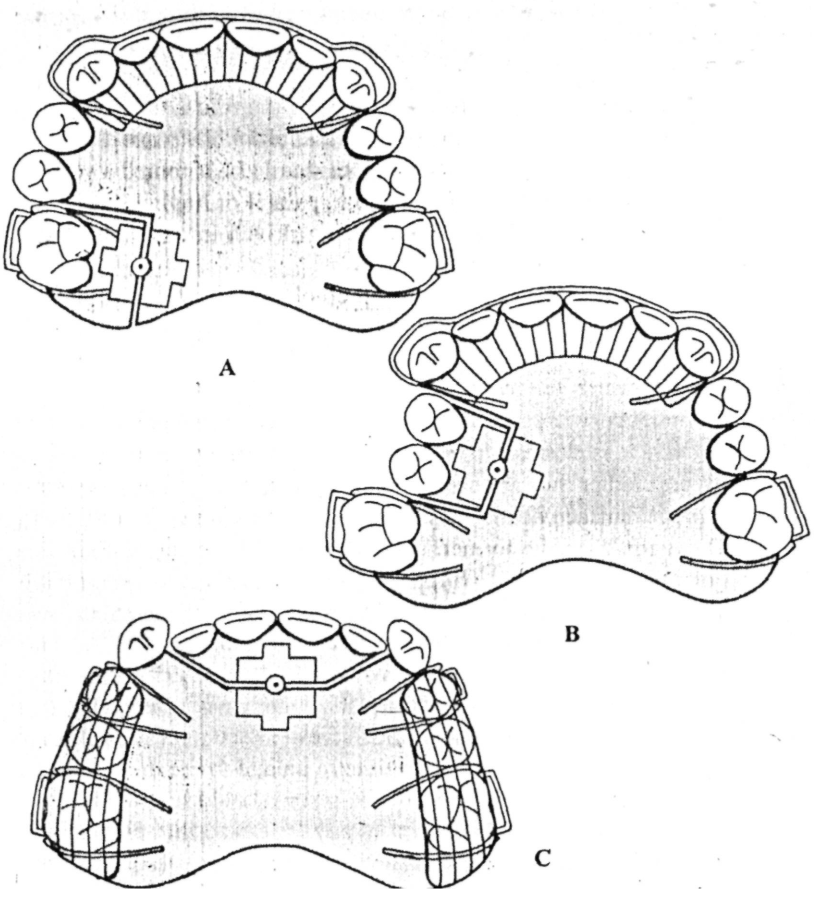


Fig. 107. Diagrams representing screw appliances to move upper teeth buccally or labially.
A Appliance to move one molar buccally.
B Appliance to move premolars buccally.
C Appliance to move incisors labially.

in all cases involving tooth movement in a distal direction the anchorage should be reinforced by means of an inclined plane and a labial bow. Furthermore, the number of teeth to be moved at one time should be limited. Only one side of an arch should receive treatment at any one time and, in the case of distal movement, the teeth should be limited to one molar or two premolars to be moved with any one appliance. Attention

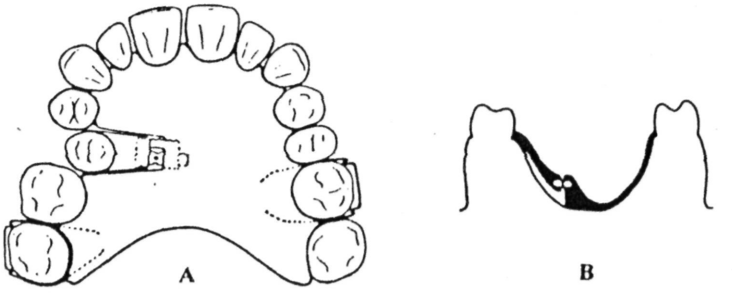


Fig. 108. Drawing of an appliance to move an upper premolar buccally (A). The ruling surface of the movable part is cut away as shown in the section (B), to avoid excessive pressure on the soft tissue. Similar bevelling should be made in the appliance depicted in Fig. 110 A, B.

to these restrictions is important if failures are to be avoided. (Where it is important that a greater number of teeth should be moved distally at any one time, extra-oral anchorage should be used as will be described later.)

Figs. 109 and 110 show the variety of distal and mesial movements of teeth which may be carried out using an appliance incorporating a screw. It will be noted that in each case the cribbing has been so arranged as to ensure that the anchorage is stable and that only the desired tooth movements will be attained.

The setting of the screw is important. Care should be taken in its alignment that, when opening, it does not drive part of the appliance into or away from the soft tissues. Consequently the axis of the screw should be parallel to the occlusal plane. Where premolar or molar teeth are to be moved distally the screw should be placed mesially to the tooth to be moved on the palatal or lingual side with the long axis of the screw parallel to the occlusal plane in one dimension, and parallel to the buccal surfaces of the molars and premolars in the other dimension. This is to ensure that, while moving distally, the tooth shall also follow the line of the arch. It should not move directly distally unless such movement is dictated by the nature of the malocclusion and, in which case, the setting of the screw is altered accordingly.

If there is any doubt about the stability of anchorage when moving upper teeth distally, extra-oral traction may be added to a removable appliance (Fig. 111). This has been made possible by Adams' development of the modified arrowhead crib, one of which will be required on a molar and a premolar of each side. It is especially suitable for appliance which include screws. For most purposes a cervical collar carrying elastics is

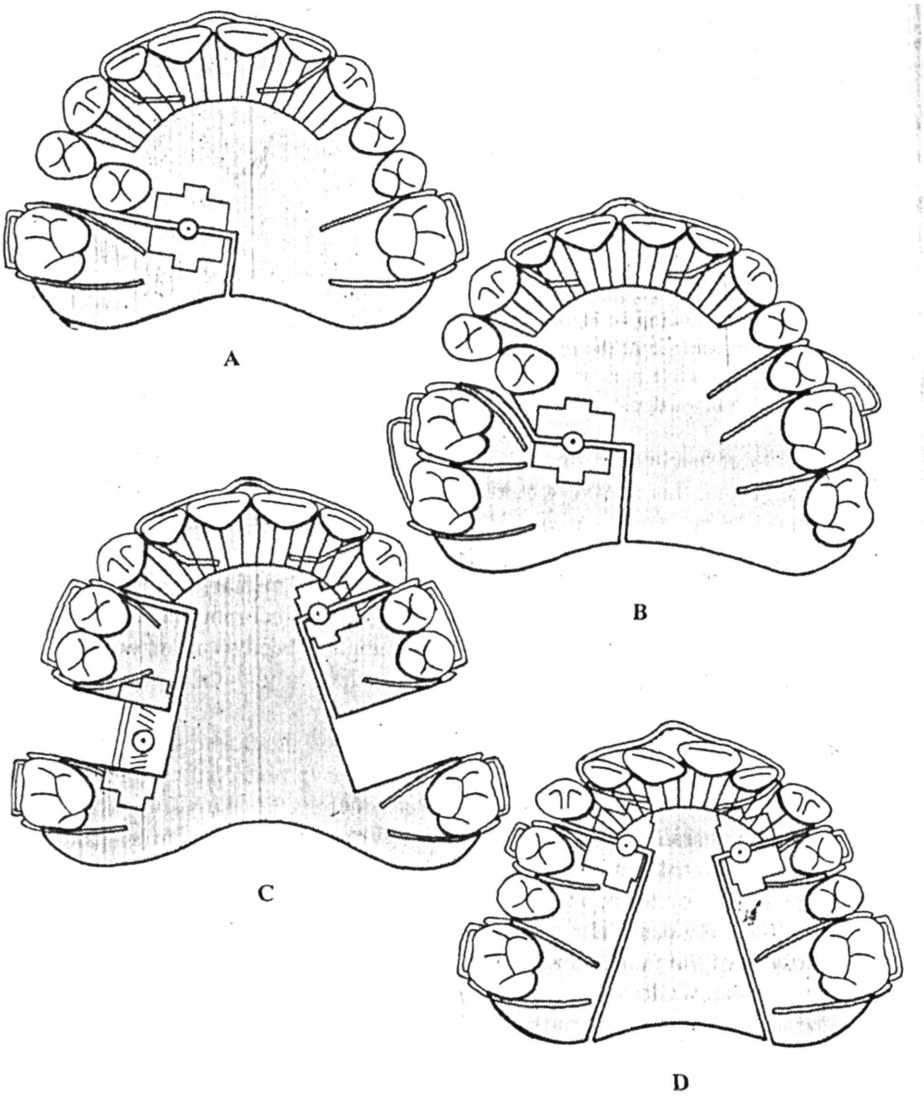


Fig. 109. Diagrams representing screw appliances to move the following teeth distally;

A An upper molar.
B Two upper molars.
C Two upper premolars.
D Upper molar and premolars.

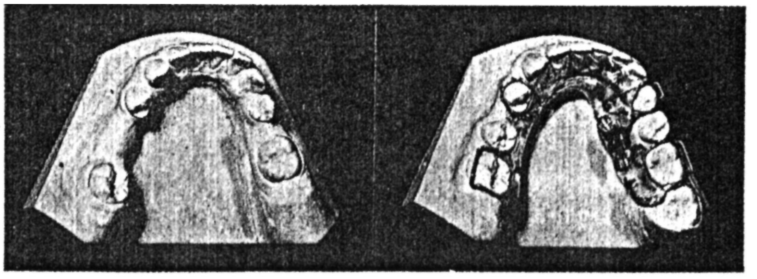


Fig. 110. Lower screw appliance used to move distally a lower right first molar.
A Before movement.
B After movement of molar and eruption of second premolar.

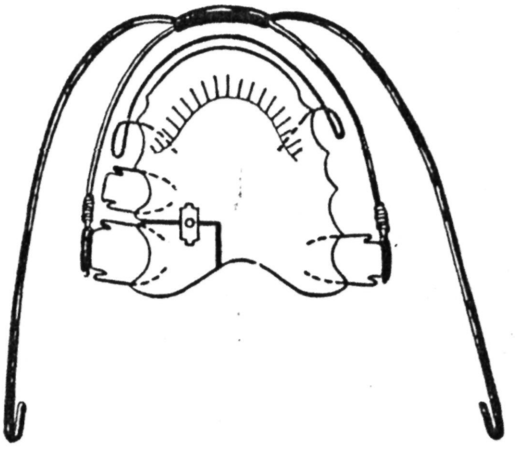


Fig. 111. Drawing of an upper removable appliance to which extra-oral traction is added for the reinforcement of anchorage. The whisker (extra-oral bow) is soldered to the intra-oral bow which in turn slides into buccal tubes soldered to the molar cribs.

adequate. These are attached to loops on the free ends of an extra-oral face bow ('whisker arch') in 1.25 mm, or 1.5 mm hard stainless steel wire which is soldered anteriorly to an intra-oral bow of 0.9 mm or 1.0 mm and which, in turn, fits into horizontal tubes soldered to the molar cribs. Friction stops near the distal ends of the intra-oral bow may be adjusted from time to time so that the bow does not bear upon the incisors. The extra-oral additions (face bow and collar) are worn throughout the

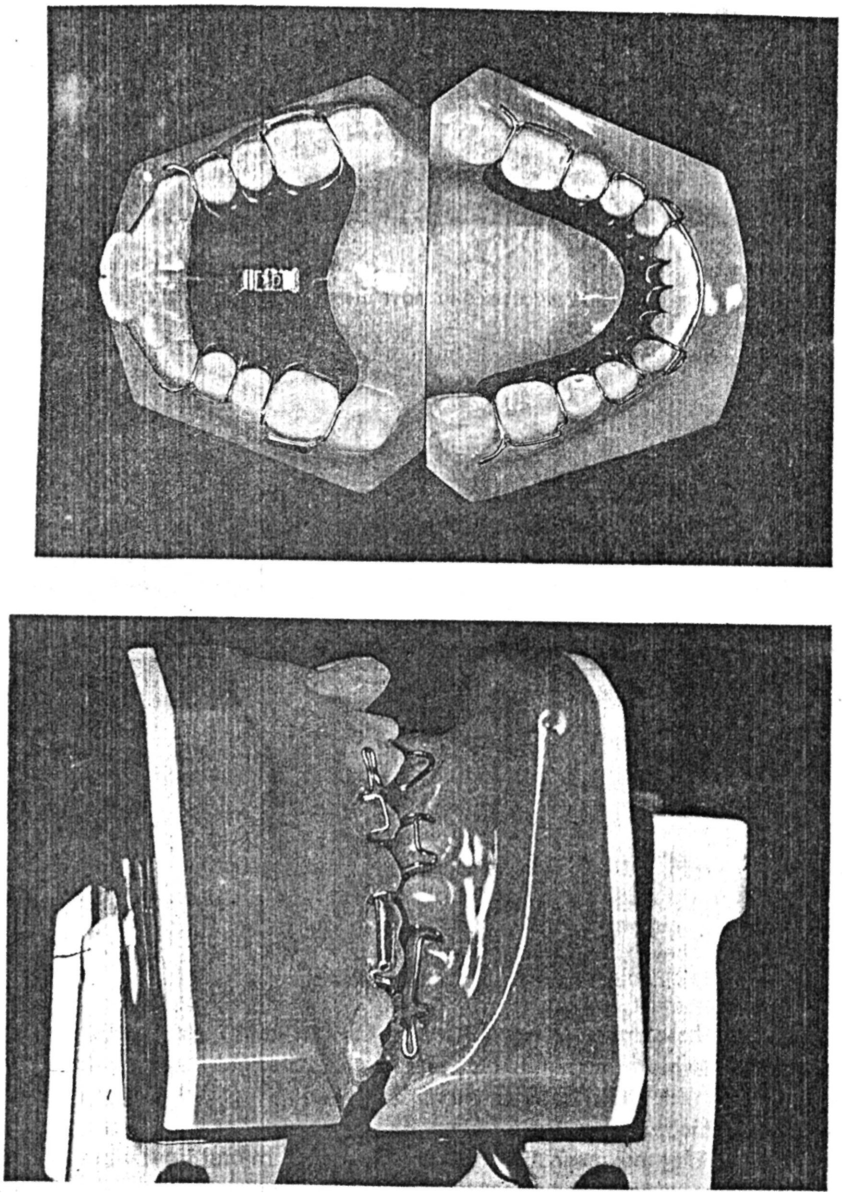


Fig. 112. Removable appliances using intermaxillary traction from elastics, to move upper molars and premolars distally.

night and for as much of the day as is reasonably possible. The removable appliance may be any of those already described for the distal movement of molars or premolars.

Serious injury to the face or eye can occur if a face bow with a sharp wire end comes loose from the appliance especially at night. Particular care should be taken with face bow design to avoid sharp wire ends by recurving that part which fits into the molar tubes and almost closing the elastics hooks. It may also be advisable to use a safety strap to prevent the face bow accidently coming out of the molar tubes.

1(is also possible to use either inter-maxillary or extra-oral traction as the only source of force in moving distally upper molars and premolars. Where intermaxillary traction is required upper and lower appliances are constructed, with modified arrowhead cribs on first premolars and first molars (Fig. 112). The upper premolar and lower molar cribs carry hooks for the attachment of elastics. In order that the buccal segments of the upper arch shall move outwards as well as backwards an expansion screw is incorporated.

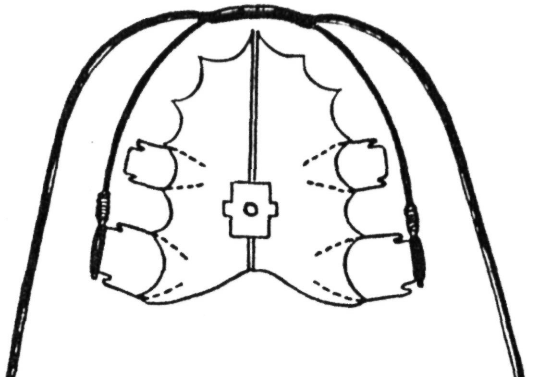


Fig. 113. Drawing of an upper removable appliance with extra-oral traction to move upper molars and premolars distally. An expansion screw is added to allow the buccal segments to move outwards as well as distally.

Provided that the patient can be persuaded to wear the extra-oral attachments for at least twelve hours per day, it is possible in selected cases to move distally the upper buccal segments by means of cervical

traction alone. A similar appliance to that used for intermaxillary traction, using four cribs and an expansion screw, is prepared (Fig. 113). Buccal tubes, soldered to the molar cribs carry the face bow.

REMOVABLE APPLIANCES WITH AUXILIARY SPRINGS

These consist of a plastic base with suitable cribs. The springs may be attached directly to the plastic base or they may be added to other wire attachments in the plastic base, e.g. a labial bow. The free end of the spring should be turned back on itself to form a small loop in order to avoid damage to the oral structures from a sharp end. Occasionally it is advantageous to secure the free end, for example by attaching it to a labial bow or sinking it into the plastic base. Hard drawn stainless steel wire is used in the construction of auxiliary springs.

Appliances of this nature can be divided into three types:

A. Appliance with auxiliary spring to move teeth labially or buccally.
B. Appliance with auxiliary spring to move teeth palatally lingually.
C. Appliance with auxiliary spring to move teeth mesially or distally.

A. *Appliance with auxiliary spring to move teeth labially or buccally*
Because the lingual surfaces of all the upper teeth and lower incisors are

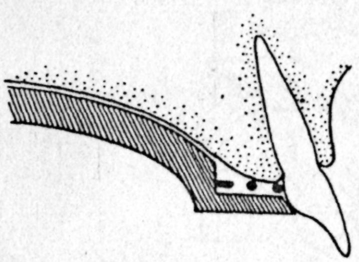


Fig. 114. Labio-lingual section to show how the spring illustrated in Fig. 115 could be boxed over.

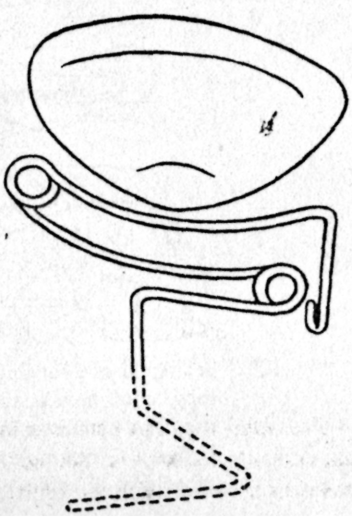


Fig. 115. Drawing of a Z-spring to move an upper incisor labially.

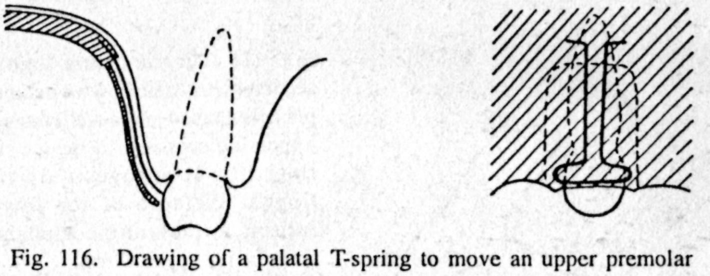


Fig. 116. Drawing of a palatal T-spring to move an upper premolar buccally.

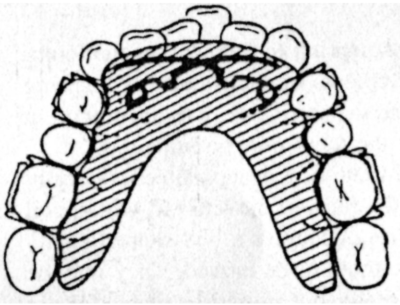


Fig. 117. Drawing of lingual cantilever springs for labial movement of lower incisors.

(i) Incorporating a 'Roberts' retractor' spring to move upper incisors palatally. This spring is bent from 0.5 mm or 0.6 mm hard stainless steel wire in the form of an inverted 'goal post' on the labial aspect of the upper incisors (Fig. 119). Each end of the goal post is bent as a helical

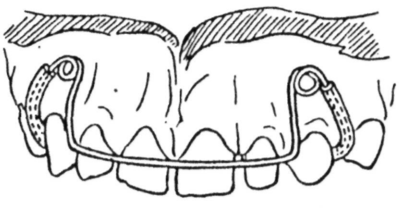


Fig. 119. Appliance for lingual movement of upper incisors (Roberts' retractor).

loop to lie flat to the alveolar process. Each end then enters a sleeve of 0.5 mm or 0.6 mm tubing which has been suitably embedded in the plastic base. These sleeves hold the distal limbs of the spring and prevent

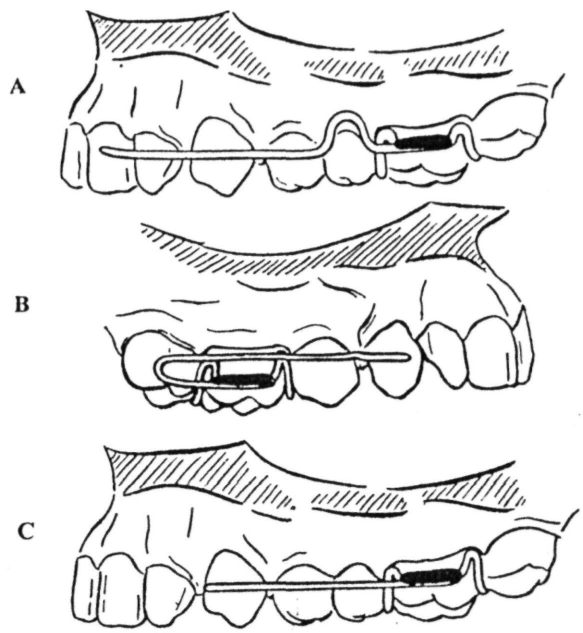


Fig. 120. A. Appliance for lingual movement of upper incisors. A long labial bow is split at the mid-line, each half being used as a cantilever spring in the horizontal plane.
B and C. Examples of cantilever springs for lingual movement of canines or premolars.

distortion as they emerge from the plastic base to pass round the distal side of each canine and upwards into the sulcus.

(ii) Incorporating a split labial bow to move incisors palatally or lingually (Fig. 120A). At times, when the patient is known to be careful with appliances, it is possible to modify the labial bow to retract incisors. For this purpose the ends of the labial bow should be attached to the acrylic just mesial to the first permanent molars. The bow is cut in the mid-line, bending back each end in the form of a small Loop, in order to use each half as a long cantilever spring. This has the advantage of simplicity and versatility but it should be adjusted with great care otherwise the central incjsors will tend to move at a greater speed and further than the lateral incisors.

There are several other types of appliances incorporating cantilever springs as shown in Fig. 120 which will move teeth palatally or lingually. Each has merits and some disadvantages. The importance of adequate anchorage is common to all types.

c. *Appliance incorporating springs to move individual teeth mesially or distally*

Such appliances arc commonly used to move premolars and molars.

A fmger spring is bent in the form of a long arm at the root of which is a coil with an internal diameter of about 3 mm where it emerges from the plastic base (Fig. 121). The spring should be attached to the plastic base at a point mid-way between the present position of the tooth to be moved and the position it should occupy when the movement is complete. This overcomes the tendency for the spring also to' move the tooth

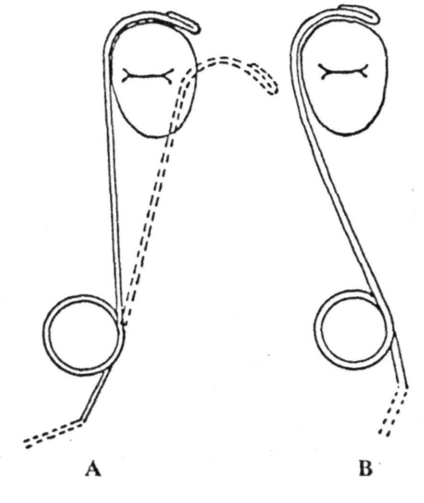


Fig. 121. Drawing of theincorrect (A) and correct (B) way to place a finger spring.

buccally or palatally. A guide wire may be added to protect the spring and prevent it from being lifted away from the plastic base (Fig. 122). Wherever possible the free end of the spring should be looped around a

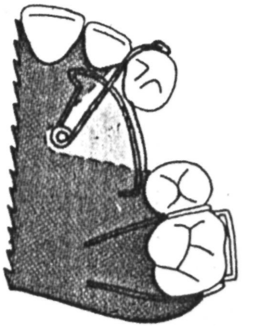


Fig. 122. The 'long' finger .spring to move an upper tooth distally. The tongue of wire parallel to the mid-line prevents the spring from being lifted away from the acrylic base.

buccal guide wire which may take the form of a labial bow (Fig. 123). This assists the patient to draw the spring away from the tooth when inserting the appliance and thus decreases the risk of damage or of altering the pressure applied. It is possible to incorporate more than one spring

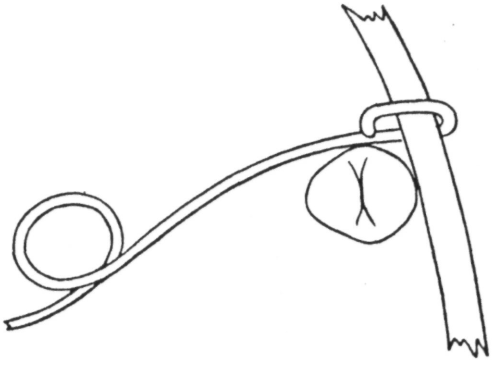


Fig. 123. The method of wrapping the free end of a finger spring around a long labial bow to facilitate correct insertion in the mouth and to avoid distortion of the spring. In order to allow the loop to slide freely along the bow it should be made oval in shape.

on an appliance provided the anchorage of the appliance is secure. The springs are made from 0.4 mm (0.016 in) hard drawn stainless steel wire.

It is not infrequently desired to move distally a canine that has erupted labial to the dental arch. In this situation the tooth is inaccessible to a

lingually placed finger spring. The spring shown in Fig. 124 overcomes the difficulty, and is simple to construct. A section of stainless steel tube may be placed over the root part of the spring to increase its strength. The spring passes from the plastic base, distally to the canine, to be bent

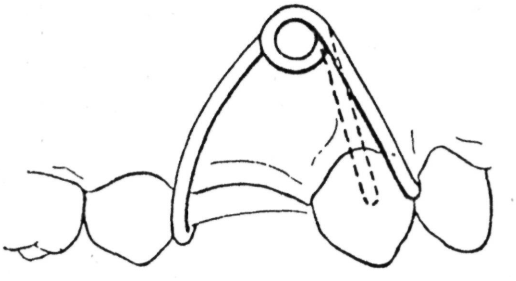


Fig. 124. Buccal cantilever spring to move an upper canine distally, as designed by Adams. The helical loop is inverted in this spring to avoid discomfort in the buccal sulcus.

in a loop which lies parallel to the alveolar process over the root of the canine. It is then curved downwards and forwards round the mesial surface of the tooth. It is activated by closing the loop; this is contrary to the usual practice and is done to make the spring less harsh to the soft tissues of the sulcus, so should not exceed 15 mm (5/8 in) in height, otherwise the tissues will be traumatised (see Fig. 132, page 194).

It is emphasized that the appliances which have been described represent only a small selection of those which have been designed by various operators to produce similar results. The reader will in turn develop his own preferences and, providing he observes the important fundamental factors in appliance design, he may be able to produce new ideas and so contribute to the armamentarium of orthodontists.

THE CONSTRUCTION OF REMOVABLE APPLIANCES WHICH INCORPORATE MECHANICAL AIDS TO TOOTH MOVEMENT SUCH AS SCREWS AND SPRINGS

For the preparation of removable appliances an accurate model of the mouth is required. The alginate impression materials give excellent reproduction for this purpose. It is recommended that the model be cast in artificial stone, as a plaster model may suffer considerable abrasion during the making and fitting of wire parts. The various cribs and wire parts are bent to shape and fitted to the model, screws are prepared and boxed springs invested in plaster. The appliance is then assembled on

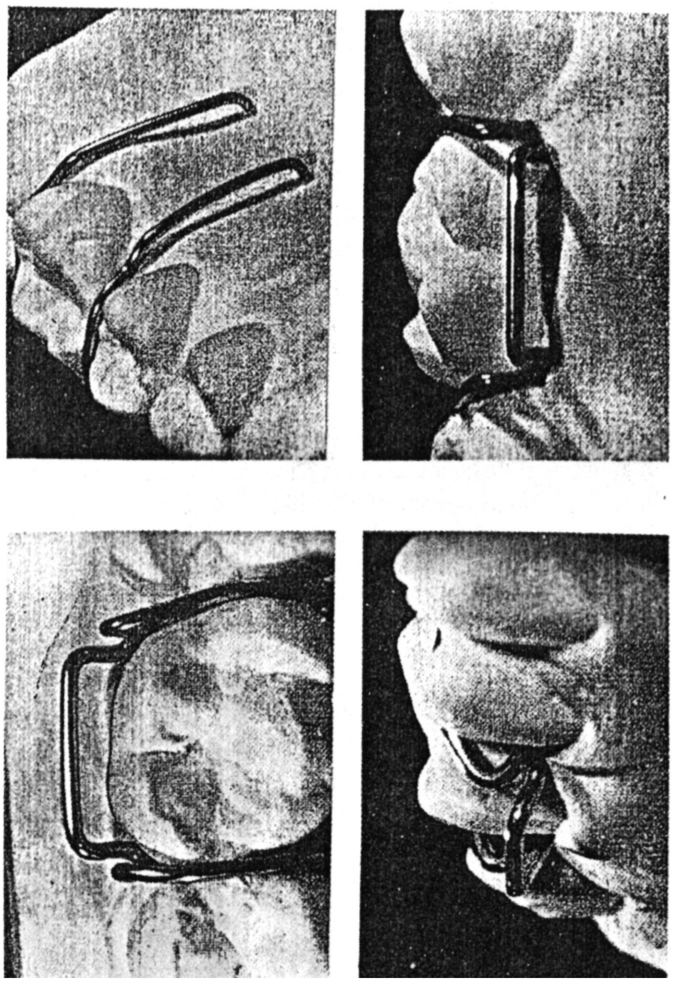
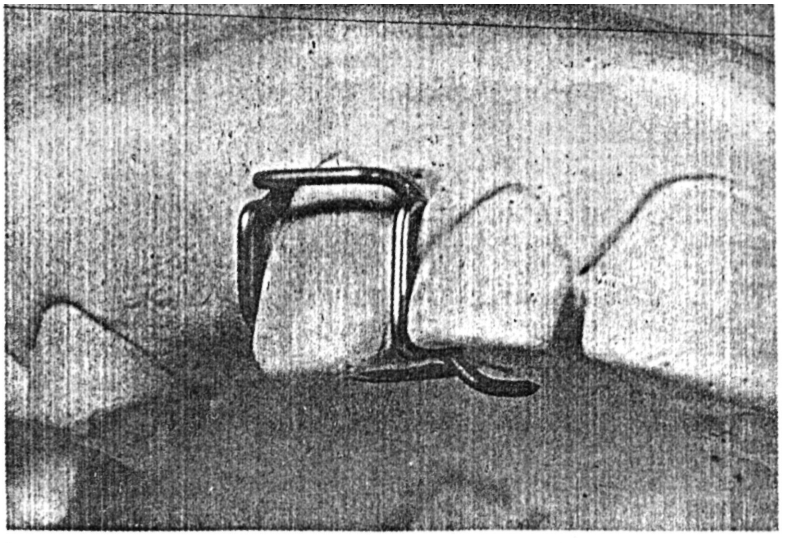
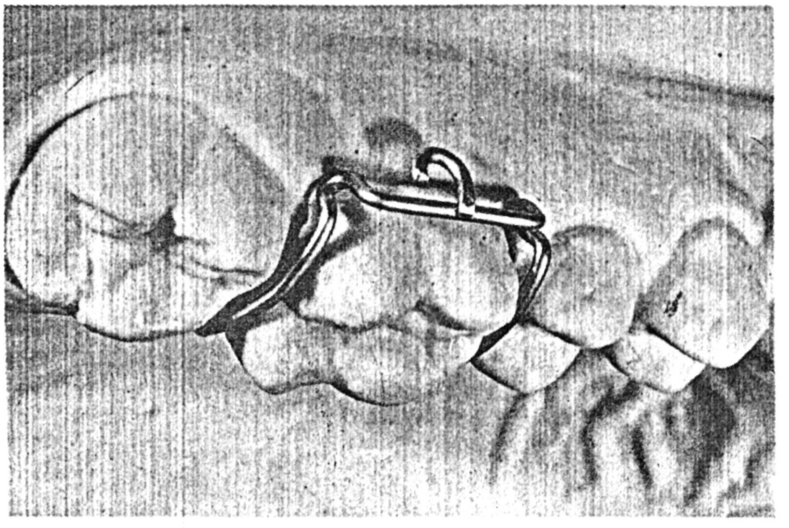


Fig. 125. The modified arrowhead crib (Adams or Liverpool crib).
(By permission of C. P. Adams and The Dental Record)

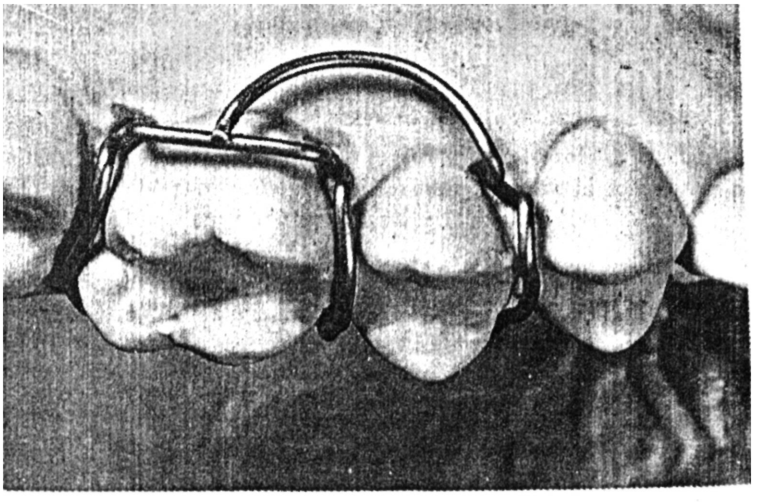


A



B

Fig. 126. Some variation in the modified arrowhead clasp:
A 0.6 wire clasp for an upper permanent canine.
B Welded or soldered hook for elastic traction.
C The accessory arrowhead clasp,



C

the model and waxed up, flasked and processed. The plastic base is smoothed and polished and, if necessary, cut to permit screws and springs to operate.

Wire Bending

The techniques for bending all wire parts are similar in principle. A general description of the techniques will be given, and the reader is referred to the excellent accounts of the technique which have been published elsewhere.

A suitable length of wire is cut off, allowing about one inch to spare at each end. The wire is straightened out by holding one end in the groove of flat beaked pliers, and running the thumb and forefinger along it. An approximately correct curve is put in the wire at the site selected for the commencement of manipulation, and this part of the wire is laid gently against the model. After adjustment, the length of wire that fits the model is marked off with a chalk or ink mark, and a further approximate curve is added in the next section of the wire. Care should be taken not to alter that pan which has been bent correctly. This is continued, marking off with chalk successive sections of the wire until the pan is completed. This technique may be used for wires which are to be closely adapted to the model, such as full and three-quarter cribs. In this case, however, the middle of the length of wire is selected as the starting point, and this is adapted to the buccal surface of the tooth.

Cribs

There are three types of crib now widely used:

(i) Adams' Crib (Modified Arrowhead Crib) (Figs. 125, 126). This most excellent crib, designed by C. P.Adams, is in almost universal use. It is a full crib designed to engage both the mesial and distal buccal angles of a molar or a premolar. For full details of the construction of this crib the reader is referred to the description by C. P. Adams in his text, 'The Design and Construction of Removable Appliances'

(ii) The Southend Clasp (Fig. 127) is unobtrusive and very effective on, upper central incisors and is fully described by Stephens, 1979.

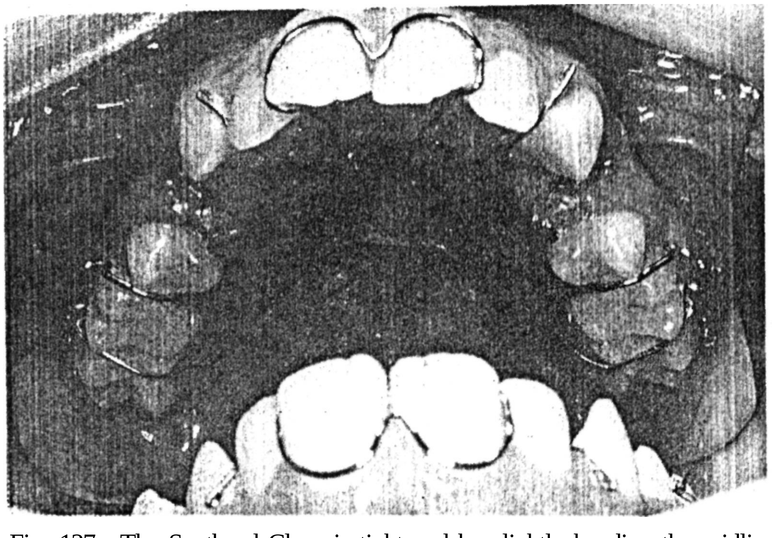


Fig. 127. The Southend Clasp is tightened by slightly bending the midline spur towards the palate.

(iii) The Three-quarter Clasp ('C Clasp) (Fig. 128) has the normal purpose of preventing the migration of a tooth but it may also assist in anchorage. The wire for this clasp is bent so that it engages the crown of the tooth buccally between its most bulbous circumference and the gingival margin either mesially or distally as required. This crib is usually made from 0.7 mm hard drawn stainless steel wire of which the free end is rounded or flattened.

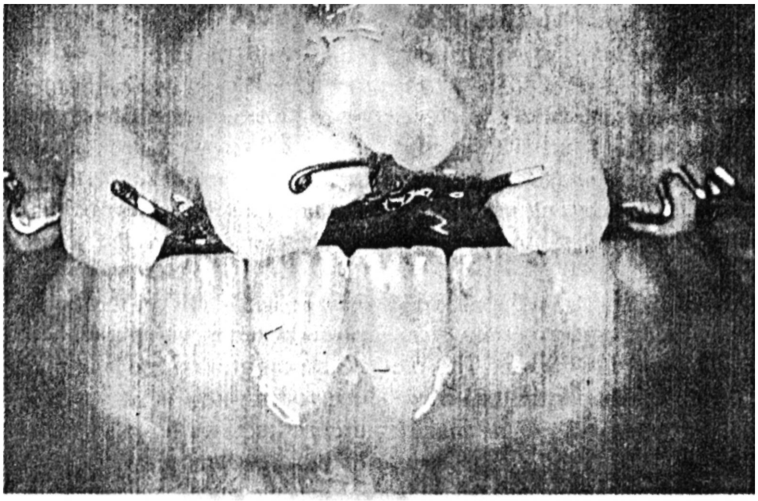


Fig. 128. 'C Clasps preventing mesial movement of upper lateral incisors.

Attachment of Springs

Springs may be attached to either the plastic base or a labial (facial) bow. In the former case it is sometimes convenient to accommodate part of the spring in a box cavity in the fitting surface of the plate (Fig. 129). There arc several ways in which springs may be attached to a bow. The most usual method is to wrap the spring wire round the bow; it is necessary to wrap it round two adjacent sections of the bow that are bent in different

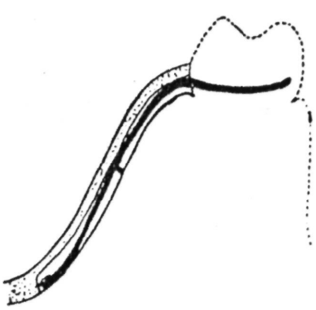


Fig. 129. Finger spring in box on the filling surface of a removable appliance.

planes. In order to wrap the spring wire, the bow wire and the spring wire are seized side by side in the grooves of the flat beaked pliers, each wire lying in a groove (see Fig. 151, page 214). The spring wire is bent at a right angle to the bow; and is then wrapped round the bow wire. If a

sliding noose is to be made, after wrapping the wire it is unwrapped by one half-turn to release the noose a little.

Investment of screws in plaster for processing into the plastic base

Either large or small screws may be selected for each case. Sometimes it is necessary to reduce the size of even the small screws to accommodate them in the appliance. In the case of the Glenross type of screw, the bulk may be reduced by cutting off one of the guide-pins.This docs not impair, materially, the strength of the screw and is done before the screw is invested.

In order that the adjustable part may be accessible in the finished appliance, the central section of the screw is boxed in with plaster before being mounted in the wax. This prevents access of wax, and later plastic material, to this part of the screw. The invested screw is shown in Fig. 130. More recently some manufacturers of screws have supplied a protective jacket for the centre section of the screw. This prevents seepage of wax round and into the thread and boss of the screw. A simple plastic former may be constructed in acrylic resin which is removed after the waxing up is completed.

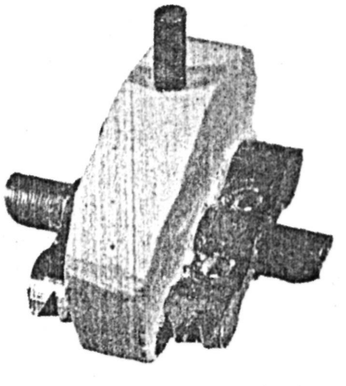


Fig. 130. Expansion screw invested in piaster of Paris, preparatory to being mounted on the model.

Waxing up and finishing the appliance

Wax is applied to the model and trimmed to shape. The wire parts are warmed and pressed into position in the soft wax. Screws are then

mounted, care being taken that the inclination of their axes is correct. If a bite plane or capping is necessary this is now added at this stage. The wax is smoothed and the edges are sealed and trimmed. Flasking and packing of these appliances varies a little, but is very similar to the method used for partial plastic dentures. After the appliance has been processed it is removed from the flask and finished in the usual way. The edges adjacent to the teeth are shaped to a shallow edge so that the

A B C

Fig. 131. Diagram to illustrale the need for trimming the filling edge of a removable appliance to a very shallow margin.
A Denture for an adull, correctly trimmed.
B Orthodonlic appliance for a child, incorrectly trimmed.
C Orthodontic appliance for a child, correctly trimmed.

plastic base fits each tooth only round its neck (Fig. 131). In a child the teeth are not fully erupted; the bulbous part of each tooth is therefore little more than a millimetre or two above the gingival margin. Because the forces exerted upon the appliance are transverse to the axes of the teeth, adequate fixation in the mouth is essential.

Failure to shape the fitting edges correctly causes the appliance to be displaced from the teeth. If screws are incorporated, the plastic base is cut with a fret-saw into segments. The edges where the appliance has been cut are bevelled and the appliance is polished.

FITTING REMOVABLE APPLIANCES

It is necessary to observe the following procedures when fitting a removable appliance:

(i) Check that the design previously described has been carried out.
(ii) Check any roughness of the fitting surface,
(iii) Carry out any adjustment to the acrylic base to ensure that the fit is adequate,
(iv) Adjust any springs and test the functioning of any screws,
(v) Make a final adjustment to perfect the fit of the cribs.

MANAGEMENT OF REMOVABLE APPLIANCES

Instructions

(i) Having confirmed that the appliance fits the mouth satisfactorily it is necessary to give the patient instruction in the insertion and removal of the appliance. It is especially important that each spring should he placed on the correct side of the tooth in order that only desired tooth movement will occur. This is best accomplished by demonstrating the insertion of the appliance to the patient with the aid of a mirror. When the patient has mastered this process the parent is invited to watch the demonstration. Subsequently the patient should be asked to remove the appliance and replace it correctly.

(ii) Clear instructions should be given to the patient and to the parent regarding the wearing of the appliance. If necessary these may be given to the patient also in writing. It is recommended that most appliances should be worn both by day and night.

(iii) After every mealtime and before retiring, the appliance should be removed for cleaning. For this, soap and water or toothpaste with a small brush should be used and the patient's teeth cleaned at (the same time. Care should be taken not to bend or dislodge any of (he wires on the appliance during this process.

(iv) Where the patient is expected to undertake adjustments himself, as in the case of screws, it is necessary to give very clear instruction. concerning the frequency of adjustment and a demonstration of the method. Such adjustments are usually made at the beginning of the day so that any stiffness may subside before bedtime.

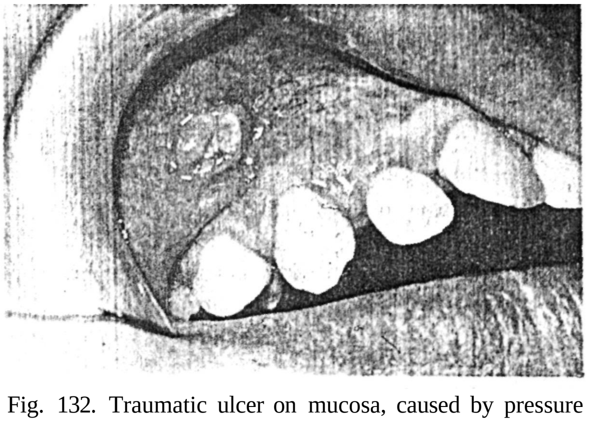


Fig. 132. Traumatic ulcer on mucosa, caused by pressure from a canine retractor in the sulcus.

(v) The patient and the parent arc warned to return immediately should there be any difficulty with the appliance. Parents may occasionally be quite unaware that a small child is suffering acute pain where an appliance is incorrectly worn or adjusted (Fig. 132).

It is most important that the appliance should not be left out of the mouth for a lengthy period nor placed without protection in a pocket. For any appliance to be worn at night only, a small carrying box should be provided.

Limitation of the appliance at each return visit

(i) It is important immediately the child enters the surgery to enquire whether the appliance has been comfortable, for this will determine whether the appliance has been worn consistently, and in accordance with instructions.

(ii) The appliance should be examined to confirm that it has been worn correctly. The patient is asked to remove the appliance so that it may be examined for facets or wear upon the acrylic, or even breakages. By asking the palicnl to replace the appliance, an opportunity is afforded for observing whether the patient has mastered easily the technique ('or managing the insertion of his appliance. Obvious difficulty in accomplishing this and a high polish on the surface of the appliance suggests that it has not been worn consistently.

(iii) It is necessary to examine the amount of movement that has been accomplished by the appliance. It should be remembered that failure of the anchorage may produce an initial appearance that movement has occurred. In order to confirm that the anchorage itself has remained stable, it is necessary to compare the occlusion with that of the plaster study models. In cases where distal movement of teeth is being undertaken an increase in the incisor ovcrjet would suggest that anchorage is failing and should therefore be reinforced. It is important to confirm that no part of the appliance has interfered with the planned tooth movement, or prevented normal developmental changes from taking place. Eruption of permanent teeth under the appliance would prevent a satisfactory fit.

(iv) The soft tissues beneath the fitting surface of the appliance should be examined in case some soreness has developed. Failure to observe strict oral hygiene may be the cause of inflammation of the mucous membrane or cervical caries around the teeth.

(v) Having given any further instructions that may be required it remains only to arrange the date of the next appointment. For most practical purposes, visits are arranged at four-weekly intervals.

FUNCTIONAL APPLIANCES

As opposed to the active treatment of malocclusion by mechano-therapy, functional therapy employs natural forces derived from the facial and masticatory musculature. This may be accomplished either by the use of certain muscle exercises or by means of an inert appliance transmitting the influence of muscle activity to the teeth to be moved.

A. P. Rogers who pioneered the field of myo-functional therapy maintained that it is possible, by the use of repetitive muscle exercises, lo establish a more favourable environment of muscle behaviour for improving occlusion. This implies a form of treatment which goes beyond (he guidance of muscle forces to effect tooth movemenl, namely the establishment of a belter pattern of behaviour. Although none will doubt the desirability of this, few have achieved as much success with this form of treatment as Rogers. Difficulty in supervision and in persuading patients to repeat the exercises sufficiently frequently may account for many of the failures.

Although it is possible that functional appliances may at times influence the behaviour of the oral musculature, the objective in using them is usually more modest. The appliance is designed in such a way that it guides forces arising from muscle activity to exert pressure upon a tooth or teeth to effect its movement. It is likely that these appliances often stimulate by their presence an increase in muscle activity; this is clearly desirable and may continue even during sleep.

APPLIANCES USED IN FUNCTIONAL THERAPY

(a) *Inclined Plane Incisor Capping*

This is the simplest of the functional appliances. It is more frequently used on the lower incisor teeth and covers them with a sloping platform in such a manner that a lingually inclined or lingually displaced upper incisor, impinging on the sloping surface during activity of the muscles of mastication, is impelled forward into correct occlusion (Fig. 133).

The capping may be processed in acrylic resin or cast in silver casting alloy, and is cemented to the lower incisors. (If the lower molars are present a removable appliance may be used as a base upon which to build the capping (Fig. 134). Occlusal rests are required in addition to the molar cribs, and a short labial bow eliminates the need to extend acrylic over the labial surfaces of the lower incisors). The capping can be shaped to engage one or more of the upper incisors and should be kept as thin as possible over the labial surface of the lower incisors. Inclined plane incisor capping is of value in young patients whose

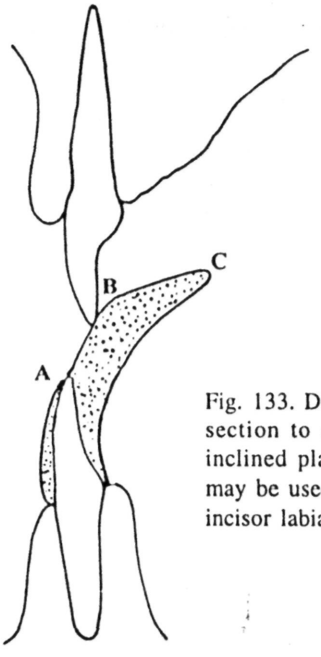


Fig. 133. Diagrammatic sagittal section to show how a lower inclined plane incisor capping may be used to move an upper incisor labially.

permanent molars have not yet erupted but who have had the misfortune to have their deciduous molars extracted and have lost all molar occlusal contact. In such cases it is often impossible to obtain fixation and anchorage for a removable appliance carrying springs or screws, and incisor capping may achieve the correction of the incisor relations so essential for the proper course of development.

Certain precautions must be observed when employing inclined plane incisor capping. The posterior teeth may become elevated and appear to over-erupt if they do not have occlusal contact and, when the capping is removed, 'gagging' of these teeth may produce an anterior open-bite with lack of the incisor overbite essential for the retention of the upper incisors in their new position. Although the position of the molar teeth may relapse within a few days, so may the new position of the upper incisors and a return to the original malocclusion may ensue. For this reason, unless the capping is successful within two or three weeks, it should be discarded in favour of some other form of treatment. Care must also be taken to ensure that, when the capping is in position, the child does not indulge in the habit of thrusting the mandible forward to engage the capping against the labial surface of the upper incisors. Space

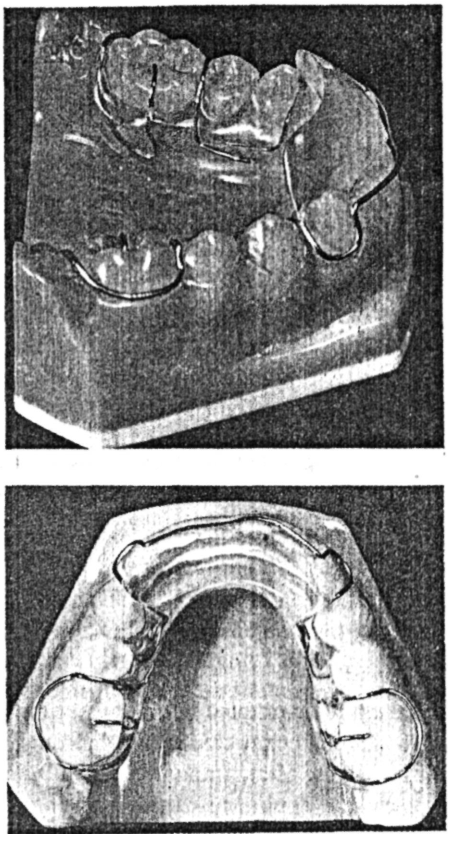


Fig. 134. Removable lower inclined plane incisor capping to move upper incisors labially. The labial bow prevents distal displacement of the appliance.

must exist in the arch for the teeth which it is desired to move by using this appliance.

(b) *The Oral Screen*

This is a sheet of acrylic resin which is worn usually at night inside the lips and outside the teeth (Fig. 135).

It can be used to move incisor teeth in a lingual direction, the force being obtained by harnessing the cheek and lip muscles (Fig. 136, 137).

Its use should be limited to cases where proclination of upper incisors

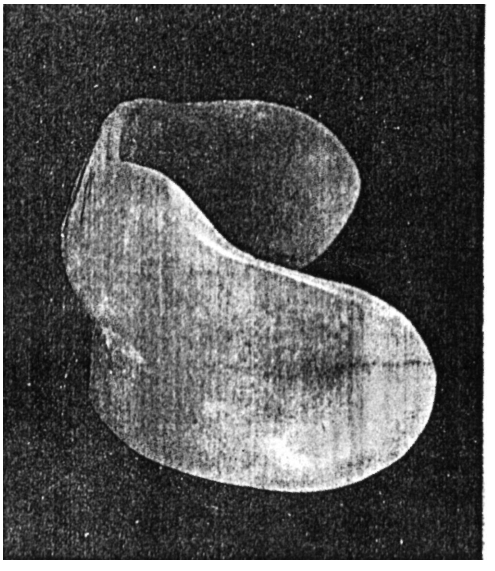


Fig. 135. Oral screen

is accompanied by spacing. Strong lip activity or a tongue thrust behind these teeth are contra-indications because of the danger that the teeth may be subject alternately to opposing forces. The oral screen prevents drying of the gingival margins and is of advantage when there is an anterior marginal gingivitis.

Method of Construction. Impressions must be taken carefully and must include all tissues to the buccal fold. The models should be articulated according to the patient's centric occlusion (in certain cases the lower may be advanced a little where it will help in the construction of the screen). Wax is then added to the models where relief is necessary, such as in front of the lower anterior teeth where there is an excessive overjet, and also along the buccal sides of the cheek teeth to present a smooth surface. In double thickness of wax, a screen is then constructed so that it extends well to the limits of the buccal fold as seen on the models, allowance being made for the frcnum and any large muscle attachments. The screen is then processed, preferably in clear acrylic so that any pressure spots on soft tissue can readily be seen through the finished screen. Both sides of the screen should now be smooth except for the area over the incisor teeth to be moved lingually, which side should show indentations formed by the crowns of these teeth.

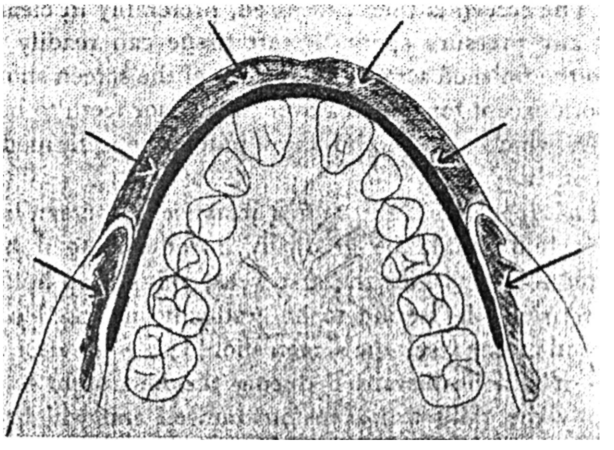


Fig. 136. Diagrammatic horizontal section of oral screen to show how upper molars are relieved of lingual force which is concentrated upon the incisors.

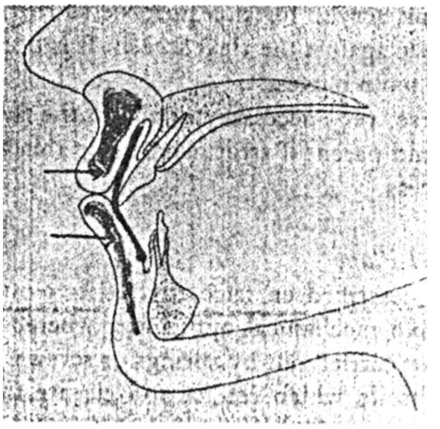


Fig. 137. Diagrammatic sagittal section of oral screen to show how lower incisors and soft tissues are relieved from lingual pressure.

Method of Application. In the first instance the screen is passive and the child should be gradually introduced to it by being instructed to wear it, for the first week, only for an hour or two before retiring, the period to be gradually increased each day. By the end of one week the screen should be worn after retiring. Perhaps it will be discarded during the

first night or so, but eventually the child will accustom himself and will be able to maintain the screen without trouble. When this stage has been reached the screen should be padded out slightly over the teeth to be moved lingually. This is done by adding a small quantity of quick-setting acrylic to the indentations on the inside of the screen. Experience will show exactly how much to add and it is wise to use pink acrylic for this purpose as the amount added can easily be seen against the clear screen. It is best to add a little at a lime as the tooth moves.

It is, of course, very necessary to obtain the full co-operation of both child and parent if treatment, using this appliance, is to meet with success.

(c) *The Inclined Plane*

This has been described on page 151. It is frequently added to upper removable mechanical appliances where, in addition to tooth movement carried out by springs or screws, it is desired to harness the muscles which retract and elevate the mandible in order to reinforce the anchorage of the upper appliance. It may also have the effect of tipping the lower incisors labially (sec Fig. 95, page 154).

(d) *The Activator of Andresen ('Norwegian Appliance')*

This is an example of an appliance which is passive in itself and serves to transmit forces generated by the oral and facial musculature (Figs. 138, 139). It is used to alter arch relations, probably by moving teeth in the alveolar processes. Its principal use is in the treatment of Angle Class II cases of malocclusion.

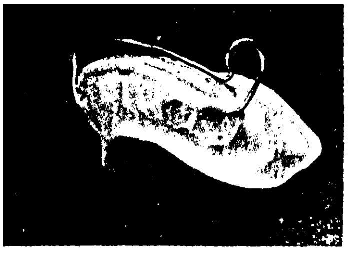


Fig. 138. The Activator.

In order to facilitate the reduction of post-normal occlusion it is necessary for satisfactory occlusion of the two arches to be possible, when in a neutral position antero-posteriorly. This may be ascertained by protrusion of the mandible so that the antero-posterior relationship of the teeth is normal. Alternatively, the ability of the two arches to occlude

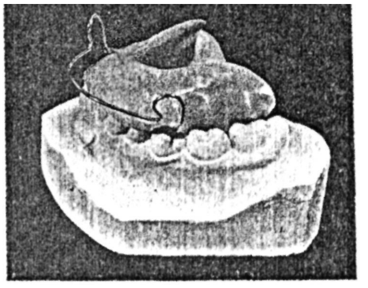


Fig. 139. Activator on model.

in this optimum position can be judged by advancing the lower model in relation to the upper. An interference with normal occlusion will become obvious and should be corrected by other apparatus before the Activator is used. The interference usually takes the form of narrowness of the upper arch, which may be corrected by expansion with a screw appliance. Occasionally lingual inclination of a lateral incisor may require correction.

The Activator resembles an upper and lower plastic base joined together and, in the treatment of post-normal occlusion, it is made to a bite taken when the mandible is slightly protruded. The construction and use of the appliance in the treatment of post-normal occlusion will be described in detail, as the proper construction and trimming of the appliance are important requisites for achieving success with its use.

Indications for using the Activator

The Activator is better suited as a means of effecting changes in occlusion of the whole arch than for the movement of individual teeth. It is at its best when used for the treatment of certain types of Class II, division 1, malocclusion. Because it is fundamentally similar to intermaxillary traction in its effect on the bone, it must be expected that forward movement of lower teeth will occur even when they remain splinted by the appliance. It is necessary, therefore, to exclude those cases where there is firm resistance to labial movement of lower incisors by a tight lower lip. Ideally there should be some spacing in both arches, either because they arc of very ample size or because teeth have been extracted.

It is at its most valuable in the treatment of Class II, Division 1 cases which suffer rampant caries or severe chronic gingivitis. The extraction of all four first permanent molars from a Class II case of ten years of age leaves so few permanent teeth that the Activator is perhaps the only

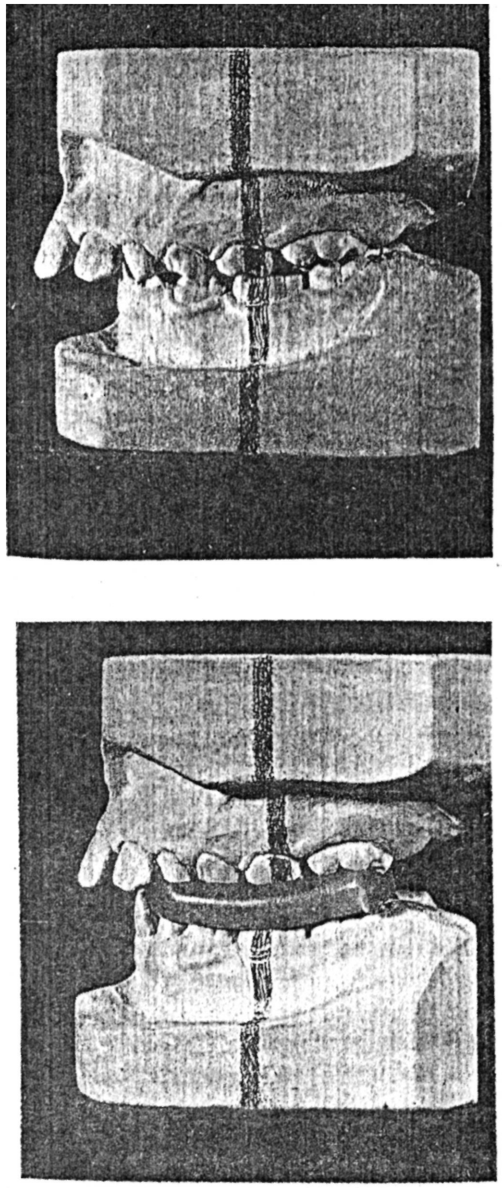
appliance that can be used before eruption of the second molars. Some operators recommend the extraction of the upper second molars especially where crowding is present and maintain that this shortens the treatment time for this appliance.

Construction of the Activator

(i) Impressions and Models: Artificial stone models should be made from accurate impressions taken with a suitable material. These models are oriented to the mandibular position, for which the appliance is to be made, with a wax bite registration.

(ii) Wax Bite Registration and Orientation: This has to be obtained with the lower dental arch forward in what might be regarded as an optimum relation to the upper and representing a more normal relation. After casting and basing the models a bite block is prepared on the upper model. A shellac base is moulded to the palate and occlusal surfaces of the molars and premolars, and a wax bite rim is added. At the next visit the bite block is tried in the mouth without warming the wax which is pared down until it occludes with all the lower teeth. Further trimming may be required to allow protrusion of the mandible to a forward bite. This bite is registered on the *cold* wax, which is then warmed a little before the final closure. The use of shellac bases can be avoided if a really tough wax containing a high proportion of beeswax is used. With a roll of this wax, softened on the surface, it is possible to obtain a bite with the dental arches in optimum relation and also to remove this wax bile from the mouth without distortion. It is not possible to do this satisfactorily with ordinary pink modelling wax.

The forward positioning of the mandible can be facilitated by placing a thumb over the labial surface of each upper central incisor and, at the same time, engaging the middle finger of each hand behind the angle of the mandible so guiding the mandible into the optimum position. At the same time, care should be taken to ensure that the centre lines of the upper and lower incisors coincide, unless a deviation of a centre line to one or other side of the arch already exists. The optimum position for the mandible during registration is best judged by an examination of the cuspal relations of the upper and lower posterior teeth as viewed on the buccal aspect. Though the teeth are kepi apart by the wax rim, the horizontal (mesio-distal) relations should be approximately normal (Fig. 140). In this position, the patient is encouraged to bite into the wax, maintaining this horizontal (mesio-distal) relation of the arches, until the upper and lower premolars are 3-4 mm apart. (Note: Where the post-nomral occlusion is extreme, it is better to construct two or more



A

B

Fig. 140. A Centric occlusion marked on the model.
B Models with wax bite registered in optimum position.

successive Activators in stages rather than to risk the danger of mandibular subluxation by 'jumping' the mandible forward too great a distance at one attempt).

To check the bite the wax bite block should be replaced on the upper model and then occluded with the lower model. Any wax which has impinged upon tissue other than tooth should be removed as it is likely to falsify the bite. This is most likely to occur distally to the lower molars. The block is then scaled to the lower model with a little pink wax. It is most important that the upper model should not be left in occlusion with tlic block until it is to be articulated, lest its weight causes a closing and distortion of the bile.

The models, together with the wax orientation, are then mounted on an articulator (Fig. 141), preferably one from which the models can easily

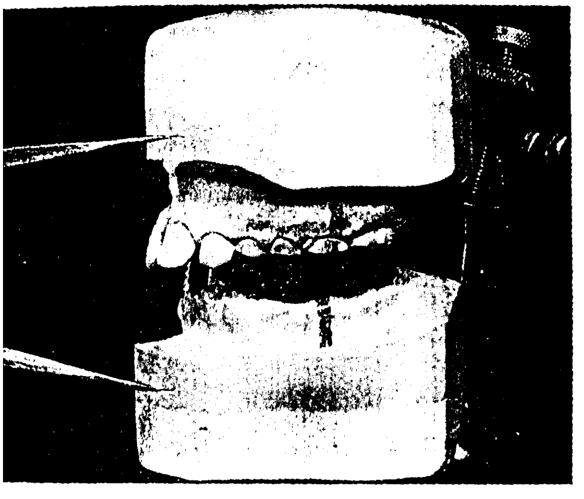


Fig. 141. Checking height with dividers.

be removed and replaced. It may be found more convenient, for waxing up the appliance, to mount the models on the articulator 'back to front' to permit easy access to the lingual surface of the teeth. Marks are now made on the upper and lower models and the height registered with callipers (Fig. 141). This measurement should be preserved and used for checking at subsequent stages in the construction; it can be conveniently recorded on the base of the lower model. The wax bite registration should be preserved with the models,

(iii) The Labial Bow: This may be constructed in 0.8 mm (0.030 in)

hard stainless steel wire, though a slightly heavier gauge may be preferred. It should carry adjustable loops and should be so shaped that it will ultimately enter the acrylic on each side at a point midway between the upper and lower teeth and just distal to each upper canine, thus removing any chance of the point of entry interfering with the teeth (Figs. 142, 143).

(iv) Waxing the Models: The upper model is removed from the articulator and dusted with French chalk. A sheet of good quality wax is softened and applied to the model with the fingers. It should cover the palatal surface of the model and the lingual and occlusal surfaces of the teeth.

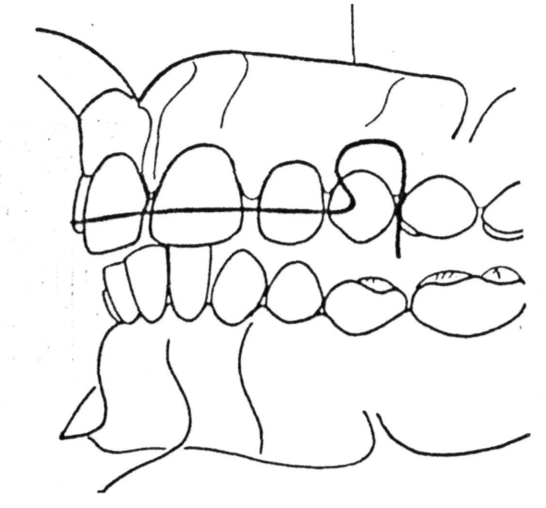


Fig. 142. Correct position of the labial bow.

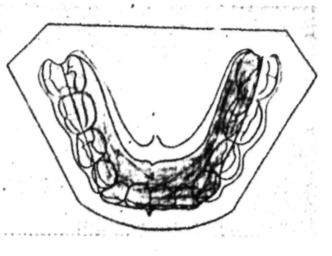
bcmg pressed well into the rugae, cervical margins and occlusal surfaces (Fig. 143). (This is very important as the appliance is to be processed off the model and an extreme degree of accuracy in waxing up is therefore essential. Unless this can be assured, it is useless to continue with the construction). Only one thickness of wax sheet is used and any discrepancy in the adaptation can be noticed on the inner surface of the wax where the French chalk has not adhered to it. The labial bow is then fixed carefully in position. Wax is similarly applied to the lower model in double thickness (Fig. 144).

The height of the articulator is carefully checked and a roll of good quality wax softened and pressed between the two wax plates from the buccal side, the two plates being sealed together with a hot wax knife.

Similarly, a roll of wax is pressed from the lingual side in order to leave plenty of space for the tongue. The wax should be carefully smoothed on the lingual side. The height is then checked for the second time (Fig. 145).

Fig. 143. Wax form on the upper model.

Fig. 144. Wax form on the lower model.



(v) Processing: The wax form is removed from the models and processed after being invested at an angle in a deep flask with the convex side down, the reverse forming a plug on the lingual aspect. After processing and removal of the 'flash', the appliance should be replaced on the articulated models and the height checked for the third time. (Fig. 146).

If the wax form of the Activator has been thoroughly adapted to the model, the processed Activator should faithfully reproduce the reverse of the cervical margins, the interdental spaces, the lingual and the occlusal surfaces of the teeth. If these features are not seen clearly in reverse, the technique of construction has been faulty and the appliance should be discarded in favour of a new one. Adequate tongue space on the lingual side must be obtained by removal of acrylic resin where it appears unduly thick.

Application and Use of the Activator

(In order more fully to understand the purpose of 'trimming' the Activator, this process will be described after the application and use have been discussed).

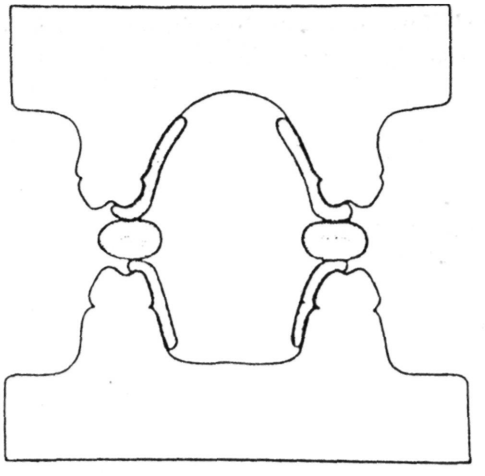


Fig. 145. Cross section showing wax roll in position.

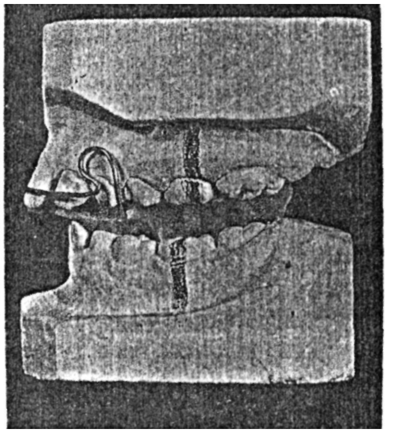


Fig. 146. Processed Activator on models.

The purpose of the Activator is to reduce a case of post-normal occlusion by improving the arch relations. Exactly how such changes in arch relations are brought about is still a matter of conjecture. It seems most probable that the greatest change is in the position of the teeth, relative to their basal bones, brought about by their movement through the alveolar processes.

It is possible that there are associated changes in the shape of the condyles and of the glenoid fossae, their form altering in accordance with functional and growth changes.

The Activator must be a loose fit. On insertion in the mouth it should fall from the upper jaw when the mouth is opened. It should also fit the lower arch loosely. This looseness is an important factor in stimulating an increase in muscle activity. The labial bow must be entirely passive. Its purpose is not to exert any mechanical pressure upon the labial surface of the upper incisor teeth, but merely to act as an extension of the Activator to embrace these teeth. In the early stages of treatment a conscious effort to maintain the Activator in position will be required of the patient; this will necessitate the mandible being held in a forward position. This is

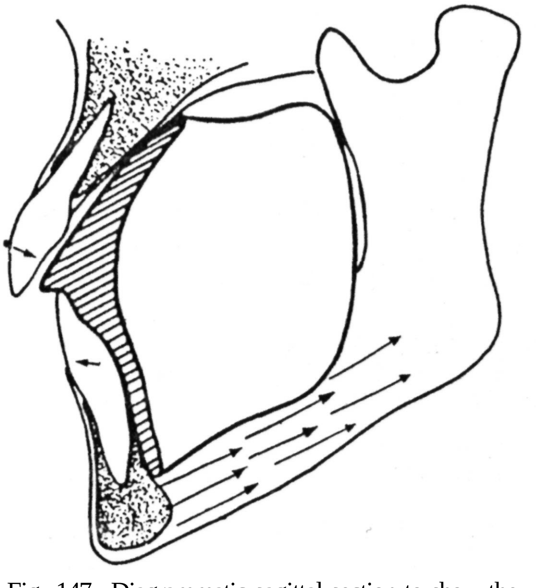


Fig. 147. Diagrammatic sagittal section to show the effect of muscle forces when the Activator is being worn.

important as the retractor muscles of the mandible are the primary source of force transmitted by the Activator in the correction of malocclusion. Later, the conscious effort may be replaced by more of a reflex act.

When the Activator is held in position by closing the teeth, whether it be by conscious effort or during the act of swallowing, the retractor muscles exert a force upon the mandible tending to draw it posteriorly (Fig. 147). This force is transmitted through the Activator to the teeth of

the upper arch which arc influenced to move in a distal direction; reciprocally, the lower teeth are innucnccd to move in a mesial direction. It is important to remember that, during the period over which the Activator is worn in the course of treatment, eruptive changes arc taking place in the position of the teeth. In this way the tilting movement of the teeth produced directly by the Activator may be modified to more upright movement by virtue of the more vertical component of tooth movement produced by tooth eruption.

Trimming

The Activator is usually trimmed away from contact with the disto-lingual aspects of the upper canines, premolars and molars. This allows these teeth to be inclined in a distal direction (Figs. 148, 149). Further encouragement is afforded by cutting the acrylic to form inclined planes which guide each of these teeth distally and a little buccally during their further eruption. Similarly the acrylic lingual to the upper incisors may be cut away to allow them to be inclined lingually. It is necessary to cut the acrylic away generously from the anterior part of the palate as well, but a horizontal platform may be left to discourage an increase of overbite. Where the shape of the lower arch is satisfactory it is wise to keep tooth movement here to a minimum by leaving these teeth splinted in the

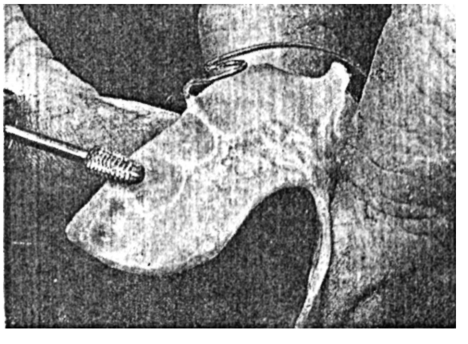


Fig. 148. Trimming the Activator.

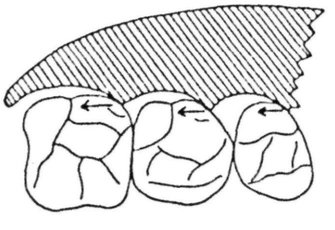


Fig. 149. Diagram to show how facets for upper molars and premolars arc trimmed to encourage distal movement of these teeth.

acrylic. Should tooth movement in the lower arch be required, facets may be cut in a similar way to those for the upper teeth. The direction of the inclined planes will be determined by the type of tooth movement required. To encourage a reduction of overbite, vertical facets may be cut for the lower molars and premolars.

Instructions to the Patient

Co-operation is essential for the successful outcome of treatment using any appliance, especially does this apply when using the Activator; similarly, complete freedom from nasal obstruction at night must be assured. The appliance must be worn at night and may with advantage be worn also during the day at convenient times, e.g. when reading at home. (It is not unusual for the Activator to be discarded at night, subconsciously, during the first few weeks). When not in use, the Activator may be kept in a glass of water in order that it remains moist. It is wise to see the patient two weeks after the first insertion of the Activator and, subsequently, every four to six weeks. Further trimming may be required at these visits. Eruptive changes may necessitate the replacement of the appliance. Muscle exercise may supplement the treatment.

Although the child may be expected to discard the appliance at first during sleep, this should cease to occur after the first few nights. Should rejection of it continue a careful examination should be made for the cause. Discomfort from the appliance may arise from a poor fit, roughness of the acrylic, sharp edges or distortion of the labial bow. These are not always apparent immediately the Activator is inserted. Distortion of the bow may be caused by lying on the appliance during sleep. Eruption of a tooth under the appliance may at first cause pain, and will prevent occlusion of the teeth into the appliance. Although children are very tolerant of variations in the degree to which the arches are held apart, excessive opening may cau.se the removal of the appliance during sleep. Similarly, excessive protrusion may be responsible for rejection of the appliance. A feeling of nausea is likely to be produced if the anterior part of the appliance is too thick. This causes a backward displacement of the tongue. Difficulty with breathing will make removal of the appliance necessary. This may be temporary during the period of a cold or more permanent where there is a partial nasal obstruction. The latter will require advice from an car, nose and throat surgeon.

(e) *Other Functional Appliances*

It is not easy to persuade patients to wear the Activator by day as well as by night. There are, however, a number of other functional appliances,

such as those developed by Baiters and Bimler, which are fabricated largely of wire and being less bulky may therefore be worn by day. Some of these are compressible and are known as dynamic functional appliances. Others, such as those developed by Stockfish and Frankel, extend into the labial and buccal vestibule of the mouth and encourage expansion of the arch outwards.

11. Fixed Appliances

Orthodontic appliances are described as being fixed when they are attached to the teeth in such a way that they can be removed only by the operator. The appliance itself may take a variety of forms.

The earliest fixed appliances circa 1723 were attached to the teeth by means of gold wire ligatures, the best example of which is the Bandalcllc of Fauchard (Weinberger, 1926). It consisted of a flexible strip of gold ribbon, perforated with holes through which were passed

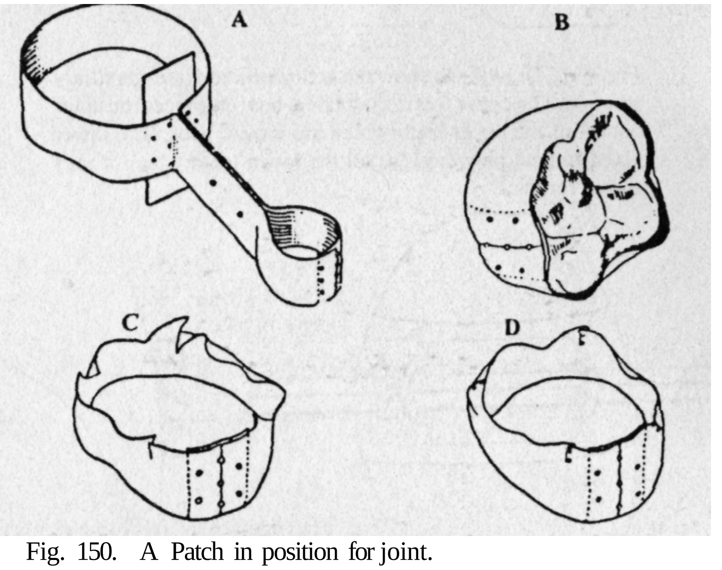


Fig. 150. A Patch in position for joint.
B Occlusal view of band on upper molar.
C Cuts made at comers.
D Comers adapted and welded.

the ligatures which were then wrapped and tied round the neck of each tooth.

Later in the 1930's, bands cemented to the teeth were introduced as a means of attaching the appliance to the teeth. The earliest were made of gold tape, but later stainless steel was used. They were moulded round the teeth and soldered or welded as a ring and then cemented to the teeth.

They could then be used as a means of attaching arch wires or springs to the teeth. An arch wire, either rigid or flexible, was attached to molar bands usually by slotting into lubes soldered to the bands. Elastics might be attached to hooks on the arch wire to move the teeth antcro-posteriorly, as with intermaxillary traction for correcting a Class II or Class III malocclusion.

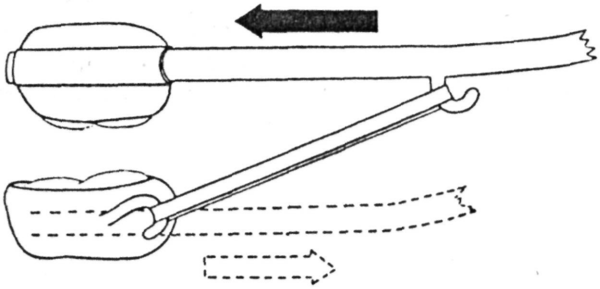


Fig. 151. Drawing to show the action of fixed intermaxillary traction. The upper frecsliding labial bow embraces the outer aspect of the upper teeth which are moved back. The lower fixed lingual bow engages all the lower teeth which it may move forward.

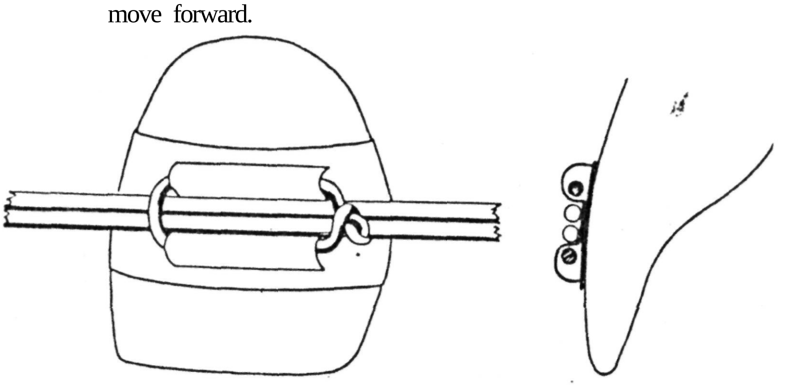


Fig. 152. Ripple bracket on incisor band; this bracket may be ligatured either to a twin wire arch as shown or to a single round wire arch or to a multi-stranded wire arch.

When flexible arches are used they are ligatured to slots or brackets on the teeth to be moved.

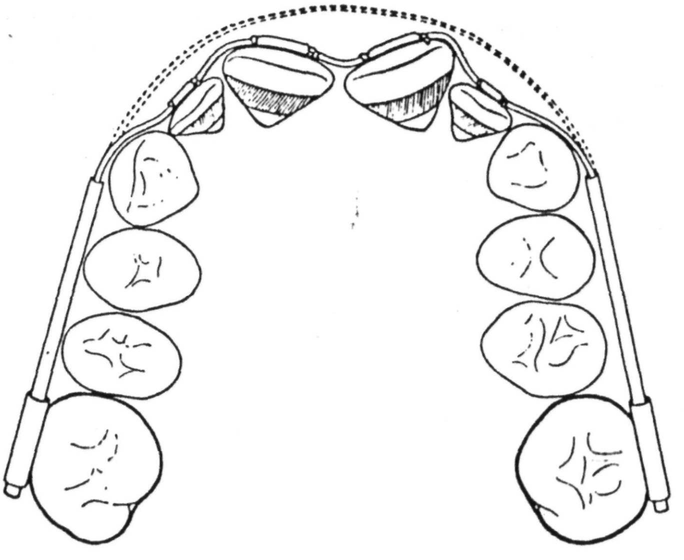


Fig. 153. Diagram to show how a flexible labial bow (Twin-Wire Arch) is attached to incisor brackets which it slowly draws into alignment.

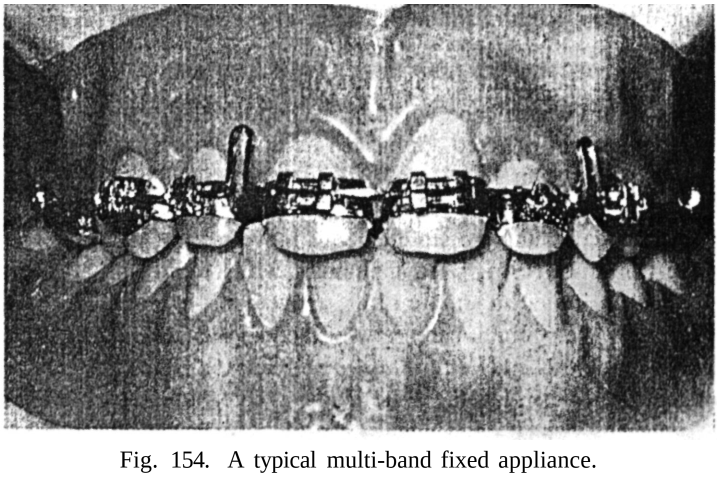


Fig. 154. A typical multi-band fixed appliance.
(With acknowledgement to C. J. Minors).

Originally these were always welded to bands. More recently, however, they have been bonded directly to the teeth themselves.

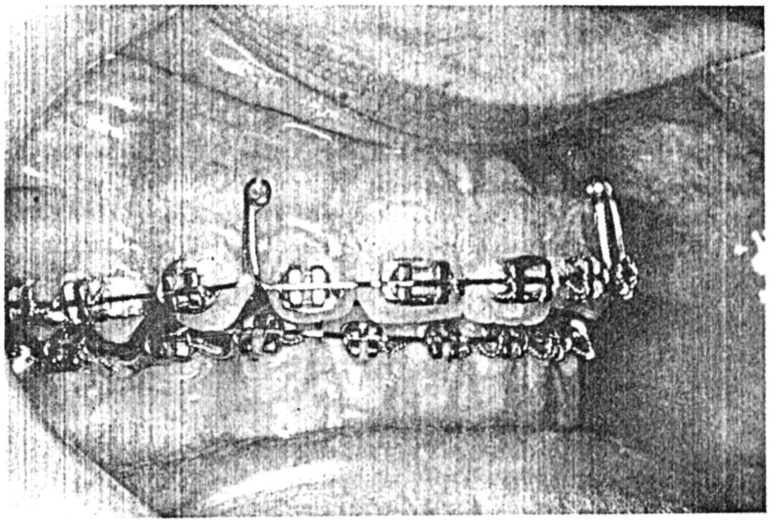


Fig. 155. Multiband Fixed Appliance with brackets bonded to anterior teeth.

These are all known as multiband or multibracket appliances and are now the basis of several treatment systems.

Other appliances have been based upon cast metal cap splints, cemented to the teeth of the upper arch. These are used with mid-line screws to expand the whole arch without allowing the teeth to lilt. In a young patient the effect of rapid maxillary expansion is to open the mid-line suture where bone will later be deposited.

The advantages of fixed appliances lie in the greater precision with which force can be applied to teeth allowing controlled tooth movement in three planes. Thus bodily tooth movement, rotation and intrusion or extrusion of teeth, and the simultaneous movement of many teeth can be readily produced using fixed appliances; whilst removable appliances are generally limited to simple tilting movements of a few teeth. The fact that only the operator can remove fixed appliances encourages full time wear but this may become a disadvantage if the appliance is damaged. Other disadvantages lie in the greater amount of chairside time required for their fabrication and adjustment, their greater vulnerability to damage and the need for a very high standard of oral hygiene. Unless teeth are kept scrupulously clean there is a high risk of

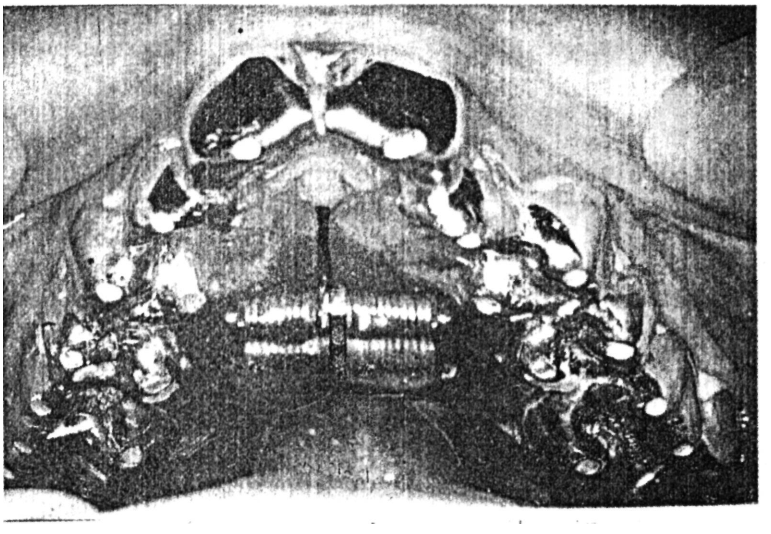


Fig. 156. Rapid Maxillary Expansion Appliance cemented to the upper arch.

decalcification and caries developing due to the retention of food debris and plaque around the brackets. Because they offer rapid tooth movement and cannot be removed by the patient, fixed appliances are potentially dangerous in the hands of an unskilled operator. For that reason they should be used only by dentists who have undergone specialist training.

FIXED ORTHODONTIC TECHNIQUES

1. E-arch.: In the late 1880s, Angle came up with his first typical orthodontic fixed appliance dependent on a rigid framework to which the teeth were tied so that they could be expanded to the arch form dictated by the appliance. Bands were placed only on molar teeth, and a heavy labial archwire extended round the arch. The end of the wire was threaded and a small nut placed on the threaded portion. This allowed the arch wire to advance so that the arch perimeter increased. It was used primarily for tipping tooth crowns and used stationary anchorage of first permanent molar teeth. This appliance could deliver only heavy force.
2. Pin and tube: To overcome the problem of the E-arch appliance of tipping the teeth, Angle in 1912 described an appliance which was capable of root movement as opposed to simple tipping. In this technique, Angle began placing bands on other teeth and used a vertical tube on each tooth into which a soldered pin from a smaller arch wire was placed.

Tooth movement was accomplished by repositioning the individual pins at each appointment. This technique was tedious in construction and adjustments.

3. Ribbon arch appliance: In 1916, Angle introduced this appliance which was the next step in the evolution of tooth alignment devices. He modified the tube on each tooth to provide a vertically positioned rectangular slot behind the tube. A ribbon arch of gold wire was placed into the slot and held with pins. This was quite efficient in aligning the teeth because of good inherent spring quality. The major drawback of this appliance was relatively poor control of root position. The resilience of the ribbon arch did not allow torquing of roots to a new position.

4. Edgewise appliance: To overcome the deficiencies of the ribbon arch, Angle in 1928 described this technique and reoriented the slot from vertical to horizontal and inserted a rectangular wire rotated 90° to the orientation it had with the ribbon arch, thus the name Edgewise. The dimensions of the slot were altered to 0.022 x 0.028 inch and precious metal was used. The dimensions could allow excellent control of crown and root position in all three planes of space. The unique feature of the rectangular wire in a rectangular slot was that twisting or torquing forces could be imparted to the arch wire to control the axial inclination of the teeth. Angle described an ideal arch wire with proper arch form, shape and torque, the concepts of which are considered to be the cornerstone of modern orthodontics. These are:

(a) The ability to obtain tooth movement in all planes of space with a single arch wire.

(b) The philosophy of treating to an ideal arch or to Angle's concept of the line of occlusion.

(c) The use of rectangular or square edgewise arches which when properly employed can control arch width, arch form, bucco lingual crown inclination, axial root inclination and incisor crown and root torque.

There are a number of techniques based upon the use of edgewise brackets which were derived from the original work of Angle.

5. Begg technique: Raymond Begg had been taught the use of ribbon arch appliances at the Angle school before he returned to Australia in 1920. The light wire technique described by Begg in 1950, used round wire exclusively. Working independently in Adelaide, Begg concluded that extraction of teeth was often necessary, and set out to adapt the ribbon arch appliance so that it could be used for better control of root position.

Begg's adaption took three forms:

(a) He replaced the precious metal ribbon arch with high strength 0.016 inch stainless steel wire which became available in the late 1930s.

(b) He retained the original ribbon arch bracket but turned it upside down so that the bracket slot pointed gingivally rather than occulsally.

(c) He added auxiliary springs to the appliance for better control of root position.

In this appliance, friction was minimized because the area of contact between the narrow ribbon arch bracket and arch wire was very small and the force of the wire against the bracket was also small. Bcgg's system relied solely on intraoral anchorage. The Bcgg appliance developed by P.R. Begg utilized the differential light force concept where by groups of teeth were made more or less resistant to movement according to magnitude, duration and direction of applied forces.

It is a complete appliance in a sense that it allows good control of crown and root position in all three planes of space. The main problem in using this appliance comes in the final stage where it could be difficult to precisely position the teeth.

6. Tweed technique: Charles H. Tweed was the first person to use the Edgewise appliance in conjunction with extraction, and this treatment method has been the classic edgewise technique for many years. At the diagnosis and treatment planning stage, considerable emphasis is placed on the use of serial cephalometric radiographs to identify the facial growth trend. The concept of ideal arch form was used as a basis for arch wire design. Accurate measurements of arch length and tooth width were taken. These measurements were used to construct a Bonwill-Hawley arch graph which was then used as a template for subsequent arch wire fabrication.

Single 0.022 inch slot edgewise brackets were used with mesial and distal eyelets to facilitate rotation and molar bands were fitted with rectangular tubes. Round arch wires were used initially inorder to facilitate levelling and correction of gross displacements.

One of the most important concepts of this technique was that of anchorage preparation in which extra oral forces and Class III traction were used to prepare the lower arch as a site for anchorage. Relatively rigid arch wires were used both for canine retraction and overjet reduction.

7. Combination technique: The Begg and Edgewise techniques are fundamentally different in their mechanical approaches to treatment. The free tipping which allows rapid correction of crowding and the ability to use accessory springs to achieve apical movement are some

advantages of the Begg appliance. The wide edgewise brackets restrict tipping, but the close fit of the edgewise arch in the bracket channel allows precise final control of tooth position.

In order to achieve combined advantage of both the systems, attempts have been made to unite them in to a single technique with the simplicity and precision of edgewise bracket and rectangular archwirc combination, and the rapid unraveling which is seen when using light forces of Begg mechanism.

In the combination technique of M.S. Fogcl and J.M. Magill, a Siamese Edgwisc bracket incorporating a vertical slot is used. The technique was developed using a bracket which is intended to confer the benefits of the Begg single point contact bracket and the possibility of changing to a rectangular arch wire in the later stages of treatment. During the first stage of treatment, the bracket insert is placed in the vertical bracket channel. Finally, rectangular archwires arc placed in the Edgewise stage.

8. Jarabak technique: In the light wire appliance used by Jarabak the bracket used is basically of edgewise type, incorporating a rectangular archwire channel. However, a large part of treatment is achieved using small diameter light wires incorporating carefully positioned vertical and horizontal loops and helices. The anterior teeth carry modified brackets with vertical slots enabling round arch wire to produce tipping, rotation and bodily movement.

9. Twin wire technique: The forces generated by the early edgewise mechanism were very high and in the 1930s Johnson introduced the twinwire arch which was designed to produce lighter tooth moving forces as explained by Shepard. Two light buccal round wires were used in combination to achieve rotation and alignment of upper incisors. In the original technique, special brackets were designed and Class III traction was used to a lower lingual arch. An advantage of this technique was its ability to correct incisor displacement with minimum of bands.

It is also possible to engage only one of the twin wires in the bracket inorder to reduce the force applied. The twin wire arch can be used with Edgewise brackets. The main drawback of this appliance is that it suffers permanent distortion fairly readily and the arch often needs replacement. It can also be used for overjet reduction using intermaxillary or intramaxillary elastic on hooks at the mesial aspect of the last tubes.

10. Labiolingual technique: As described by Trapely, Mershon developed this technique with relatively rigid mandibular and maxillary lingual arches attached to molar bands. These arches carried springs

similar to modern removable appliances. The lower arch was used for tooth movement in the upper arch by means of Class II elastic traction. From a mechanical point of view the labiolingual technique, offered much less control over tooth position than the Edgewise technique.

11. Lingual appliance: In 1976, Dr. Kurz submitted the specific design and concept of a unique lingual appliance. The routine use of bonded attachments has enabled the development of appliances used on lingual and palatal aspects of teeth. The main attraction of this appliance is cosmetic and may be indicated in adult patients. A number of different attachments have been developed and arc based on principles that apply in normal fixed appliance technique. Both Edgewise and Begg methods of treatment arc used. The main problems with this appliance are that it interferes with speech after it is first fitted and is much more difficult to clean than the conventional appliance. The considerable disadvantage from an orthodontist's point of view is that access is extremely difficult, both from the aspect of initial bonding and for changing archwires. It is, therefore, a time-consuming appliance.

12. Universal technique: It was designed by Dr. Spencer Atkinson. It is a multibanded precision appliance consisting of one flat 0.012 x 0.028 inch and one round 0.014 inch wire used in combination. The flat wire is placed incisally. At different stages of treatment, various combinations of round and flat wires may be used according to the type of movement desired. According to J. Fastlich, the control provided by the bracket in three planes of space is such that canines can be retracted bodily with a minimum of mechanical effort and maximum control.

The wires are held in place by small locking pins. Because of many adjuncts used and the possible combination of archwires, the appliance is very versatile. Its greatest advantage would seem to be its value in the treatment of permanent dentition.

13. Bioprogressive therapy: Bioprogressive therapy developed by R.M. Ricketts, may be considered as an evolution from the edgewise technique, with features of certain light wire methods. Perhaps no other technique is as deliberate or entirely circumscribed in its clinical approach as is bioprogressive philosophy. In this technique priorities were sought and movements of teeth were selected in keeping with the forces of occlusion, the forces of growth and forces of nature. This accounts for the prefix 'bio' being used to suggest the strong biological implications to be constantly born in mind with this technique.

14. Straight wire appliance: It is the recent appliance therapy evolved from Edgewise system with the introduction of space age wires like nickel-titanium and dual-flex in treatment mechanics. It can be

considered as the most sophisticated and efficient fixed appliance therapy to date. The original appliance was developed by Andrews in 1970. Though there are other straight wire appliances, Ronald Roth considers Andrew's straight wire appliance at the present time as the only truly straight wire appliance from the standpoint of a level-slot line-up, in which all the slots of the brackets are at the same height and level, in all three dimensions when the teeth are in correct positions.

Andrews published what he called the six keys to normal occlusion. They are: i) molar relationship, ii) crown angulation, iii) crown inclination, iv) rotation, v) tight contacts, and vi) curve of Spee.

15. Tip-edge technique: Kesling describes tip-edge brackets as dynamic in action. This facilitates both appliance manipulation and tooth movement. The progressively increasing control is partly automatic because of the design of the archwire slot and is partly selective due to the application of a unique elastomeric tipedge ring, an uprighting spring and/or a rectangular arch wire. The initial use of a 0.016 inch round, high tensile arch wire permits tipping in all directions yet provides rotational control. Therefore the tooth crown can move along an individual path of least resistance in response to relatively light forces generated by the arch wires and elastics. Subsequent use of larger (0.022 in) arch wires provide increased vertical and horizontal fixation during space closure and major root uprighting.

12. Examination of the Patient

Although there may be more than one effective method of treating a case of malocclusion, none will be entirely successful unless the treatment plan has been based upon full and adequate recognition of the abnormality, the conditions which created it and the factors which may be inhibiting self-correction. It may take many years of intelligent clinical observation of both normal and abnormal development in children before proficiency in diagnosis can be attained.

Accurate diagnosis of malocclusion requires the presence of the child, and it is of great advantage also to have at least onp of the parents available. Both study models and radiographs are usually needed. The examination of the patient is an essential part of diagnosis for which models, charts and radiographs can be no substitute; these are only diagnostic aids which augment the clinical examination but in no way replace it. They may confirm facts suspected clinically and may even bring to light information which is not otherwise available, but their use renders no part of the clinical examination redundant. As orthodontic treatment is usually based upon a large number of factors, it is necessary to adhere to a systematic procedure when examining the patient so that every relevant point which may affect the treatment is considered.

The order of examination of the patient is as follows:

A. FACIAL EXAMINATION

(a) *Full face:*

Symmetry.

(b) *Profile:*

Dental base (skeletal) relationship,

(i) Antero-posteriorly.

(ii) Vertically.

B. INTRA-ORAL EXAMINATION

(a) *Soft tissues:*

(i) Gingival health and hygiene,
(ii) Frena,
(iii) Palate.

(b) *Teeth:*

Number

(i) Teeth present and erupted,
(ii) Teeth present but uncrupted,
(iii) Teeth known to have been extracted,
(iv) Teeth congcnitally absent,
(v) Extra teeth.

State

(vi) Caries,
(vii) Non-vital teeth,
(viii) Proportion of tooth size to arch size,
(ix) Trauma to teeth,
(x) Malformed or fused teeth.

Position

(xi) Irregularities in position of individual teeth or groups of teeth,
(xii) Migration of teeth, especially following extractions.

(c) *Relationship of dental arches:*

(i) Antero-posteriorly,
(ii) Transversely,
(iii) Vertically.

C. FUNCTIONAL EXAMINATION

Points to be observed:

(a) *Path of closure.*
(b) *Position of lips at rest and behaviour during swallowing.*
(c) *Behaviour of the tongue.*
(d) *Speech.*

GENERAL INFORMATION

There is in addition a certain amount of general information which will be required before a complete assessment of the aetiology and prognosis

can be made. This includes the following:

(i) Age.
(ii) Relevant medical history.
(iii) Dental history, including sucking habits.
(iv) Home environment,
(v) Altitude of patient and parent to treatment.
(vi) Availability for treatment.

The necessity, when dealing with growth of part of the body, to understand the growth of the whole has been emphasized in Chapter 1. Each patient should be regarded as a whole person rather than as a 'pair of jaws'. The examination, therefore, begins immediately the patient enters the surgery. If possible, both parents should be present at the examination; this affords an opportunity to observe any hereditary characters which may be present, and also an opportunity to discuss the medical history, diagnosis and treatment. Previous illnesses, especially those that affect the respiratory system, are of importance to the orthodontist. Abnormal conditions which influence the growth of bone should be noted. Previous surgical operations should be recorded; those involving the nose or mouth particularly concern the orthodontist. Inquiry should be made concerning various sucking habits, even though they may have been abandoned at the time of examination. Information concerning sucking habits is often more reliable from the parents than from the child. Where there is doubt some confirmation may often be obtained by examining the hands. A small pad of hard skin on the dorsal surface of the thumb may be caused by thumb-sucking. A wrinkled palmar surface of unusual cleanliness is often indicative of day-time sucking. It should be remembered that, while such habits may not be a primary factor in the cause of the malocclusion, they are almost certain to be detrimental to the attempts at treatment. The presence of an appliance in the mouth may often help a child who is already trying to give up a sucking habit.

The age of the child should be ascertained and normally this corresponds to within about one year of the developmental age. A comparison of the actual age with the developmental age indicates the pace of development. An approximate comparison of the development of the child to the normal for the district can be obtained by asking the patient in what way his height compares with that of his classmates of the same age.

It is helpful to remember that the general appearance, behaviour and turn-out of the patient may often reflect the type of care and consideration

that an orthodontic appliance is likely to receive. No matter how excellent the treatment, success or failure often depends on this.

Any further inquiries which are required will be suggested by the findings of the later examination in detail.

FACIAL EXAMINATION

(a) *Examination, full face*

In the examination of the face, complete relaxation of the patient is essential. This is not always easy to achieve at a first visit and much can depend upon the personality of the operator. A few minutes 'small talk', can help to relax the child and put him at his case, and will also afford an opportunity, not only to get to know the child, but also to assess his intelligence and possible co-operation in future treatment.

The latter point is important because enthusiasm and parental encouragement are often not strong enough to ensure the successful completion of a course of orthodontic treatment. It is recommended that the operator is seated at this stage of the examination with the patient's chair raised and the operator's stool lowered so that his face is level with the patient's mouth. This encourages confidence in a possibly nervous child and also makes it easier for the operator to observe the ' action of the lips and tongue in function.

Some degree of facial asymmetry can be detected in most individuals, but is only likely to be of significance where it is easily detectable or where the mandible itself appears displaced to one side. (Fig. 191, page 271). The latter may be a true asymmetry of the mandible or may arise from premature cuspal contact which has encouraged lateral displacement of the mandible. True asymmetry of the mandible will always be seen even in the 'rest' position, whereas a displaced mandible is likely to return to a central position when at rest. The displacement may often be detected as a lateral swing of the mandible just before the teeth approach occlusal contact (see pages 65 and 99).

(b) *Examination of the face in profile (skeletal relationship)*

Both the antero-posterior and the vertical relationship of the dental bases are likely to be reflected in the mutual relationship of the dental arches. It has been shown already how the maxillary base may be relatively further forwards or backwards than that of the mandible. The assessment of this relationship is made easier by reference to cephalometric radiographs (see page 245, but it is possible to make an approximate assessment on the patient. This is accomplished by orienting the head so that the Frankfort plane is parallel to the floor, and then retracting

the upper and lower lips to view the outline of the alveolar process in profile,

A method suggested by Ballard,' although not so simple, may be used with more accuracy at the chairside. Where the inclination of the teeth is normal and the dental base relationship is also normal, it can be expected that upward projections of the axes of the lower incisors would pass through the crowns of the upper incisors. When this occurs the case is designated as being a Skeletal Class 1.

Should the lower apical base be relatively too far back, the lower incisor axes would pass palatally to the upper incisor crowns. This is said to be a Skeletal Class 2 relationship.

Conversely, if the lower apical base is placed relatively too far forward, the projections of the lower incisor axes would pass labially to the upper incisor crowns. This is called a Skeletal Class 3 relationship.

These propositions have assumed that the inclinations of the incisor teeth within each arch are normal. However, it frequently occurs that this is not so and a mental correction of the incisor inclinations has to be made. This is done so that the axis of the lower central will make nn angle of about 90° with the mandibular plane (inferior border of the mandible), and that of the upper central an angle of about 110° to the Frankfort plane. If, after mental correction, the lower incisor axis would still pass palatally to the upper incisor crown, the case is a Skeletal

Fig. 157. Variations of the angle formed by the Frankfort and mandibular planes,

' Ballard, C, F, (1948), *Trans. B.S.S.O.*. p. 27.

Class 2, and, similarly, if it passes labially to the upper incisor crowns the case is a Skeletal Class 3.

The significance of infra-orbital facial height lies in its association with the amount by which the lower lip covers the upper incisors, and with the depth of incisor overbite. Stability of lingual movement of upper incisors by orthodontic treatment is usually doubtful where the infra-orbital height is large. Variations of the vertical height of the face are usually expressed in the angle formed by extending posteriorly the Frankfort horizontal plane and the mandibular plane (Fig. 157). It is necessary to measure the angle with the teeth in occlusion.

The Frankfort plane is a term borrowed from physical anthropology where it is described as a plane passing through the most superior points of each bony external auditory meatus and the lowest point of the inferior border of the left bony orbit. For clinical application this has to be modified because the bony points are inaccessible. The notch above the tragus of each ear is used and the infra-orbital margin is palpated to locate the lowest point.

The mandibular plane is located clinically by placing a flat plane against the posterior part of the inferior border of the mandible. Neither

Fig. 158. Application of protractor and sliding callipers for measuring the Frankfort mandibular plane angle.

of these planes is therefore quite the same as that used for ccphalometric analysis (see page 250).

The angle formed between these planes may be measured with a protractor-like device similar to that shown in Fig. 158. When measured in this way the average angle is 30°; those cases with an angle above 35° being considered large, and those cases below 25° i;onsidcrcd small. In the absence of a protractor it is possible to base an approximate estimate of the size upon the position of intersection of the planes. In the average case this lies in the region of the occiput; when the angle is large the planes intersect near the mastoid region, and if small some distance behind the occipital region.

INTRA-ORAL EXAMINATION

Examination of the mouth should be commenced only when the above-mentioned information has been noted; it must be undertaken systematically,

(a) *Soft Tissues*

The soft tissues, i.e. gingival margins, frcna and the tongue should be investigated first. An anterior marginal gingivitis (Fig. 159) usually

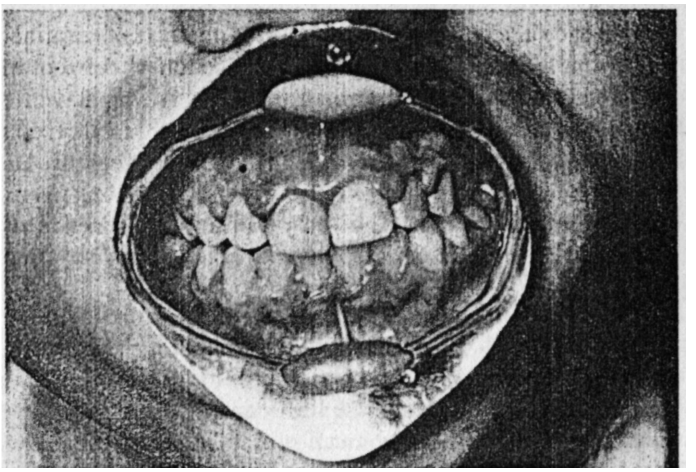


Fig. 159. Anterior marginal gingivitis associated with continual parting of the lips and drying of the gingival margins.

occurs when there is difficulty in keeping the lips together. General marginal gingivitis on the other hand is usually found in those cases where the oral hygiene is poor.

A persistent and thickened labial frenum (see page 90) may be present in 25 per cent of children at the age of eight years, but its incidence decreases with age. Blanching of the palatal tissues around the incisive papilla when the lip is stretched is evidence of a fibrous band passing from the lip to the incisive papilla.

The hard palate and sulci should be examined visually and by palpation. Asymmetrical contours of the palate are usually caused by unerupted teeth, but may occasionally arise from a small isolated cleft. Uncrupted upper and lower second premolars may be palpable in the palate, or in the lingual sulcus if space for them has been lost. Uncrupted canines on the other hand may often be palpated labially, but may sometimes erupt towards the palate in the case of upper canines or the lingual sulcus in the case of lower canines.

(b) *The teeth of each arch*

Each arch should be examined separately. The teeth are identified one by one from the mid-line; absent teeth, extra teeth and malformed teeth also being noted. It is at this stage of the examination that radiographs are particularly useful. The dental age may be estimated by reference to the degree of calcification of the tooth roots and by the identification of erupted teeth.

The presence and position of uncrupted teeth is determined by *observation*, *palpation* and *radiography*. Deflection of the root of the adjacent tooth, as revealed by the orientation of its crown, may often be used to deduce the position of a neighbouring uncrupted tooth. Examples of this are seen frequently in the incisor and canine regions. Digital palpation of the alveolar process is a useful aid in localizing uncrupted teeth or supernumerary teeth; not only can any prominence of the alveolar bone be detected, but the outline of the underlying crown or root may also reveal its orientation.

In assessing the state of the teeth it is necessary to view the long-term prognosis for each, especially when extraction of other teeth is contemplatedy. The presence of cervical cavities is a particularly unfavourable sign when assessing the life-span of the teeth.

It is necessary to ascertain how much space has been lost and which teeth have moved as a result of tooth movement following extraction. The amount of space lost may be assessed with dividers and by reference to other arch segments which are intact. In some cases the crown of the tooth alone moves to an abnormal position, while in others both the crown and the apex of the root are in an abnormal position. If a tooth is lost from the anterior part of the dental arch, the centre line may deviate

markedly towards the side of loss (Fig. 160). Premature loss of deciduous molars is likely to have been followed by mesial migration of the permanent molars (see page 102) and this should be assessed so that in the next stage of the examination with the teeth in occlusion the relation between the arches may be judged more accurately.

Crowding is most likely to occur in cases where the teeth are relatively large for the arches. Although crowding is usually apparent in the incisor region, it may be transferred to the premolar region as a result of

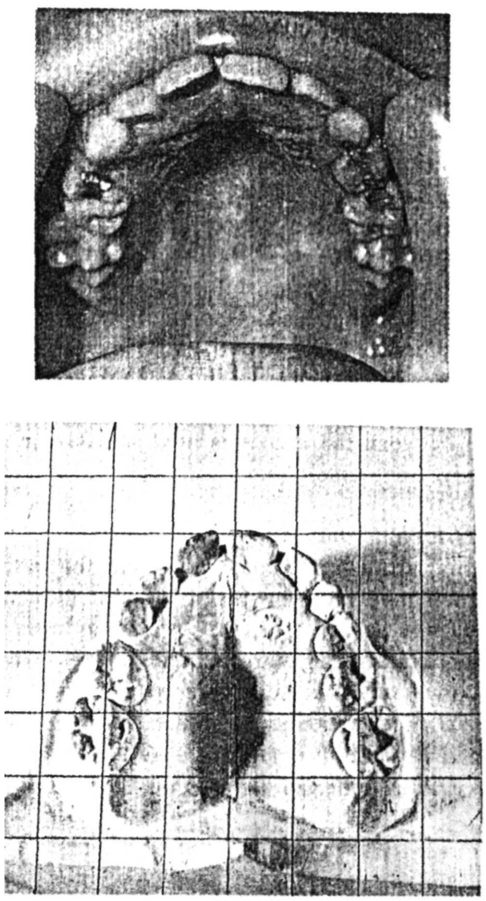


Fig. 160. Deviation of the upper centre line and forward drift of the upper right first permanent molar following premature loss of the upper right first deciduous molar.

premature extraction of deciduous molars. Cases arc occasionally seen where there is a local disproportion of the dental bases. This is usually found in the upper or lower incisor regions or the upper molar and premolar region. It is characteristic of this condition that even when they are fully established, the roots in the affected area will converge apically. Difficulty in repositioning the apices usually makes it necessary to extract teeth from the area of crowding.

(c) *The relationship of the dental arches*

The patient is now persuaded to close the dental arches together in their usual relations, care being taken that the relation is really the usual one for that patient. It is often found that the mandible is protruded to an abnormally forward position if the patient is made conscious of his mouth. To overcome this, one may place the two forefingers over the lower premolars on each side and ask the patient to close on them slowly. As he closes, the fingers are withdrawn. It will usually be found that the patient then assumes the normal pattern of closure. Another method is to ask the patient to "place the tip of the tongue on to the junction of the hard and soft palates and then to close slowly keeping it there. If palpation detects contraction of the temporalis muscles as the patient closes, then the arches are likely to be in centric occlusion. Examination of the occlusion is assisted by the use of study models, which allow the examination of the lingual cusps in occlusion.

The relation between the arches is now assessed in three planes: antero-posteriorly, transversely and vertically.

(i) *Antero-posterior relation*

In assessing this, allowance should be made for individual tooth migrations which may have occurred. Mesial movement of first permanent molars is particularly likely, and may alter their mutual relationship in occlusion, giving a false impression of the arch relationship. To overcome this the relation of the canines and premolars should also be examined. The case may then be allotted to one of three Classes of Dental Arch relation (see page 69). In addition, the incisor ovcrjct is expressed as a measurement in millimetres.

(ii) *Transverse relation*

There may be an abnormality of the bucco-lingual relationship of the molars and premolars. If only one tooth is involved it is described as being in a lingual or buccal occlusion, but if several teeth are involved it is usual to refer to it as 'crossbite' (see page 64).

A bilateral crossbitc may be associated with prenormal occlusion or with marked narrowness of the upper dental arch. Where a crossbite occurs on one side only (i.e. a unilateral crossbite, Fig. 191, page 271 and Fig. 40, page 63), it may arise in one of two ways. There may be some symmetrical narrowness of the upper arch with mandibular deviation laterally on closure, or there may be true asymmetry of one or both arches. The differential diagnosis of these has already been discussed on page 99 and the treatment on pages 268-72.

Buccal occlusion of upper premolars is not uncommon in Class II cases, and may be found also occasionally in the molar region. There is usually as much lingual inclination of the lower teeth as there is buccal inclination of the upper teeth. Where this occurs unilaterally it is again necessary to differentiate true asymmetry from cases where there is a lateral deviation of the mandible on closure. Bilateral cases involving all molars and premolars are rare and may suffer some distal displacement of the mandible on closure.

(iii) *Vertical relation*

Vertical anomalies in arch relationship are usually expressed as a degree of incisor overbite or as open bite (see page 66). This is not necessarily an indication of the distance between the body of the mandible and the body of the maxilla. In planning treatment the significance of the depth of overbite is almost as important as that of the antero-posterior relationship, and the stability of the completed case is often dependent on the amount of incisor overbite at the completion of treatment. It has already been explained how the degree of overbite changes normally (see pages 31, 37); this should be remembered when assessing any departure from the normal.

The overbite may be excessive or deficient. Antero-posterior contraction of the dental arches, i.e. mesial movement of molars or lingual movement of incisors, tends to increase the overbite. Conversely, therapeutic increase of antero-posterior dimension of either arch by means of appliances tends to decrease the depth of the incisor overbite. An excessive overbite usually accompanies Class II dental arch relations; this is caused largely by over-eruption of the incisors due to lack of contact with antagonists. A deficient incisor overbite often arises from mechanical interference with eruption of the incisors as in thumb-sucking (see Fig. 42A, page 65). More rarely it may be associated with an unusually large infra-nasal height which is indicated by a high Frankfort mandibular plane angle (see Fig. 47, page 78)

FUNCTIONAL EXAMINATION

Path of closure

The rest position of the mandible can only be established satisfactorily when the patient is in a state of relaxation; this is usually achieved by conversation with the child. It is important to note the position of the mid-line of both upper and lower arches in relation to the mid-line of the face. It will be recognised that asymmetrical extraction near the front of cither arch may have caused lateral drifting of the centre lines so that these do not coincide. This must be distinguished from the non-coincidence of centre lines due to a deviation in the path of closure of the mandible. (Fig. 191, page 271). An assessment is made by parting the lips without any disturbance to the mandibular position. This is accomplished by securing the mandible gently with the palm of one hand while the lips are lifted away from the incisors, thus revealing their relationship in the 'rest position', i.e. the initial position from which the mandible moves through its path of closure into centric occlusion. When that movement is being made (sec pages 52 and 101), the teeth follow arc-like paths in the sagittal plane about a central axis in both condylar heads. This upward and slightly forward path of movement may be disturbed when there is abnormality of either the rest position or the occlusal position. Alteration of the rest position may be seen in Class II malocclusions where it aids approximation of the lips but it may be difficult to detect. An anomaly in the occlusal position will be associated with displacement of the mandible cither forwards, backwards or laterally. Forward displacement of the mandible occurs in postural or pseudo-Class III malocclusions, backward displacement is found occasionally in some Class II, Division 2, cases, and lateral displacement is usually associated with a unilateral crossbile (sec page 99). It is important that a crossbite associated with a lateral deviation of the mandible on closure should be differentiated from a truly asymmetrical condition because the treatments are quite different. In the former, the upper study models will usually show symmetrical narrowness of the arch. Clinical examination of cases where there is true asymmetry will reveal a normal path of closure, and asymmetry of arch relationship which is present in all positions of the mandible; it may affect the maxillary arch, when it can be detected on the study model, or more rarely, the mandible, whose inferior border will be asymmetrical. Condylar hypertrophy of one side is usually associated with a mandible larger than normal and displaced towards the opposite side and with a prenormal occlusion which tends to deteriorate up to

the age of puberty. On the other hand, unilateral arrest of condylar growth, from whatever cause, gives rise to a mandibular displacement towards the affected side and is associated with postnormal occlusion with a severity proportional to the amount of growth lost.

Position of the lips at rest and behaviour during swallowing

The importance of the relationship of the lower lip to upper incisors has already been discussed on page 95. In order to study the position of the lips at rest it is an advantage to make this observation while the patient's attention is directed to conversation or reading. Where the infra-nasal height is large the lower lip may fail to cover the upper incisors. In such cases, in order to create a seal between the upper and the lower lips, the level of the lower lip is raised by excessive activity of the Mentalis muscle, identified by dimpling over the chin (see Fig. 63, page 97). This anterior sealing is an important phase in swallowing and may be expected to occur more persistently as the child becomes older. When the lower lip covers the labial aspect of the upper incisors it is more likely to assist in preventing them from moving labially. Patients with an excessive ovcrjct find it difficult or impossible to bring the lips together on account of the prominence of the upper incisors. In this situation there is a lip trap with the lower lip resting behind the upper incisal edges and contacting the tip of the tongue to produce an anterior oral seal. This behaviour pattern tends to maintain upper incisor proclination and may produce lower incisor retroclination. Because the tongue rests over the incisal edges of the lower incisors, it prevents their continued eruption and produces an incomplete overbite.

A type of muscle activity may be seen occasionally in which the lower lip appears to be drawn tightly around the arch. Swallowing may be accompanied by contraction of the lower part of Orbicularis Oris muscle. This is likely to be associated with some lingual inclination of the lower incisors, and shortening of the anterior part of the lower dental arch. Limitation by the musculature of the lip will invariably cause relapse if any attempt is made to move the lower incisors labially.

It is only rarely that failure to approximate the lips at rest is accompanied by mouth-breathing or even oro-nasal breathing. A convenient test for the presence of mouth-breathing is to hold a double-sided mirror at an angle just below the nostrils. A warning is needed here to exclude cases where there happens to be an acute cold in the nose or hay fever at the time of observation.

Behaviour of the tongue

The importance of the tongue in contributing to arch form has already been discussed in Chapter 6. Although the shape and size of the tongue, a mass of intrinsic muscle, can be assessed by direct observation there is always some difficulty in determining its position at rest and behaviour during speech and deglutition. Care is needed, when parting the lips in order to view the tongue position, that its position or behaviour is not disturbed.

Where the tongue penetrates between the upper and lower incisors (anterior tongue thrust) it is likely to encourage labial inclination of the upper incisors. This behaviour may contribute to a relapse following appliance therapy aimed at reducing the incisor overjet, particularly if muscular control from the lower lip is inadequate. In most cases this behaviour is adaptive, being a response to the need to create a seal with the lips during deglutition. It may be eliminated by bringing the incisors into occlusion. An anterior tongue thrust is often found in association with an incomplete incisor overbite and increased infra-nasal height. The upper incisors are therefore not likely to be under the control of the lower lip. Although it may be anticipated that the tongue thrust will diminish as the child grows, the prognosis for complete reduction of the overjet must still be uncertain. On rare occasions a tongue thrust is endogenous in origin, being a behaviour pattern which is inherent in the patient. Because it does not respond to correction of incisor relationship or to functional therapy it is likely to perpetuate a space between upper and lower incisors; this has to be accepted when planning treatment. This type of tongue behaviour is not easy to identify but is usually associated with an anterior sigmatism.

Speech

In the course of the general and facial examination, conversation with the child will provide an opportunity to observe any defects of speech. The nasal air emission characteristic of cleft palate cases is easily detected. There are several types of sigmatism (lisping) of which the most significant in orthodontics is an inter-dental sigmatism. In this type, when the letter 'S' is sounded, the tip of the tongue engages the incisal edges of the upper incisors instead of the palate immediately behind them. Whenever this is associated with a thrust forwards of the tongue during the act of swallowing—and this is also associated with an excessive overjet and an anterior open bite—the prognosis for retracting the upper incisors and maintaining them in the new position is poor,

The results of the foregoing clinical examination will have indicated some further points which require investigation or upon which further information may be required from the parents. Some cases of malocclusion are known to have a genetic background and observation of the parents may help in the assessment of the case. Some cases are simple and the aetiological factors easy to detect; these may not therefore require the same amount of detailed examination and consideration.

Once all the data have been gathered they must be sifted and those which arc considered relevant assembled for further consideration. It is quite possible that sonic factors may be found lo be in conflict. It is in such cases that experienced judgement is particularly required before the best treatment plan can be outlined. Where necessary, the advice of an orthodontic specialist should always be sought.

It will be necessary to discuss with the patient and the parents the treatment that is required. An opportunity is thereby afforded for gauging the attitude of both the patient and the parents to the treatment proposed, its duration and the amount of home support that can be expected. Much depends upon this. Where the home support is likely to be inadequate, treatment may have to be simplified or even abandoned altogether.

AIDS TO DIAGNOSIS

(a) *Study Models*

Study models (Fig. 161) are prepared before the patient is examined and are of value for the following reasons:

(i) They make it possible to view the occlusion from every aspect,
(ii) They enable accurate measurements to be made of the dental arches,
(iii) They may be used later for the assessment of treatment progress,
(iv) They would be necessary to assist another practitioner to whom the patient may require to be transferred in the future,
(v) They are helpful in explaining the treatment plan and progress to a patient or parent,
(vi) In certain cases treatment planning may be assisted by simulating the proposed treatment on study models.

Study models should always have a neat appearance (Fig. 161). They should depict not only the teeth but also as much of the alveolar process as possible; for protection they arc mounted on bases which also help the upper and lower teeth to be placed incorrect occlusion. It is customary to trim the bases in such a way that the models fall into the patient's occlusion when standing on their rear surfaces or sides on a

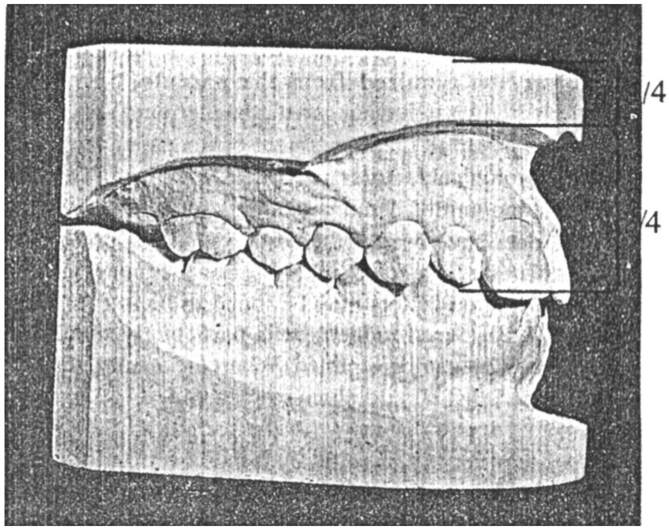


Fig. 161. Study models, correctly trimmed.

level surface. The top surface of the upper model and the lower surface of the lower base should be mutually parallel when the models arc in occlusion (Fig. 162)

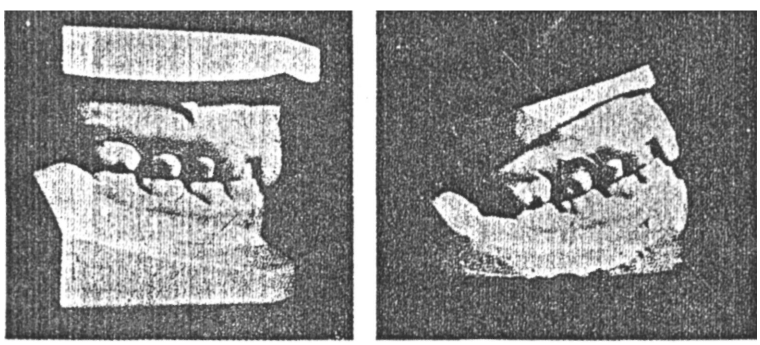
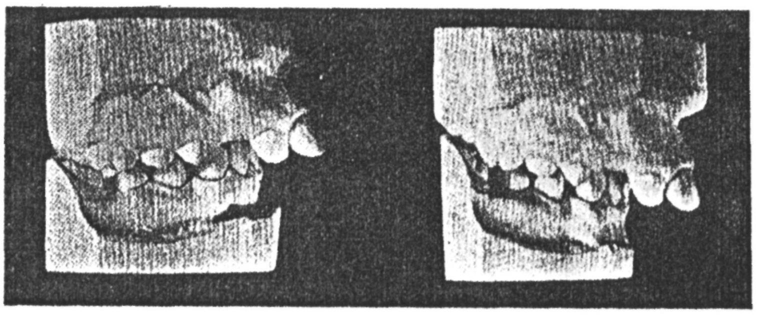


Fig. 162. Examples of well-based and incorrectly based study models.

The occlusal plane is usually orientated so that it is inclined with an 8 degree downward tilt towards the front of the models (Fig. 163), and the mid-line of the palate is at right angles to the rear surfaces of the models (Fig. 164). Failure to orientate the anatomical portions correctly on their bases may give a false impression of the type of malocclusion (Fig. 163).



A B

Fig. 163. A. Incorrect and B. correct slope of the occlusal plane of study models showing the totally different appearance of two pairs of models, each of the same case; B. being the slope of the occlusal plane at approximately the same angle as it occurred in the mouth in this particular case.

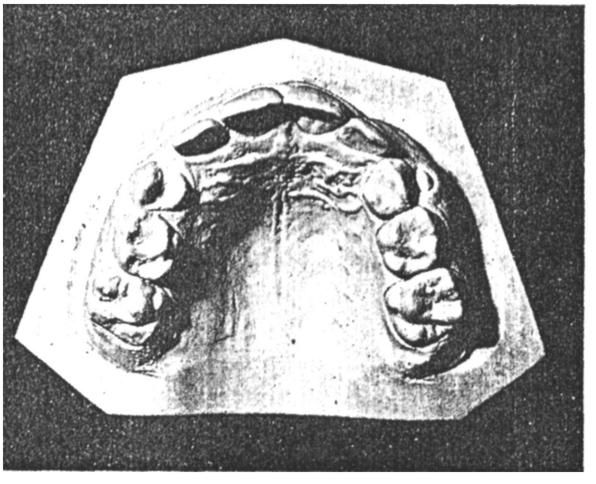


Fig. 164. Occlusal view of an upper model showing how the posterior border of the base is cut at a right angle to the median raphe of the palate.

In cases where asymmetry of tooth position is suspected in the upper arch, a transparent grid may be placed over the model so that its mid-line is superimposed over the mid-line of the palate (see Fig. 160, page 231). The nature of the asymmetry then becomes apparent and can be assessed against the grid.

Impressions

Good models are only made from good impressions which in turn require the selection of the right tray inserted in the most advantageous manner (Fig. 165); in this way, the excess alginate impression material, instead of penetrating the pharynx, over-extends the sulcus giving the type of model shown in Fig. 161.

The average 'box' tray's rim is too shallow to achieve this result and it is recommended that orthodontic trays are used since their rim in the labial region is at least 3/4 inch (20 mm) (Fig. 165), and their edge is beaded to secure the alginate. The size of trays selected should not only cover the last molars but also be 1/8 inch (3 mm) clear of the outer aspect of the teeth and alveolar process. As the tray is being inserted in an oblique sagittal direction (Fig. 165B), the patient's lip is held forward and the excess alginate impression material pushed into the sulcus to expel any air. In the production of good study models a further aid to the technician is the provision of a wax bite taken with

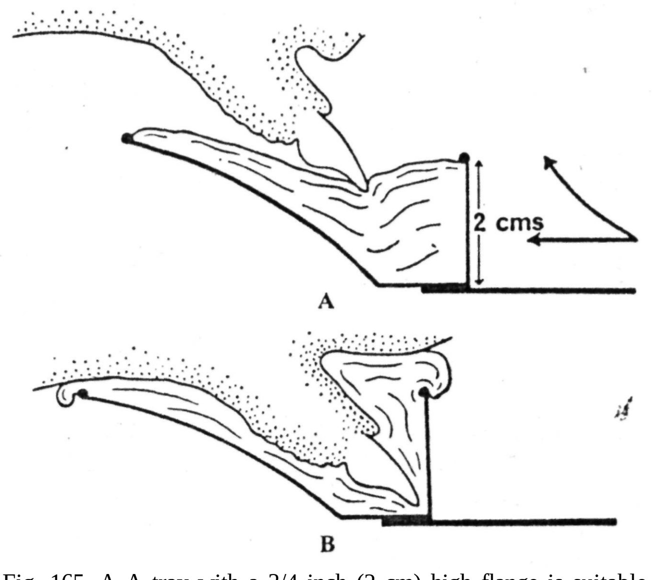


Fig. 165. A A tray with a 3/4 inch (2 cm) high flange is suitable for orthodontic impressions. Here it is being inserted for an upper impression in an upward and backward direction in order to extend over the alveolar process.

B Following the upward and backward insertion the excess material flows into the labial sulcus and is supported by the high flange of the tray.

the teeth in the usual occlusion for that patient. This should be obtained as accurately as possible with a 'W'-shaped roll of wax, between the posterior teeth (Fig. 166), and care must be taken not to distort it on removal from the mouth.

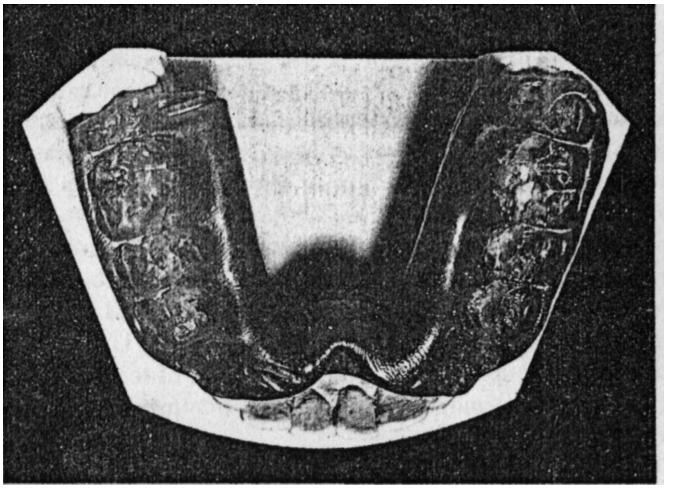


Fig. 166. A 'W'-shaped wax bite to record the correct occlusion.

Model Trimming

The impressions are cast as far as their periphery in stone plaster, as this makes the cusps and incisor edges more resistant to fracture, but white plaster may be used in the base-formers (Fig. 167), or in other methods to provide a neat appearance to the bases. Between six and

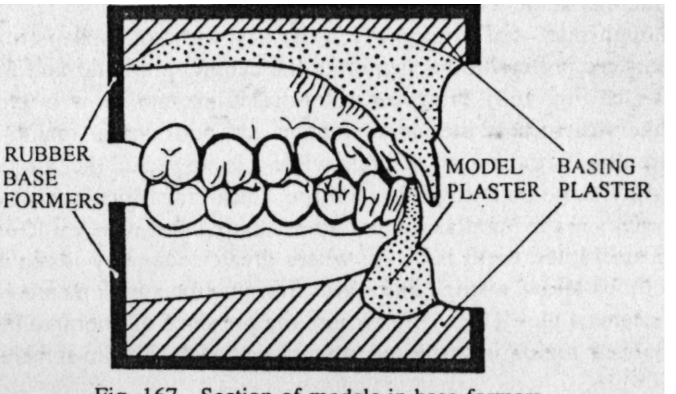


Fig. 167. Section of models in base formers.

twelve sets of models can be based at one lime if a delaying agent is added to the white basing plaster.

(b) *Radiographs*

Radiographs are used as an aid to diagnosis in orthodontics for the following purposes:

(i) To establish the absence or, if present, the exact position of unerupted teeth. This is of particular importance when extractions are contemplated: e.g. if the second deciduous molars are still present, the presence of the unerupted second premolars must be established before extraction of the first premolars can be contemplated (see pages 80 and 136).

(ii) To establish the presence or absence of supernumerary tcelh, especially in those cases in which there is a space between the upper and central incisors or where there is a misplaced central incisor (see Fig. 53, page 85 and Fig. 90, page 141).

(iii) To confirm the axial inclination of the roots of teeth, especially where extraction may form part of the treatment (see Fig. 75, page 118).

(iv) To determine the extent of calcification or resorption of the root of a tooth,

(v) To confirm the identity of a tooth; e.g. in a patient of twelve years with only one permanent molar erupted, a radiograph would reveal the stage of its root formation and whether other molars were present,

(vi) To confirm the presence and extent of pathological and traumatic conditions; e.g. an apical abscess or the fracture of a root,

(vii) When thought necessary, to confirm diagnoses with the aid of tracings made from cephalometric radiographs.

Although intra-oral films provide the best view of incisors extra-oral films are preferable for depicting the canine, premolar and molar regions (sec Fig. 168). However, intra-oral films can show in clearer detail the structure of the alveolar bone and periodontal membrane. They are therefore the most suitable when it is suspected that a tooth is affected by some pathological condition. Intra-oral films may also be used in pairs in the parallax method to ascertain upon which side of the arch an unerupted tooth is lying; where greater accuracy is required, and facilities allow, a single intra-oral film may be supplemented by a vertex occlusal view (Fig. 169). Where the presence of unerupted teeth in the incisor region is suspected, an anterior occlusal film is valuable (Fig. 169).

Fig. 168. Rotated oblique lateral radiograph used to show the upper and lower canines, premolars and molars.

Extra-oral Radiographs-
Extra-oral radiographs may be taken with a standard dental X-ray machine and arc especially useful for young children because:

(i) Tiicy require less co-operation as they avoid the discomfort of holding an intra-oral film in the lower lingual sulcus,

(ii) They require less exposure, i.e. two rotated oblique lateral views and two anterior occlusal views give a complete picture of the child's dentition; the equivalent in twelve smaller intra-oral films would involve three times the exposure,

(iii) A wide field is visible from the antral and nasal floor down to the lower border of the mandible showing any uncruplcd extra teeth or other anomaly outside the field of the smaller intra-oral film.

When taking a rotated oblique lateral view, for economy, a l/2 -plate cassette (or its modern metric equivalent 13 cm x 18 cm) containing intensifying screens may be used with a lead-rubber flap protecting one half of the film whilst the other half is being exposed (Fig. 171).

As these extra-oral films arc not provided with an embossed 'pip', it is necessary to use a metal marker to indicate the side of the patient being radiographed. A head-positioning board and a wire antenna may be used to simplify the technique (Fig. 171).

Alternatively a panoramic view of the whole dentition extending from the nasal floor to the lower border of the mandible may be obtained by means of a rotating panoramic X-ray machine such as an Orthopantomograph or a Panorex (Fig. 172).

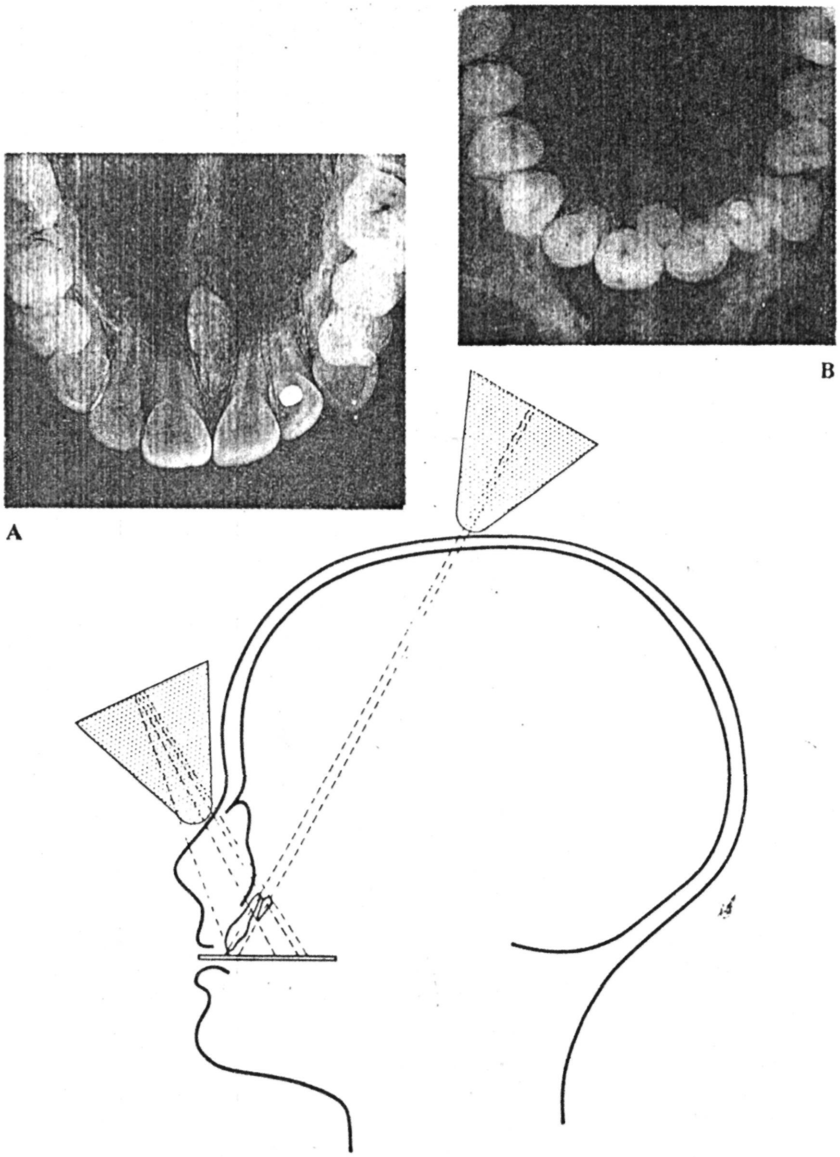


Fig. 169. Position of dental X-ray cone when talcing:
A An anterior occlusal view and
B A vertex occlusal view
(With acknowledgement to G. H. Roberts)

When an unerupted tooth is situated beyond the apices of erupted teeth, its exact position may also be localized by using an antero-posterior and a lateral skull film. It is common practice to use for this purpose the machine for taking cephalometric radiographs.

(c) *Cephalometric Radiographs*

In order to study the growth changes in the human skull, Broadbcnl in 1931, introduced a radiographic technique whereby the head was positioned in a specially designed headholdcr (ccphalostat) by means of car rods, so that, at regular intervals, serial frontal and lateral radiographs of the same individual were obtained with the minimum of inaccuracy (Fig. 173). Information gathered from these growth studies has encouraged its employment as an aid to diagnosis.

In order to compare cephalometric radiographs with one another, it has been found necessary to trace the outline of the relevant structures on acetate tracing paper. The traced outlines can then be superimposed. This is made meaningful by locating each tracing by means of a fixed point, or registration point. This point should be capable of precise identification and should be as free as possible from the influence of growth. Although a number of registration points have been used in the past it is now common practice to use the centre of SellaTurcica. Further location is required in order to orientate the tracing around the registration point, and the line S.N. (Sella Turcica to the 'front-most' point of the fronto-nasal suture) is now frequently used for this purpose. It has been shown by De Coster that the small amount of growth change to be expected here after the age of seven years makes this area of the cranial base an acceptably stable site for the registration of lateral skull radiographs.

Where quantitative analysis and comparison is to be made it is necessary to make measurements. In order to overcome difficulties arising from enlargement and the projection of a three-dimensional structure on to a two-dimensional image the measurements are not linear but angular only. It has been found that the measurement of an angle which subtends a dimension on the radiograph is less deceptive than the use of linear measurement itself. For this purpose several planes are used, some of which have been derived from anthropology (Fig. 174).

The technique for using these radiographs is described in detail elsewhere, and the reader who wishes to pursue the subject further is advised to refer to the bibliography at the end of the book.

Fig. 170. Path followed by the centre beam of the X-rays when taking a rotated oblique lateral radiograph.

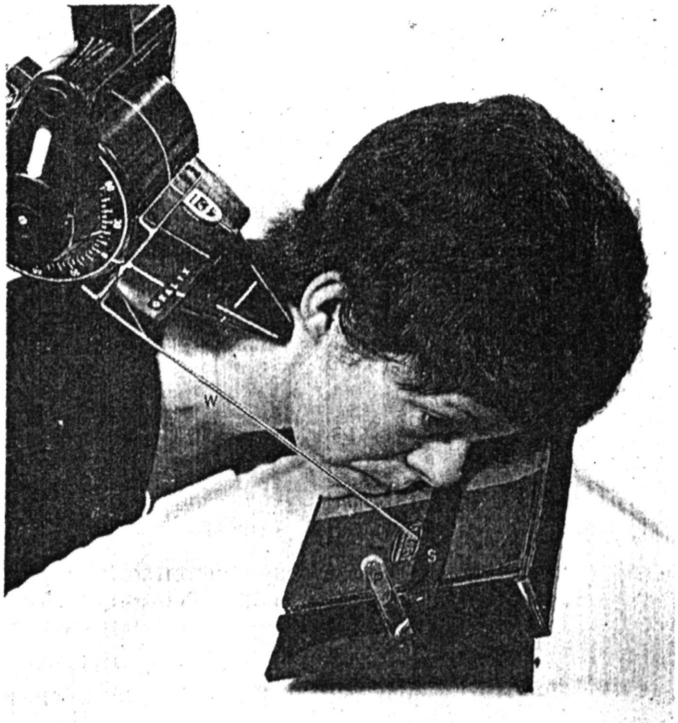


Fig. 171. Relationship of the tube, patient and the cassette when taking a rotated oblique lateral radiograph. W is the wire antenna, P the ear post, F the lead rubber flap and S the strip over the lead markers.

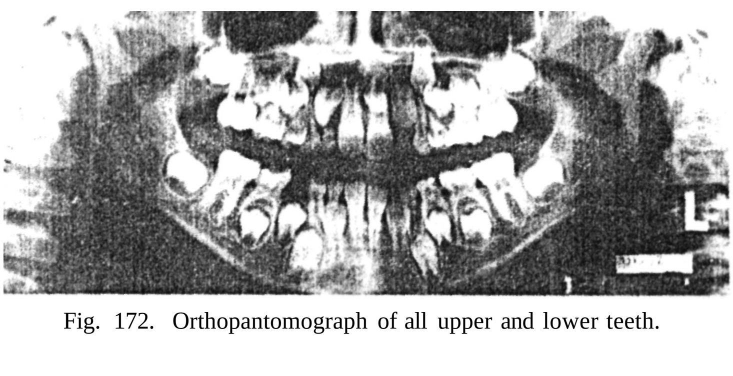


Fig. 172. Orthopantomograph of all upper and lower teeth.

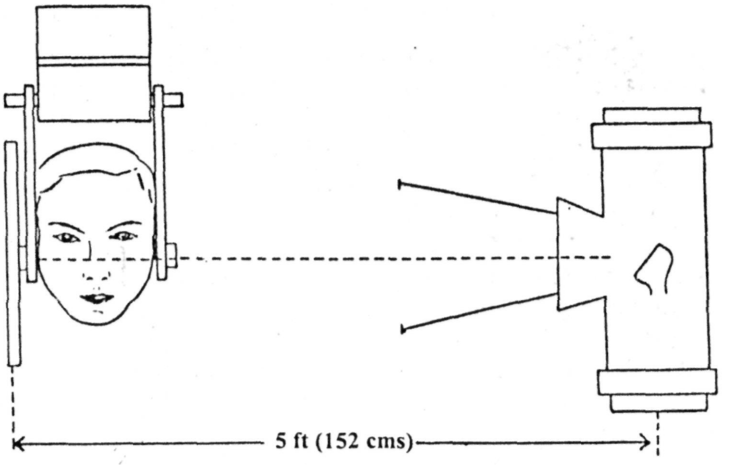
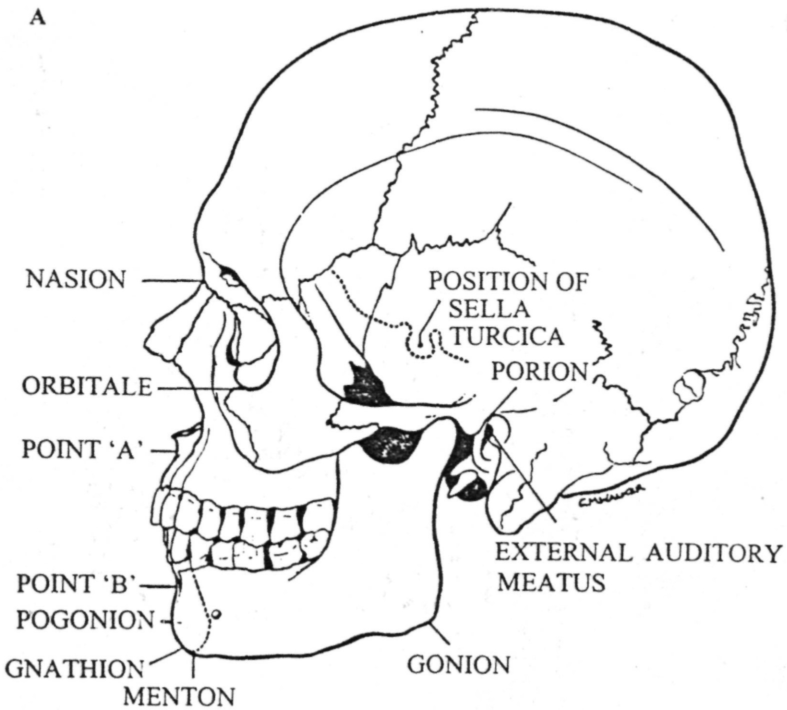


Fig. 173. Drawing of patient in cephalostat.

Points of reference used in cephalometry

Porion (P)	The highest bony point on the upper margin of the external auditory meatus.
Nasion (N)	The most anterior point midway between frontal and nasal bones on the fronto-nasal suture.
Orbitale (O)	The lowest point on the inferior bony margin of the orbit.
Point A (A)	The deepest point in the mid-line between the anterior nasal spine and the alveolar crest of the maxilla. It is usually found by drawing a tangent to this contour from nasion.
Point B (B)	The deepest point in the mid-line between the alveolar crest of the mandible and the mental process. It is usually found by drawing a tangent to this contour from nasion.
Menton (M)	The lowest point on thp cross-section of the mandibular symphysis.



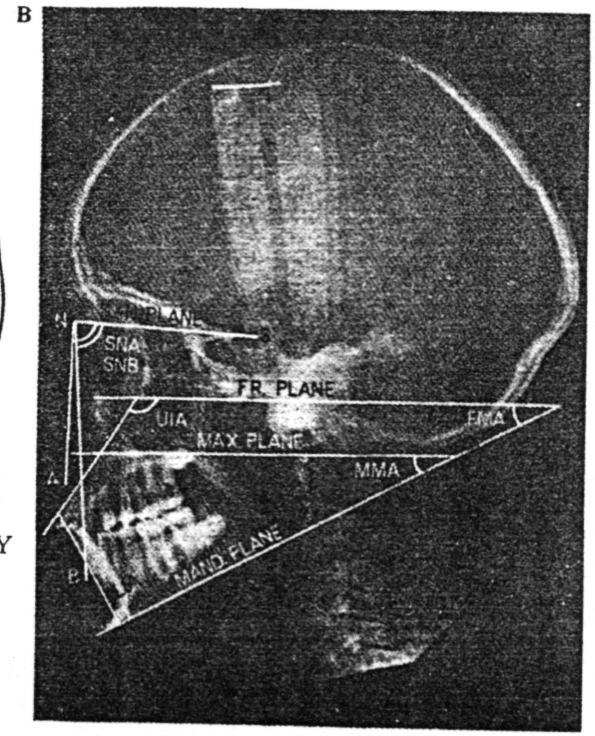


Fig. 174. A Points used in cephalometric radiology.

B Planes used in cephalometric radiology.

Gonion (Go)	The point on the angle of the mandible crossed by the bisector of that angle formed by the mandibular plane and plane tangent to the posterior border of the vertical ramus.
Sella Point (S)	The mid-point in the outline of Sella Turcica determined by inspection.

The following planes are used in cephalomctric analysis:

Sella-Nasion Plane (S-N)	This plane is now usually used for registration. It has also been used as a baseline for growth studies,
Frankfort Horizontal Plane (P-0)	This plane passes through both poria and the left orbitale. It has the advantage of being identifiable clinically as well as on a radiograph.
Maxillary Plane	This extends from the anterior nasal spine (ANS) to the posterior nasal spine (PNS) and is possibly easier to identify on a ccphalograph than the Frankfort Horizontal Plane.
Mandibular Plane (MP)	This plane passes through menton and both gonia. It is usual to take the mid-point between the two gonia when drawing it upon a tracing.
Axial inclination of upper central incisor (UIA)	A line drawn through the incisal edge and root apex of an upper central incisor. It is usually extended to intersect the Frankfort plane, the average angle being 109°.
Axial inclination of lower central incisor	A line drawn through the incisal edge and root apex of a lower central incisor. It is usually extended to intersect the mandibular plane, the average angle being 89°. It has been found to be inversely proportional to the Frankfort mandibular plane angle when the incisors are in normal contact.

The following angles may be used in making clinical assessments:

Frankfort-Mandibular Plane Angle (FM A)	The angle formed by backward continuations of the mandibular and Frankfort planes is used as a measure of vertical development of the anterior part of the face. The infra-nasal height is proportional to the size of this angle which averages 28°.
Maxillary-Mandibular Plane Angle (MMA)	The angle formed by the backward continuation of the maxillary and mandibular planes. Its use is similar to that of the Frankfort-Mandibular Plane Angle. It also averages 28°.
Sella-nasion to Point A Angle (SNA)	This angle is a measure of the degree of prominence of the upper dental base '(maxillary prognathism). Its average is 82°.
Sella-nasion to Point B Angle (SNB)	This angle is a measure of the degree of prominence of the lower dental base (mandibular prognathism) its average being 77°. Comparison of these two angles will show the relative prominence of the upper dental base to the lower. A difference of 2-5° will occur in Skeletal Class 1 cases. Difference of more than 5° or less than 2° will occur in Skeletal Class 2 and Class 3 cases respectively.

13. Diagnosis and Treatment Planning

The analysis of data gathered during the examination of the patient and its application in formulating a plan of treatment is a most exacting aspect of orthodontics, for it is here that experience and judgment arc of foremost importance. In making a diagnosis it is necessary not only to assemble all the relevant facts, but also to weigh the importance of each in determining the course of treatment. A treatment plan will include, in addition to the results of clinical observation, an assessment of any circumstances which may diminish the success of treatment such as caries or non-co-operation. Before discussing treatment planning in detail, it would be appropriate to outline the objectives of treatment.

These are:

(i) To produce a satisfactory harmony between tooth size and the dental arch size,

(ii) To improve the occlusion between the dental arches,

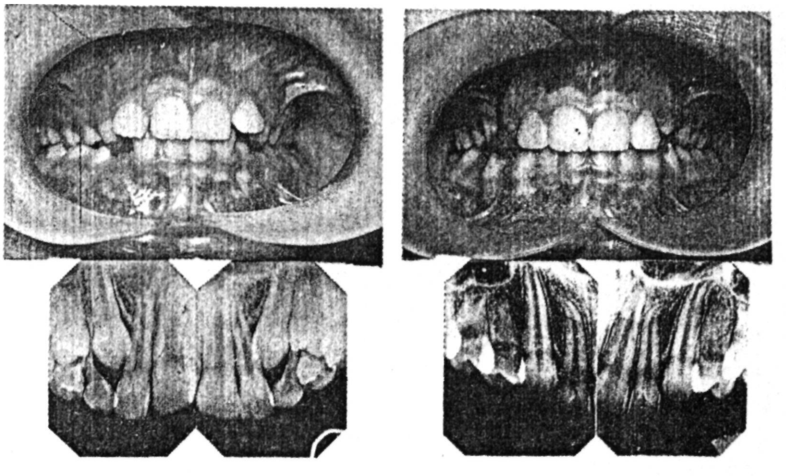
(iii) To produce a pleasing dental and facial appearance.

The importance of maintaining the muscles associated with the jaws and teeth in a state of equilibrium must not be forgotten. A balance of the muscles in keeping with the type of malocclusion may already have been created and even an untreated case is unlikely to present itself in a state of structural balance, e.g. the lower lip lying palatal to prominent upper incisors (see Fig. 62, page 96). If a stable result of treatment is to be obtained, a muscular balance which will tend to maintain the teeth in their new occlusion must be assured (see Fig. 31, page 47).

THE PARENT'S POINT OF VIEW

The objective of parents is often limited to an improvement in the

appearance of the.anterior teeth of their child (see Fig. 178, page 257). Because of their unfavourable appearance, it is probable that Class II Division 1 malocclusions prompt more patients to attend than any other malocclusion. Slight irregularities in the alignment of teeth commonly accompany the early stages in the development of the permanent dentition and it may only be with difficulty that the dental surgeon succeeds in convincing the parent that what appears to be the forerunner of an ugly arrangement of the anterior teeth, is merely a temporary phase during the process of normal development. Concern is often expressed regarding the distal tipping of the crowns of the permanent upper incisors shortly after they have erupted. Such a condition is frequently due to the influence of the developing canine upon the root of the lateral incisor (Fig. 175). Left alone, this condition will often correct itself as the crown of the canine descends.



A B

Fig. 175. Case showing distal inclination of the upper lateral incisors at the time of their eruption. Although this condition may cause anxiety to the parent, it often becomes resolved spontaneously.
A At 10 years 2 months. B At 11 years 6 months.

Anxiety on the part of the parent that the child shall possess teeth in perfect alignment is an excellent and desirable reason for seeking treatment. This may enable the dental surgeon to treat many cases in the early stages of mal-development. Other cases may arise where the

immediate treatment can be confined to a reassurance of the parents and to careful observation of the development at regular intervals, with the possibility in mind of removing permanent teeth to allow other teeth to develop into better alignment.

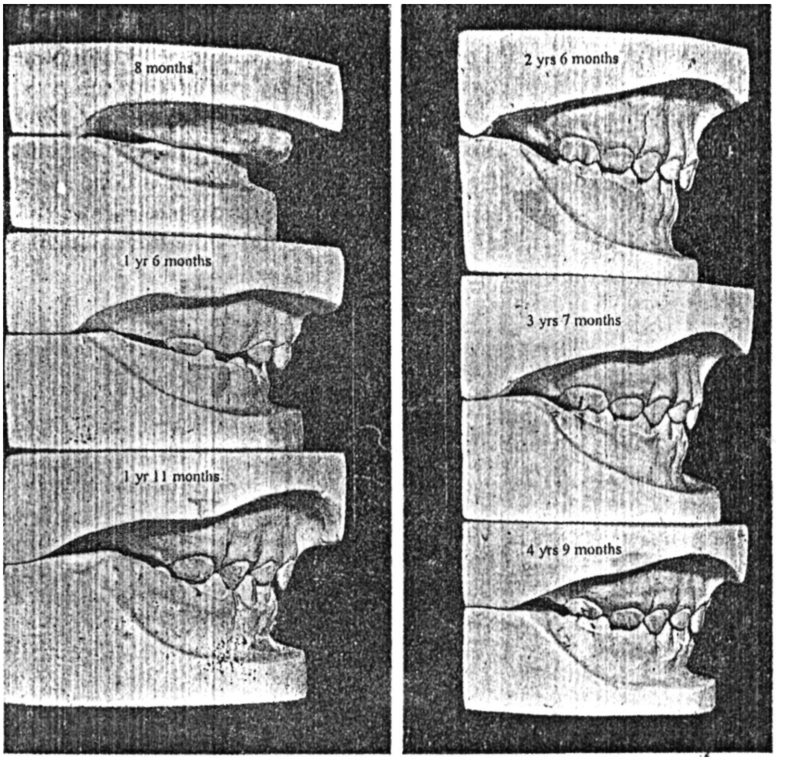
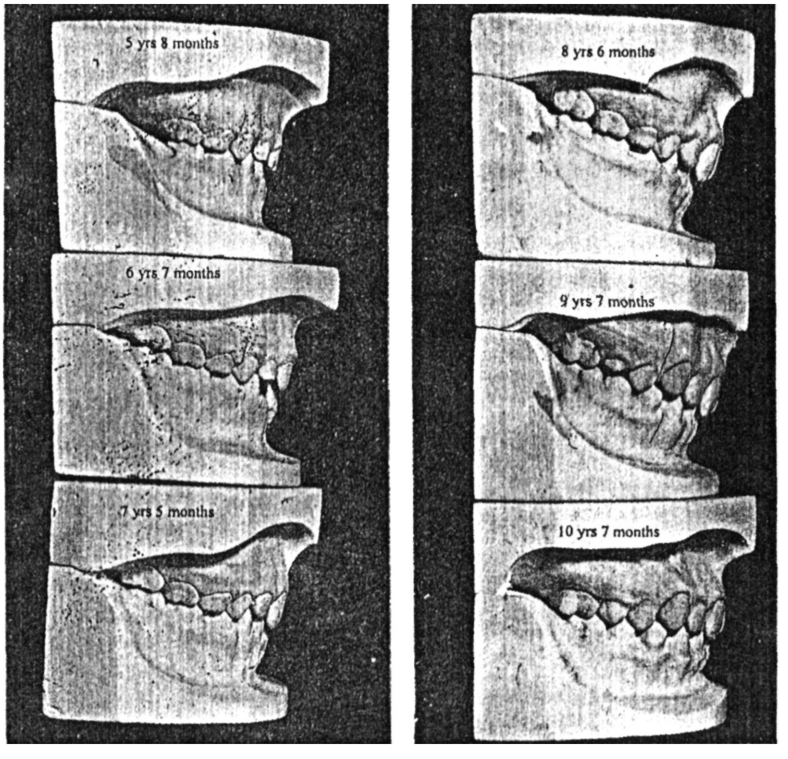


Fig. 176. Series of study models of a patient to show the development of normal occlusion from.
8 months; 1 year 6 months; 1 year 11 months, 2 years 6 months; 3 years 7 months; 4 years 9 months; 5 years 8 months; 6 years 7 months; 7 years 5 months; 8 years 6 months; 9 years 7 months to 10 years 7 months.

THE DENTAL SURGEON'S POINT OF VIEW

In addition to aesthetics, the dental surgeon must be concerned with the quality of individual teeth, the functional efficiency and stability of the masticatory apparatus and the availability of the child for treatment. In a child the masticatory apparatus is not static. The dentition and the

occlusion are undergoing constant change during the process of normal development (Fig. 176) and the dental surgeon must be familiar with this constantly changing picture. It is necessary to be aware of the influence of ethnic factors as well as characteristics inherited from each



parent. Only with this knowledge will the dental surgeon be able to recognize abnormalities during their early stages of development and advise upon their treatment. Seldom indeed is a child brought to the surgery by a parent anxious about a lack of functional efficiency in the dentition. It is the duty of the dental surgeon to advise the parent upon such matters. Though he may not feel competent to deal with the treatment of all types of malocclusion, he is obliged to advise whether the services of a specialist should be sought and how they may be obtained. It is also the responsibility of the dental surgeon to ensure that in addition to a desire to have their child's teeth aligned, the parents arc also realistic about the part they will need to play. It is especially

important for them to ensure the attendance of their child, often during school time, throughout what may be a prolonged course of treatment, stretching over several years.

PLANNING TREATMENT

When considering treatment and prognosis, cases may be divided broadly into two types:

(i) Those with good anlcro-poslcrior and transverse rclalions between the upper and lower denial arches both to each other and to their respective bases (Fig. 177).

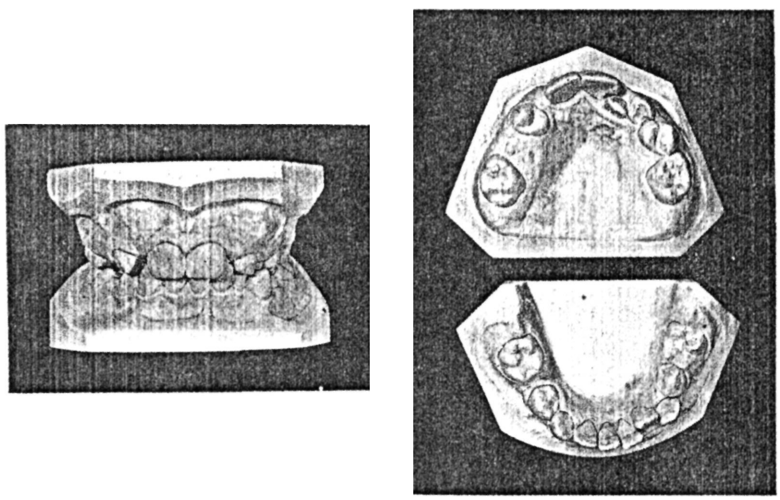
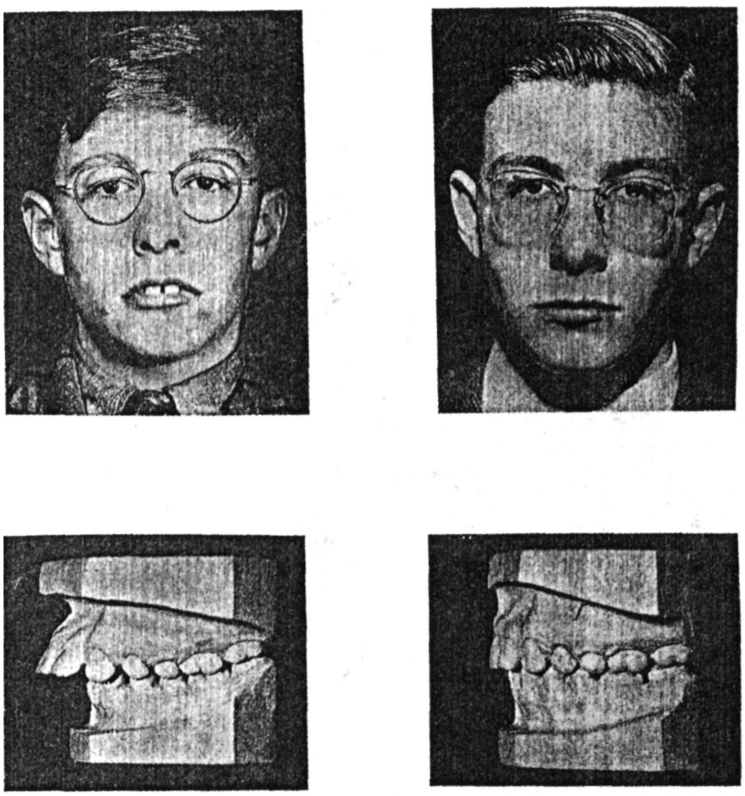


Fig. 177. Case of crowding in addition to which there has been mesial movement of the permanent molars after early loss of deciduous molars.

(ii) Those in which the antero-posterior or bucco-lingual relation of the arches or segments of the arches is disturbed (Figs. 178 and 179).

The former require treatment to correct the alignment of the teeth within each arch, whereas the latter need also subsequent correction of the relationship of the arches or segments of the arches. It is amongst these latter cases that the possibility of eventual relapse must be considered most seriously; should this be likely, modification of the treatment plan may be necessary.



A B

Fig. 178. A boy for whom appearance as well as function was improved by simple orthodontic treatment.
A Before treatment. B After treatment

The preparation of a treatment plan requires careful consideration of the information assembled after examining the patient, parents, study models and radiographs. Eventual decisions are placed in a logical sequence thus:

(i) Estimation of co-operation from patient and parents,
(ii) Assessment of the condition of the teeth and the oral hygiene,
(iii) Whether or not extraction is needed to create space for tooth movement,
(iv) Nature of tooth movement(s) and type of appliance(s) required.

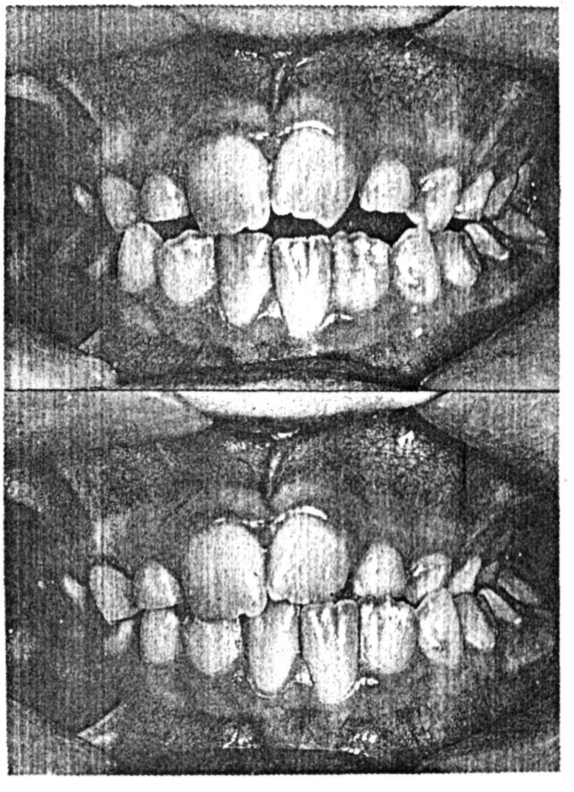


Fig. 179. Lateral path of closure associated with premature contact of the buccal cusps of the molars and the canines.

(a) *Co-operation*

Before treatment is commenced, it is wise to discuss the plan of treatment with one or both parents. In this way their interest can be stimulated beyond a mere desire to have the front teeth 'straightened' and the possibility of treatment being forsaken when only partly accomplished can be avoided. While it may be undesirable for the parents to be present in the surgery at each visit of the child, they appreciate a short progress report at intervals.

As most forms of orthodontic treatment involve regular visits, the operator must satisfy himself that both patient and parents are sufficiently interested to undergo the full course of treatment and will observe carefully all the instructions. If the patient lives at a distance, the parents must be prepared to sacrifice time and schooling to make the treatment possible. Of the number of cases accepted for treatment, it is frequently found that a smaller number are completed, owing to loss of interest by the patient or the parents. This occurs especially where the alignment of the incisor teeth is accomplished early in the course of treatment.

(b) *Condition of Teeth and Oral Hygiene*

Because caries may determine the choice of teeth for extraction, it is essential to undertake full conservation treatment of the teeth before extractions or appliance therapy are commenced.

(c) *Extractions and their Timing*

This subject has been dealt with at some length in Chapter 7 (Therapeutic Extractions and Other Surgical Procedures). Because of the high prevalence of crowding in this country, extractions are a necessary part of treatment in a large proportion of cases.

(d) *Tooth Movement and Type of Appliance*

The tooth movement required will be indicated by the nature of the defect in tooth position. Provided this defect in position is confined to the crown without the root apex being displaced, simple appliance therapy to move the crown into a more favourable position may be the only treatment required. Bodily movement of the roots of the misplaced teeth (see Fig. 36A, page 59) is usually more difficult to accomplish and frequently requires the use of fixed appliances.

If there are doubts about co-operation or attendance because of travelling problems or boarding school, due allowance should be made for this when determining the type of appliance to be used. Similarly, facilities provided by the technical laboratory may impose limitations on the complexity of the appliance required.

PLANNING TREATMENT FOR VARIOUS MALOCCLUSIONS

Certain well-recognized malocclusions have come to be associated with British children: the rest of this chapter will be devoted to summarizing the treatment of these malocclusions. It must be emphasized strongly that no two cases of malocclusion are exactly alike in their nature and

response to treatment, and the summary which follows must be read with this in mind.

Generalized crowding

This affects many forms of malocclusion and usually, in Britain, involves the extraction of teeth to provide the space needed for aligning the remaining teeth. The lower arch should be considered first because the labio-lingual position of the lower incisors is not easily changed and attempts to create space by moving the lower molars distally may prove difficult. If reduction in the number of lower teeth is indicated, it will usually also be necessary to remove compensating upper teeth in Class 1 and Class II malocclusions.

In Britain a common form of treatment to eliminate crowding in both dental arches is to extract all four first premolars using the space provided to arrange the remaining teeth in better alignment (Fig. 180).

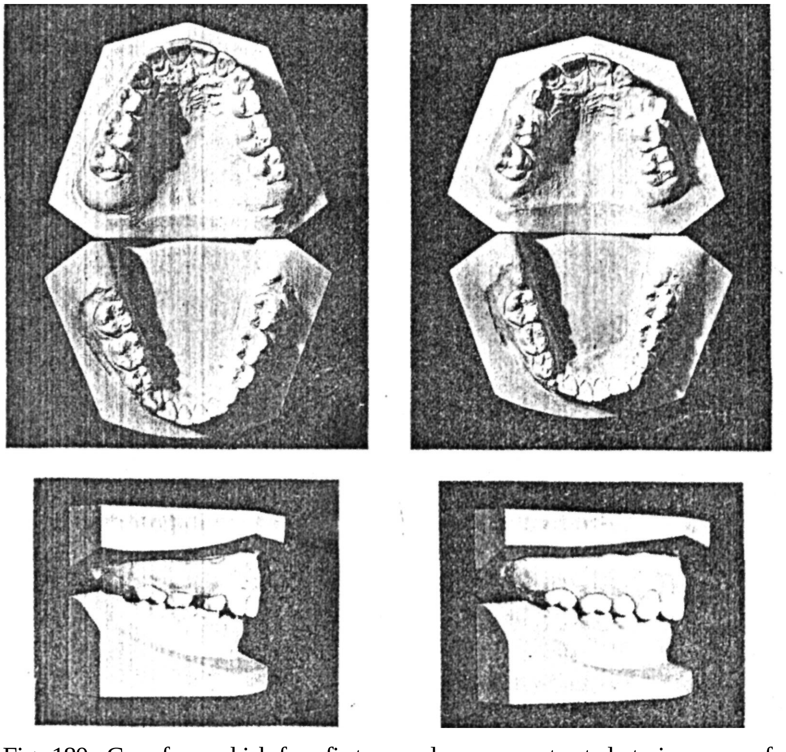
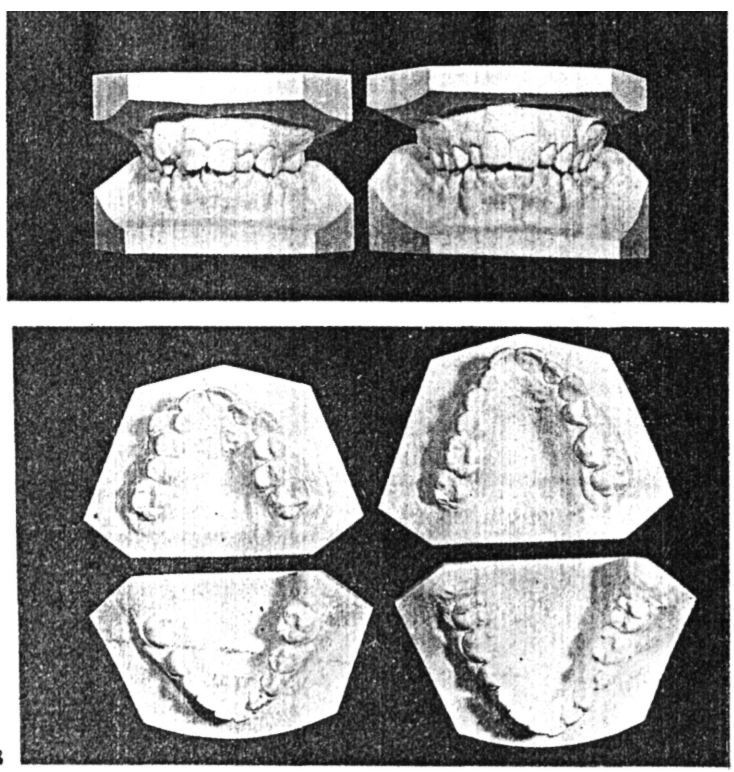


Fig. 180. Case from which four first premolars were extracted at nine years of age.

This has the advantage of creating space near to the anterior region where the crowding is usually apparent. Such a decision however will depend not only upon the age at which the child presents for treatment but also the extent of caries present. Should the case present before the first premolars have erupted, consideration may be given to extracting these teeth surgically (see page 128) or initiating a programme of serial extractions (see page 126) in order to allow spontaneous alignment of permanent incisors as they erupt. It should be borne in mind that members of other ethnic groups with dental arches of a more generous size may present with apparent overcrowding at an early age, which, however, may resolve itself during further development without the need for extraction.

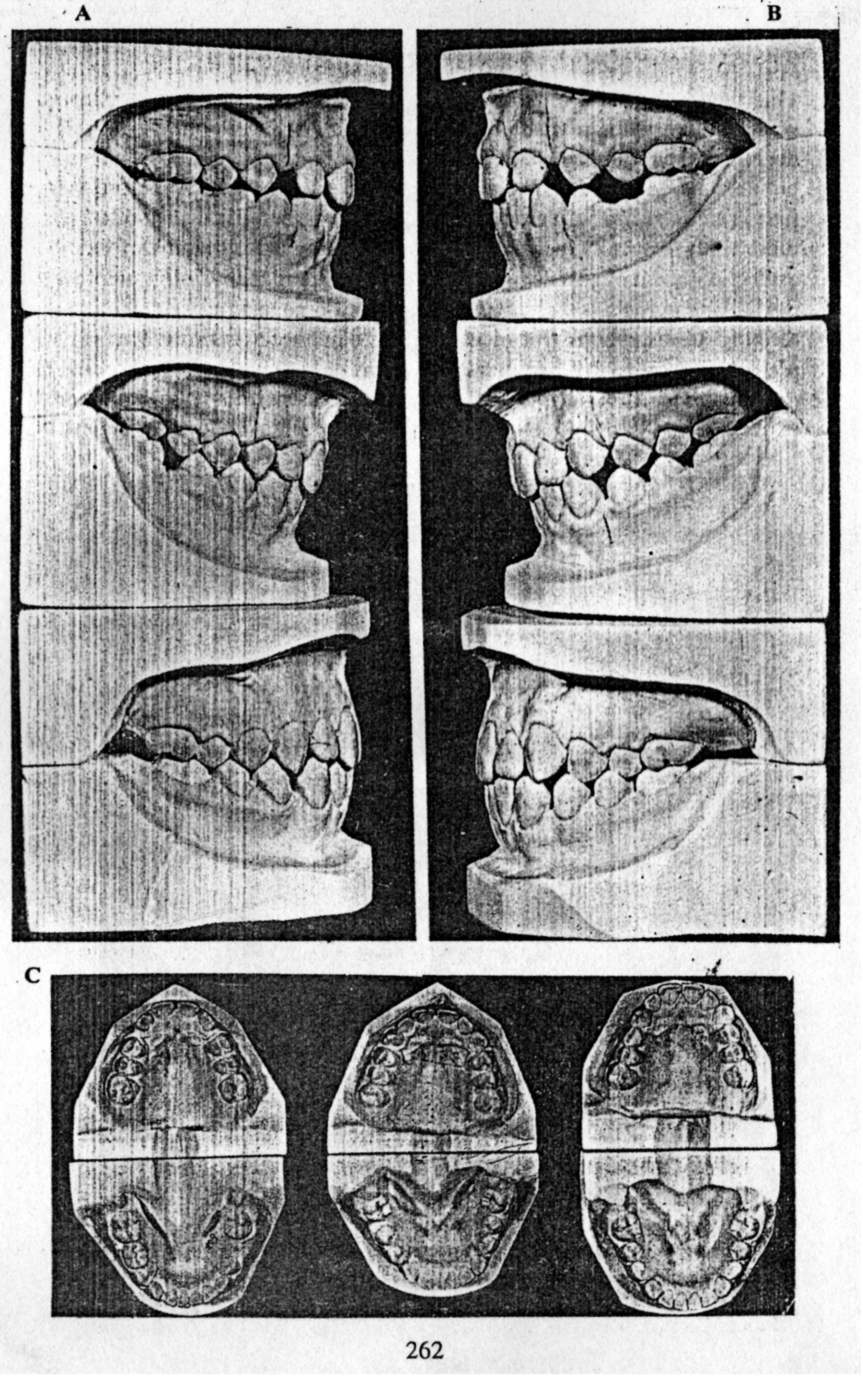


A

B

Fig. 181. Case from which a right upper canine was extracted at twelve years of age together with a left upper second premolar and two lower first premolars.

A. Front view. B. Occlusal view.


A
B
C

Providing the space created by extracting the first premolars proves adequate, spontaneous alignment of the anterior teeth may occur in the lower arch where muscle pressure from the tongue and the lower lip combine with a favourable incisor overbite to align the lower incisors. Because the forces are gentle and intermittent, the process is a slow one. However this is much less likely to occur in the upper arch where an appliance might be needed to effect the tooth movement. In the absence of any restraint from an appliance, the molars and second premolars will also be free to move mesially into the space created. Where crowding of incisors is severe, it will be necessary to ensure that as much of the space as possible is made available for their alignment by using immediately upper and lower active appliances to retract the canines before undertaking alignment of incisors. Should the canine be inclined distally, that is with its root apex displaced mesially, its bodily movement with a fixed appliance would be required in order to achieve a distal movement of the root. Occasionally the position of the canine may make it necessary to extract an incisor or even the canine itself (Fig. 181).

Although the extraction of first premolars is commonly chosen in this country for the treatment of crowding, it may be contra-indicated where other permanent teeth arc absent or in poor condition. It is not uncommon for second premolars to be congenilally absent when space is better provided by extracting the second deciduous molars. If the prognosis of the first permanent molars is poor, the extraction of these, instead of the first premolars, must be considered (see pages 104 and 122). Where crowding is mild, extraction of the first permanent molars at about the age of nine years may, occasionally, give adequate results without the use of appliances (Fig. 182). Delay in the extraction of lower first permanent molars may result in spacing between the second premolars and second permanent molars. When incisor crowding is moderate or severe, spontaneous improvement following the extraction of the first permanent molars is unlikely to be adequate. In such cases it may be advisable to delay the extraction of first molars, conserving them if necessary, until the second permanent molars have erupted into occlusion; subsequently an appliance will prevent their mesial movement whilst moving distally the premolars and canines.

Fig. 182. Class 1 case from which all four first permanent molars were extracted at the age of nine years. Note the undesirable rotation of the second premolars.
A. Right side.
B. Left side.
C. Occlusal view.

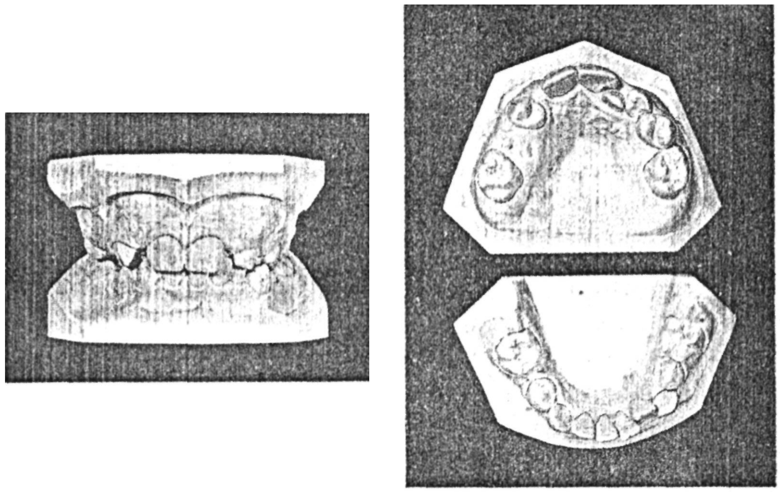


Fig. 183. Case of crowding in addition to which there has been mesial movement of the permanent molars after early loss of deciduous molars.

Localized crowding

Local crowding, affecting only one segment of a dental arch usually arises when a tooth has been lost or has failed to erupt at the correct time. In the premolar region, space loss following premature extraction of a deciduous molar may occasionally be regained spontaneously in the lower arch. More frequently, however, there is already some generalized crowding (Fig. 183) and either appliances will be needed to regain the space or premolar extraction will be necessary.

Space loss in the upper incisor region may occur when a permanent central incisor is prevented from erupting into the arch by an uncruptcd supernumerary tooth (Fig. 184) or because its root is d'ilacerated following a blow to the deciduous predecessor. Where damage to the permanent central is severe its extraction is unavoidable (sec Fig. 70, page 112).

Crowding in the lower incisor regions may be accompanied by a bunching together of the incisor apices (see Fig. 75, page 118). In such cases, the extraction of one incisor may be indicated and treatment so planned as to leave the neighbouring teeth vertical (Fig. 185). The case illustrated in Fig. 74 on page 117 shows how the results of lower incisor extraction can sometimes be unpredictable; it is important therefore to obtain the opinion of an orthodontic specialist before embarking upon the extraction of lower incisors.

Upper mid-line space

A common complaint from parents about the mixed dentition stage concerns the upper mid-line space or median diastema. Some of these spaces may simply represent a stage in the development of the dentition and require no treatment since they close spontaneously as the permanent canines erupt. Occasionally, a mid-line space persists beyond this stage. This may be due to a familial or racial tendency. Before any treatment is commenced, the presence of an unerupted supernumerary tooth should always be suspected and, if present, it should he extracted (see Fig. 53, page 85). Diminutive lateral incisors (sec page 84) or even their complete absence (sec page 81) may contribute to a mid-line space. After approximating the central incisors the small laterals may be crowned or, if absent, restored artificially (Fig. 186). In other

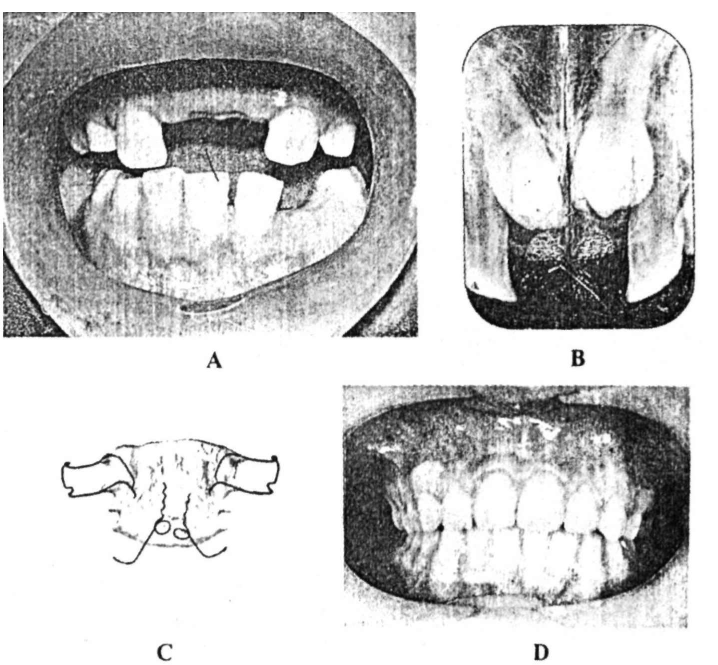


Fig. 184. A Space loss in the upper anterior region, caused by the presence of unerupted supernumerary tcclh which have interfered with eruption of the central incisors.

B Radiograph of the condition shown in A.

C The appliance which was used to increase the size of the space after removal of the supernumerary teeth.

D The final result of treatment.

A B C

Fig. 185. A Lower model of a patient of nine years of age with crowding of lower incisors which arc inclined distally.
B Tliree months after extraction of the lower left central incisor.
C Alignment of incisors, five years after the extraction.

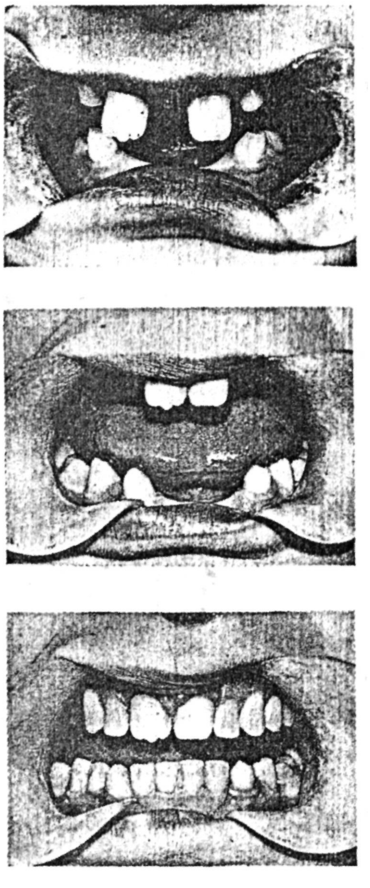


Fig. 186. A case of partial anodontia (oligodontia) in which a large upper central diastema was closed with an orthodontic appliance before fitting partial dentures.

cases upper incisor spacing may be caused by prociinalion of the incisors and may be resolved by their retraction.

In many cases it is necessary to move the central incisors together without causing them to tilt mesially. Such bodily movement may be accomplished by means of the appliance shown in Fig. 187.

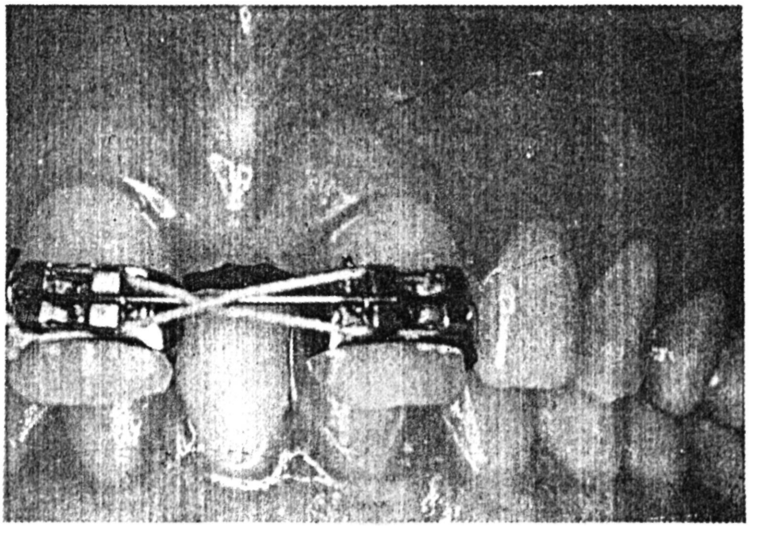


Fig. 187. Appliance used for reciprocal mesial movement of upper central incisors.

Very occasionally, a prominent upper labial frenum may be associated with a median diastema (Fig. 188). If the patient has reached the age of eleven years, this may be resected (see pages 129-131) and an appliance used to approximate the central incisors.

Lingual Occlusion of Upper Incisors

One or more permanent upper incisors may erupt into lingual occlusion with the lower incisors.This may have been brought about by a persistent deciduous incisor (see Fig. 85, page 136) or an uncruptcd supernumerary tooth, which should be removed before any tooth movement is attempted. If the patient presents as the incisor is erupting and there is sufficient room mesio-distally in the upper arch to receive the lingually inclined incisor, labial movement of the incisor(s) may be achieved by means of a simple removable appliance with half-capping (posterior occlusal blocks) and an auxiliary spring (see Figs. 114 and 115, page 180) or a

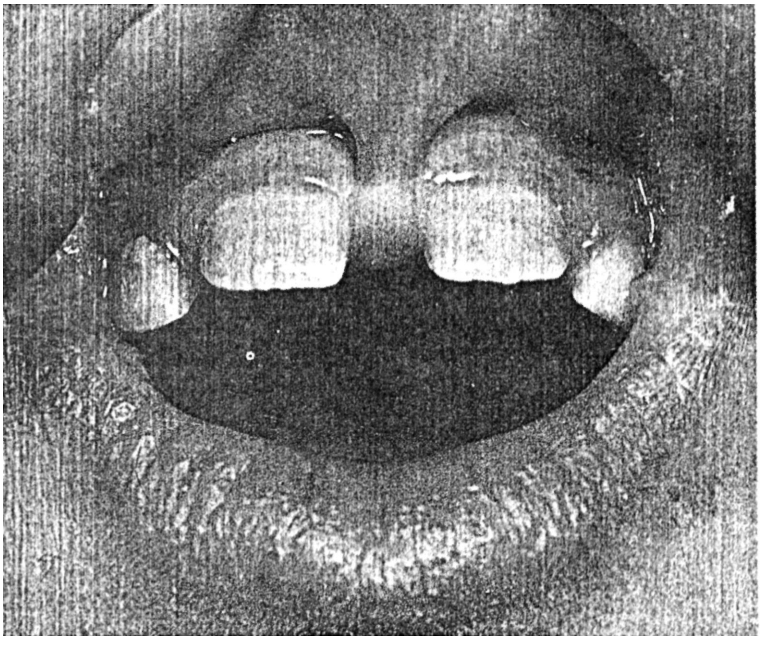


Fig. 188. Large fleshy frenum associated with spacing of upper central incisors.

small screw (Fig. 189 and see also Fig 197, page 282). If there is a small amount of crowding in the upper incisor region, the lingually occluded tooth or teeth may be corrected by moving all the upper incisors labially with a screw type appliance such as that shown in Fig. 107C on page 174. Where the crowding is severe and the canines have erupted into a position labial to the lateral incisor (see Fig. 71, page 114) it will be necessary to treat the crowding before attempting any labial movement of the incisors.

Transverse mal-relations

A bilateral posterior crossbite is usually associated with a skeletal discrepancy between maxilla and mandible. Most are skelctally pre-normal and others are associated with narrowness of the maxillary apical base. For this reason they do not respond to simple lateral expansion of the upper arch and may have to be accepted without treatment. A unilateral crossbite may also be associated with a mild skeletal disproportion between maxilla and mandible. More frequently, however,

these may have been associated with sucking habits which encourage a lingual inclination of the upper posterior teeth. Where there is no skeletal discrepancy, these cases of posterior crossbite respond very well to lateral expansion of the permanent upper dentition. This is indicated in all cases where there is a lateral deviation of the mandible on closure (Fig. 190). Where there is true asymmetry, it is necessary to limit tooth movement to the affected side (Fig. 191). Should an individual tooth be in a crossbite relationship and there is adequate room for its alignment in the arch, a 'T'-shaped palatal spring (see Fig. 116, page 181) or a screw (sec Fig. 108, page 175) may be used; altcrnalivcly bands may be fixed to the affected upper and lower teeth with hooks to carry an elastic ligature (Fig. 192).

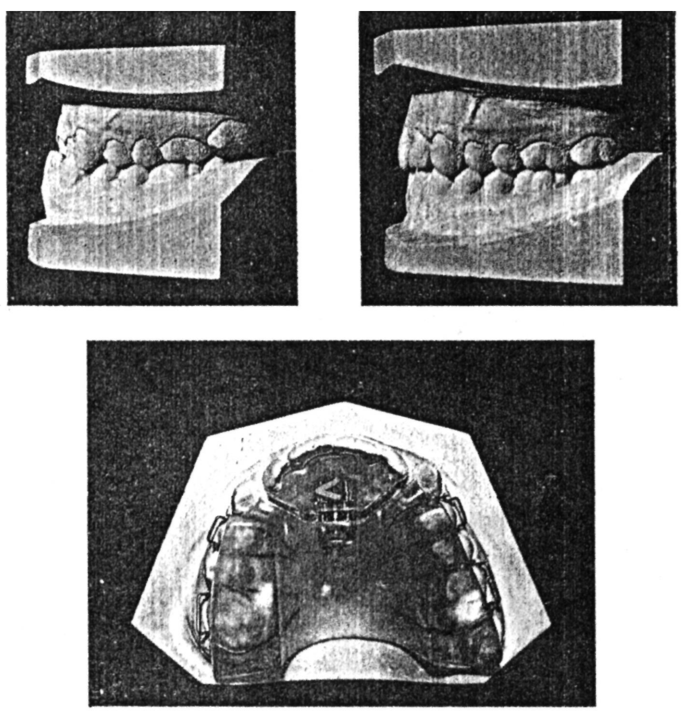


Fig. 189. Example of upper screw plate with posterior occlusal capping to reduce lingual occlusion of upper incisors as shown.

Buccal occlusion of upper molars or premolars outside their lower antagonists is a less common condition. Treatment should aim to expand the lower arch and, if necessary, to contract the upper arch. This latter

movement may be accomplished by using an appliance in which the acrylic is extended over the occlusal surfaces and on to the buccal side of all the upper posterior teeth. In the mid-line is an opened screw

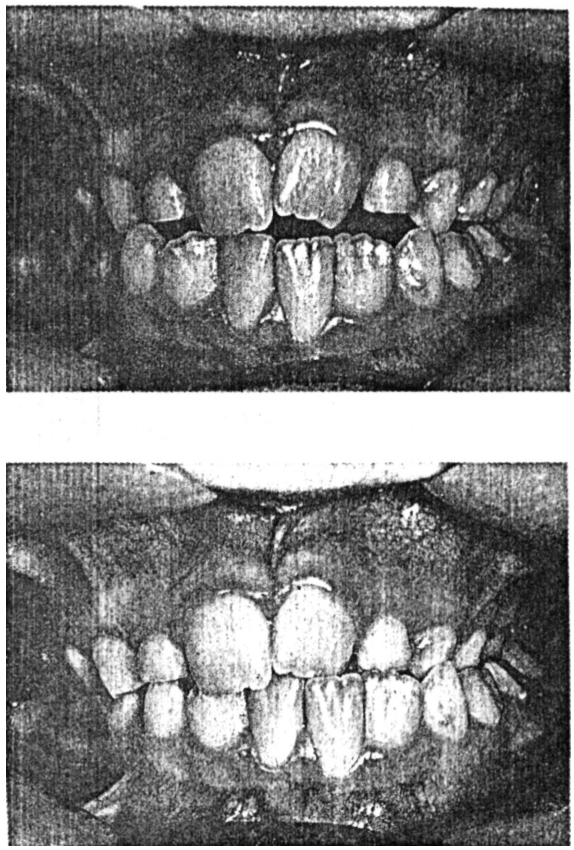


Fig. 190. Lateral path of closure associated with premature contact of the buccal cusps of the molars and the canines.

between the widely separated halves of the appliance. As the patient *closes* the screw the upper posterior teeth are moved lingually. Where buccal occlusion of some upper teeth occurs unilaterally, the possibility of an abnormal mandibular path of closure should always be borne in mind.

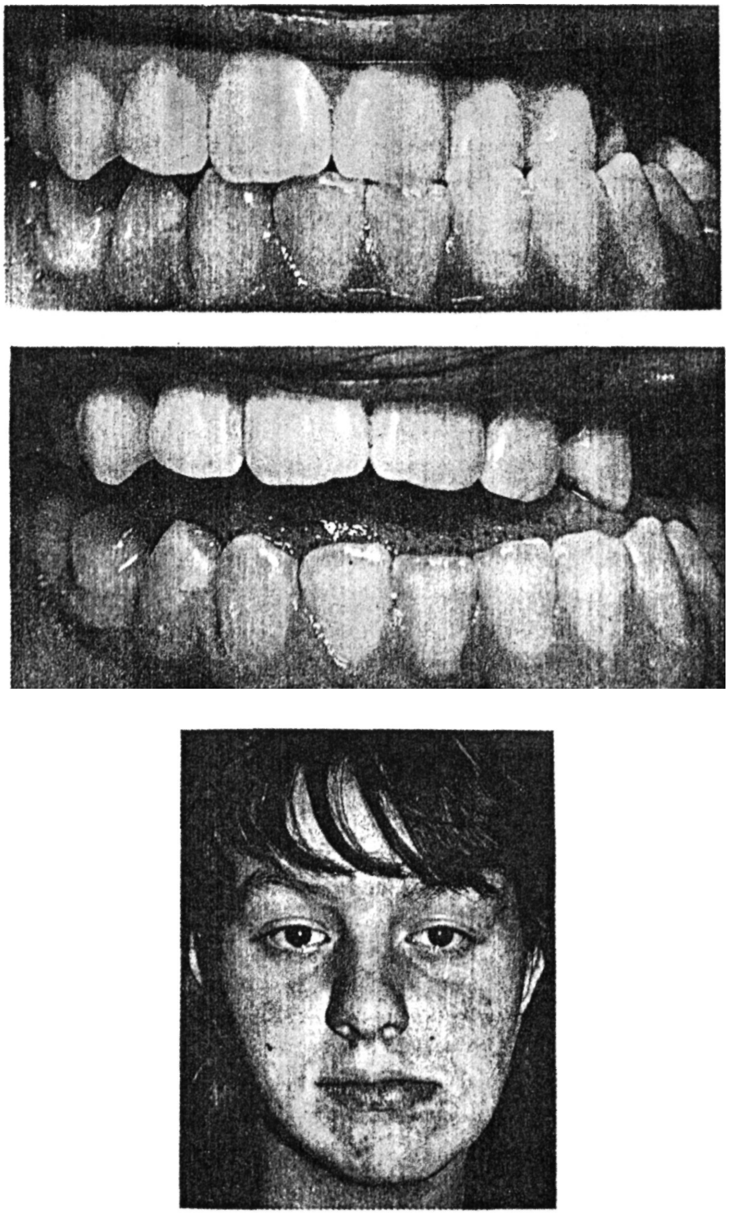


Fig. 191. Case in which a unilateral crossbite is associated with true asymmetry of the mandible. This is reflected in the facial appearance.

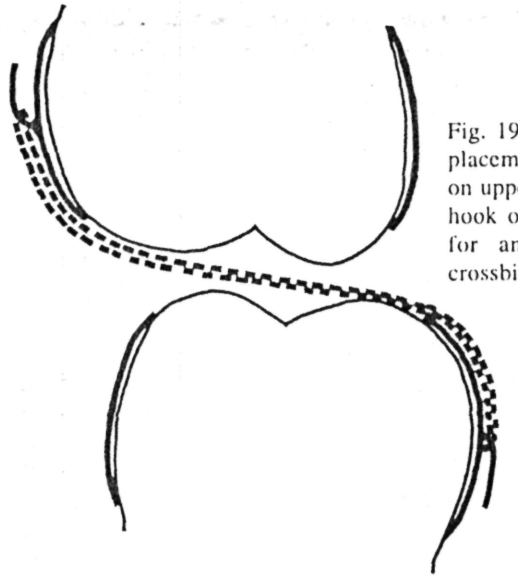


Fig. 192. Diagram to show placement of a palatal hook on upper molar and a buccal hook on lower molar bands for an elastic to correct a crossbite relationship.

Post-normal Occlusion With Pn)clination of Upper Incisors
(Class II Division 1 Malocclusion)

As many post-normal cases in this country arc complicated by crowding or by the drifting of permanent teeth following the premature loss of deciduous teeth (see page 102) the question of extraction is of some importance. Unless caries or spacing contra-indicatcs this, a commonly accepted form of treatment is to extract the upper first premolars, move the upper permanent canines distally, reduce any increased incisor overbite (sec page 72) then reduce the overjet by retracting the prominent upper incisors (Fig. 193). Such a form of treatment does not change the post-normal occlusion of the molar teeth. The question of extractions should not be neglected in the lower arch where any sign of crowding would make it necessary to consider extracting either the lower first premolars if the crowding is very marked, or the lower second premolars if the crowding is less marked, or even the lower second permanent molars; the choice would depend upon presence or absence of other tcclh and their condition. The question of anchorage is important when considering the distal movement of such long-rooted teeth as the upper canines, since it is possible for the upper posterior teeth to drift forwards ('anchorage slip') unless special precautions are taken. In order to overcome this difficulty it is possible to reinforce the anchorage of the

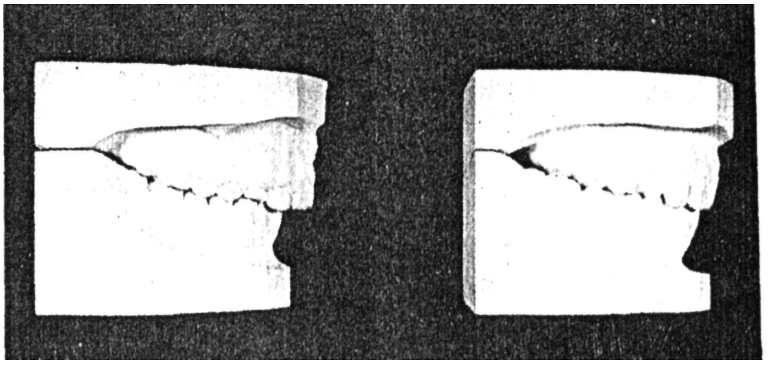


Fig. 193. Class II Division (1) case treated by extraction of upper first premolars. The upper canines and then the upper incisors were retracted with simple appliances. Lower second molars were extracted later.

upper plate with a sloping bite plane (sec Fig. 95, page 154) with a low labia! bow (sec Fig. 98, page 156) or a Svcd-lypc incisor capping (sec Figs. 96 and 97, page 155) or by extra-oral traction (Fig. III, page 177).

In those cases of Class II Division 1 malocclusion where crowding does not exist but the upper third molars arc present, the whole upper dental arch may be moved distally. Where there is some degree of spacing between the teeth in each arch, the lower arch may be used as anchorage from which to move the upper teeth distally. This may be accomplished by means of the Activator (sec pages 201-11) or even by some form of intermaxillary traction (see pages 1.79-80). If there is little or no spacing in the lower arch, the employment of any form of intermaxillary traction may cause lower incisor crowding by encouraging the forward movement of the lower teeth. This disturbance of lower teeth may be avoided by using instead extra-oral traction to move the upper teeth distally (sec pages 175-80). Often this is made easier by extraction of the upper second molars.

In Fig. 194 a case is shown where the extraction of first permanent molars at ten years allowed spontaneous correction of mild crowding. Should such a case also have a mildly post-normal occlusion, this may be corrected by using an Activator immediately after the extractions (pages 201-11). If the prognosis for the first permanent molars is poor and there is a severe post-normal occlusion, it may be advisable to delay the extraction of the upper first permanent molars until the upper second molars have erupted. It is possible with removable appliances

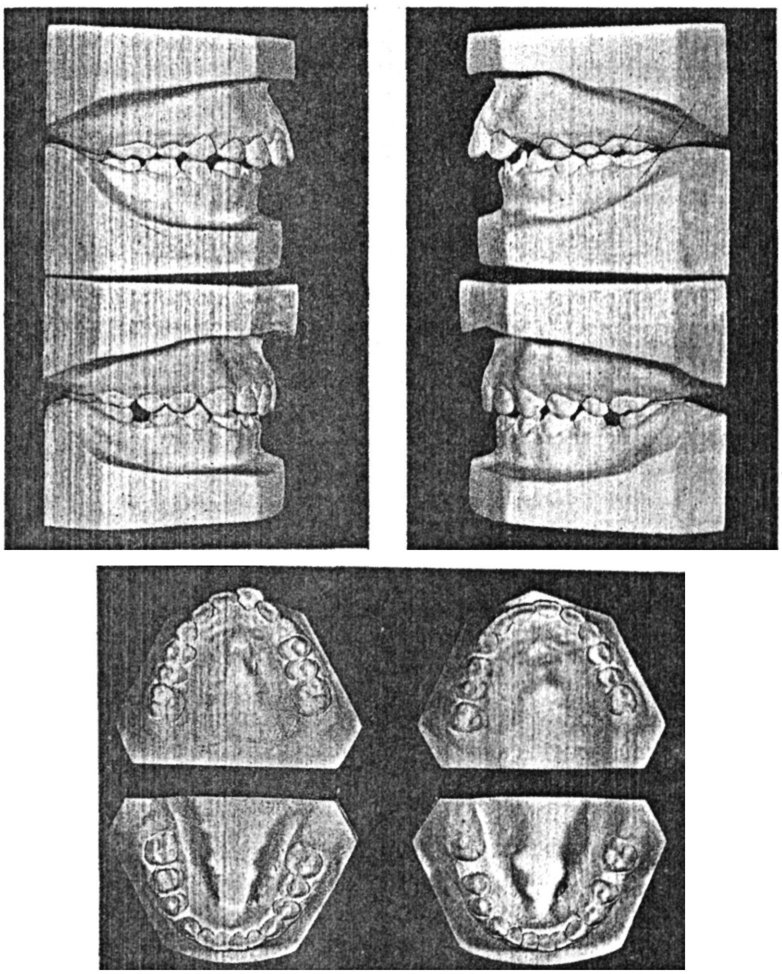


Fig. 194. Mild Class II case with some crowding. Caries made it necessary to extract the first molars at ten years. Note failure of lower molar spaces to close completely and tilting and mesio-lingual rotations of the second molars.

to prevent the upper second molars from moving mesially while the upper premolars and canines arc moved distally and subsequently the incisors retracted.

Post-normal Malocclusions With Upright Incisors

In addition to Angle's Class II Division 1 and Class II Division 2

malocclusions it is not uncommon to find cases where there is a post-normal occlusion but the upper incisors are neither proclined nor retroclined (see Fig. 46, page 73). Such cases are usually skeletally post-normal and have an increased incisor overjet. If these cases are treated simply by tilting the upper incisors towards the palate, these teeth will assume a lingual inclination which will be both unsightly and probably unstable. Should there be any crowding present in the upper incisor segment, it may be permissible to extract two upper premolars, retract the permanent canines and align the incisors. If the incisor overjet is small and there is no crowding, the case may be improved by means of an Activator. In the more severe cases, however, with a marked incisor overjet and no proclination of upper incisors, it may be necessary to correct the position of the incisal apices by means of more sophisticated appliances or even by surgery.

Post-normal Occlusion With Retroclination of Upper Incisors
(Class II Division 2 Malocclusion)

As liiis malocclusion varies considerably in its complexity, so also does its treatment. Some types of this malocclusion may be aesthetically acceptable while others may require very extensive treatment.

Because most Class II Division 2 cases have a deep incisor overbite which might easily become traumatic, every effort should be made to maintain contact between the lower incisors and the cingula of the upper incisors. Where this contact exists, treatment is limited to aligning the upper incisors without disturbing the incisor overbite. For this reason it is rarely wise to extract the lower premolars unless lingual movement of lower incisors can be prevented by complete closure of the resulting space. The irregularity of the upper incisors is usually due to lingual inclination of the central incisors rather than to any disproportion in the size of the teeth. It is often advisable to correct the post-normal occlusion by distal movement of the upper molars and premolars and thereby provide space for the upper incisor alignment. This may be made easier by extracting the upper second molars. A screw appliance is fitted having an anterior bite plane to disengage the molars and premolars during their distal movement (see Fig. 109, page 176). Later the upper canines are retracted and the lateral incisors moved lingually (Fig. 195). Where the crowding of incisors is more severe, upper first premolars may be extracted and the canines retracted before the lateral incisors are moved lingually. This is unlikely to change the inclination of the upper central incisors and it may have to be accepted that little reduction of incisor

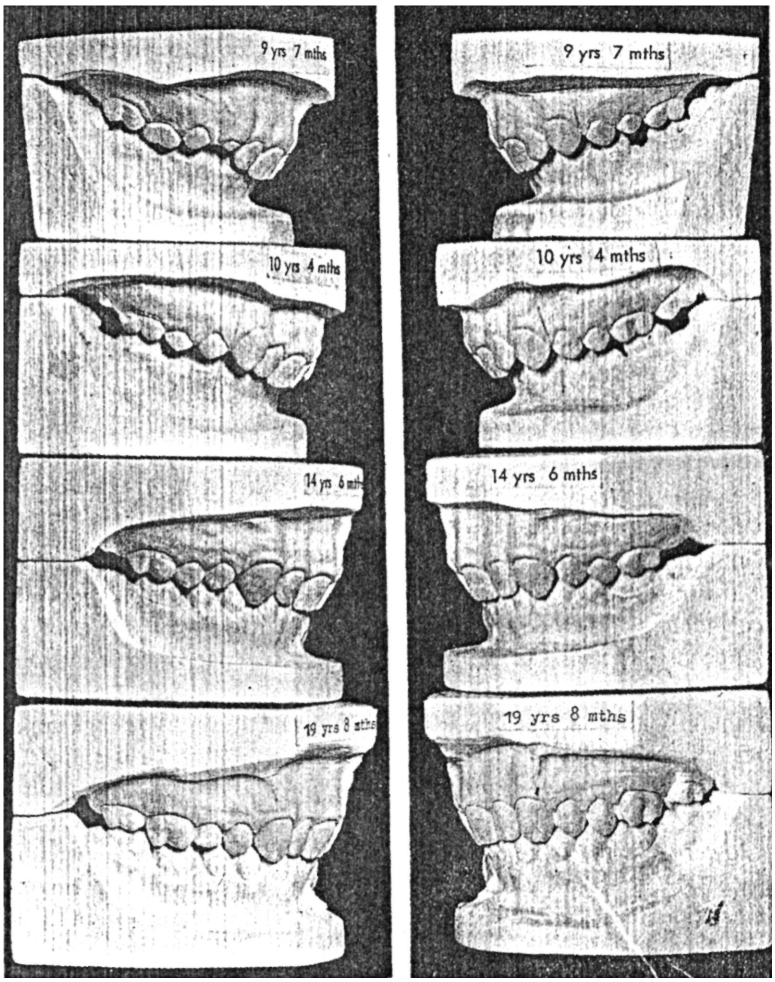


Fig. 195. A Class II Division 2 case treated by retraction of upper and lower second molars and distal movement of upper buccal segments with a screw appliance. Although the molar occlusion and overbite arc improved the incisors still appear to be retroclined.

overbite will occur. Where the lower incisors have escaped the upper cingula to erupt into the palate, more sophisticated treatment will be required to establish occlusal contact between the lower incisors and the upper incisor cingula.

Retention of these Class II Division 2 cases after treatment needs to

be prolonged but despite such precautions there is a tendency for the upper lateral incisors to rotate back into their original positions.

Pre-normal Occlusion

(Class III malocclusion)

It has already been shown (page 74) that Class III malocclusions fall broadly into two types, those with a postural pre-normality and those with a true pre-normality. In the former the incisor relation is created partly by the forward path of closure of the mandible and is in fact a much milder condition than appears at first. It may be identified by a more generous overbite and the ability to bring the incisors into an cdge-to-edgc contact on being asked to 'bite on the front teeth'. Usually in these cases the Frankfort-mandibular plane angle is small or normal and the sagittal skeletal malrelation is not marked. Such a condition may be treated by means of an appliance to move the upper incisors labially (see Fig. 107C, page 174) and thereby remove the need for a forward posture of the mandible. Usually the treatment is of short duration and is uncomplicated (see Fig. 189). Where, in addition to a rctroclination of the upper incisors there is also a proclination and spacing of the lower incisors, an inverted labial arch with long vertical portions,

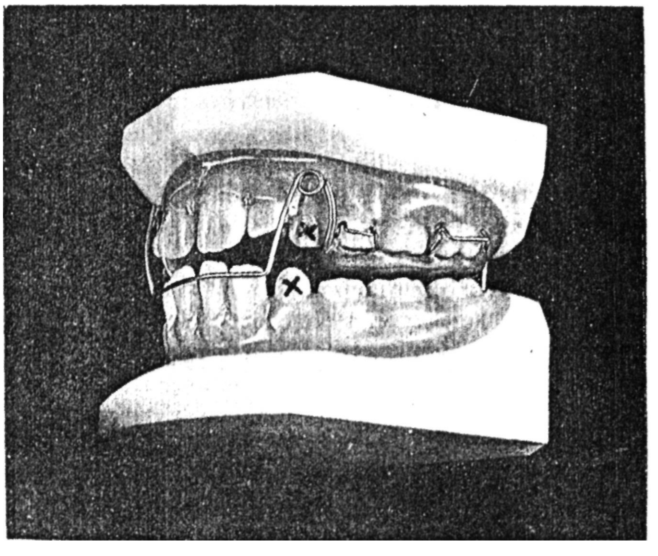


Fig. 196. A modified Nordin-Dickson labial bow to move lower incisors lingually.

as suggested by Nordin and G. C. Dickson' may be extended downwards from the upper plate to engage the prominent lower incisors (Fig. 196), Alternatively a combination of head and chin cap with elastic traction to an upper plate could be used at night time (see page 156). Should there be no lower spacing, it may be necessary to extract two lower premolars and perhaps to retract the lower canines (see pages 162 and 185) before using either of these appliances. Before undertaking cither of these treatments a second opinion is advisable to ensure that there will be an adequate incisor overbite present after treatment, otherwise retention can present difficulties. It should also be noted that there is a danger of a traumatic occlusion being created if the inter-incisal angle is too small; this is more likely to occur where the skeletal relationship is more pre-normal.

In cases where there is a marked pre-normal skeletal and arch relation and some ;spacing exists between the lower incisors, any attempt to produce a lingual movement of the lower incisors is unlikely to remain stable. In such cases the advice of an orthodontic specialist should be sought. If a Class III malocclusion has an associated open anterior bite, then it is probably wiser only to align the teeth of each arch, making no attempt to change the labio-lingual position of the incisors. Many of these markedly pre-normal malocclusions can only be treated satisfactorily by means of surgery in conjunction with some orthodontic treatment.

Age At Which Treatment Should Be Commenced

Ideally treatment should be given as early as possible in order to establish favourable conditions for normal development. Where the patient presents at an early age, it gives the operator the opportunity to select the optimum time for any extractions that may be indicated. Ungual occlusion of an upper incisor should be treated as soon as it develops because of the danger of attrition disfiguring the incisal edge of this tooth. The response of the tissues to orthodontic forces is more favourable and co-operation a less formidable problem in very young children who are under close parental supervision. Also absence from school at that age is not so critical. These advantages are largely offset by difficulties in making an accurate diagnosis during the stage of the deciduous dentition. Treatment at such a stage may well have to be repeated for the permanent dentition and early treatment may require prolonged supervision subsequently,

' Dickson, G, C. (1964). *Orthodontics in General Dental Practice.* Second Edition, Pitman Medical Publishing Co. Ltd., London, p. 254.

14. Retention After Treatment

In Chapter 9 the histological changes which accompany tooth movement have been described. In addition to changes in the internal structure of the bone, the soft tissues around the neck of the tooth arc stretched. Because of their elasticity and flexibility the forces they transmit to the bone stimulate a less complete response. The soft investing tissues themselves arc slower than the bone to become adapted to the new position. They therefore tend to pile up in the path of tooth movement, especially if it is rapid. This produces stresses in the tissues which will cause relapse if the tooth is released before they have been allowed to resolve. Retention of the teeth in their new position for several months is necessary to reach a stage of equilibrium.

During tooth movement the trabeculae of bone are resorbed and reformed in a general direction *parallel to that of the force applied to the tooth.* This reorientation of trabeculae takes about six months to complete. After completion of tooth movement the trabeculae are reorientated again in the direction of the *long axis of the root of the tooth.* This, again, takes about six months to complete. The bone during this period is found usually to be more responsive to the influence of pressure and relapse may occur if the occlusion or natural muscle forces will not hold the tooth or the teeth in the new position. Therefore it may be necessary, after active orthodontic treatment, to prevent the tooth or teeth from returning to the former position.

The improved relation of the teeth following orthodontic treatment may be maintained by the natural forces of occlusion. These may be divided into two groups:

(a) The occlusal relation of the teeth.
(b) The influence of muscles and soft tissues.

Both can work together and may or may not require the assistance of a retention appliance.

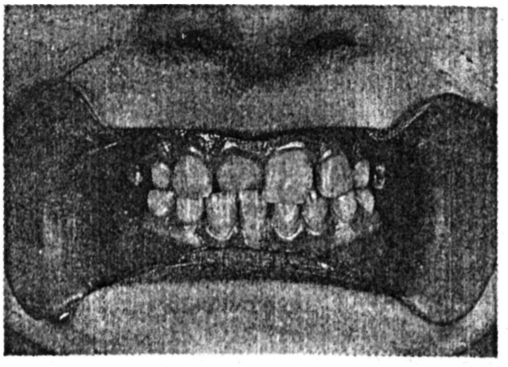
Occlusal relation

In Chapter 3 it was explained how the normal occlusion of the teeth so guides the force of mastication that it helps maintain their relative positions. Providing the other forces are normal, the establishment of a normal relation of the teeth should be self-retaining. However, this normal relation may not always be attainable. The correct relation of the premolars and canines (see Fig. 13) is of great value in maintaining improvement in antero-posterior relationship and preventing the re-establishment of a post-normal occlusion. Owing to their sharpness, the inclined planes of the premolar cusps exert a powerful guiding force on the antero-posterior relationship of the dental arches. To obtain the greatest advantage of this factor the upper canines should occlude accurately on the labial aspect between the lower canines and first premolars. The proper intercuspal relationship and occlusion of the molars and premolars maintains improvement in bucco-lingual apposition.

The inclination of individual teeth may be a factor in determining not only the health of their attachments to the bone but also their stability in the arch. Although minor abnormalities of inclination often improve spontaneously under the guidance of occlusal forces, gross departure from normal is less likely to remain stable.

The incisor relationship may also play a part in preventing the relapse and a return to malocclusion. Correction of a lingual occlusion of an upper incisor can be maintained by the lower incisors most easily where the overbite is generous (Fig. 197). Similarly, relapse following rotation of an upper incisor is less likely to occur where the overjet is small and the overbite large. In Class III cases it is likely that a generous incisor overbite at the end of treatment will occur only if the pre-normality is mild.

If the case is a severe one, extreme proclination of the upper incisors, in an effort to bring them labial to the lowers, may produce a relationship which is not only unstable but also traumatic. In some of these cases extraction of lower teeth and retraction of lower incisors may be indicated and may indeed be the only way to reduce the difficulty. Where the Frankfort-mandibular plane angle and the infra-nasal height are large, the overbite may be so deficient that occlusal contact is not a factor in maintaining stability. Here it matters little whether the upper incisors are just within or without the arch of the lower incisors because their position is determined entirely by the skeletal relationship of the basal bones of the jaws and by the balance of muscle forces. Correction of very extreme abnormalities in jaw shape and relationship is possible only with the assistance of surgery.



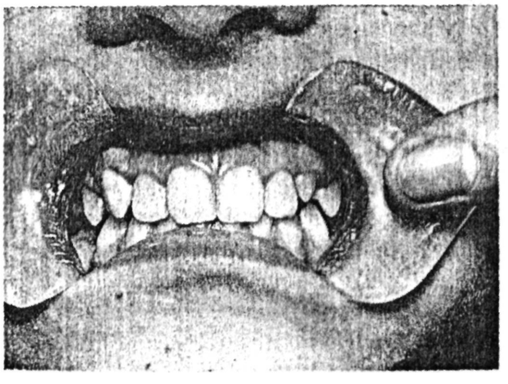


Fig. 197. Self retaining improvement of incisoi relation after treatment.

The relation of the lower incisors to the lower canines may also be a factor in effecting a stable completed case. If the lower canine overlaps the labial surface of the lower lateral incisor, the pressure in a mesial direction exerted by the posterior teeth (see page 116-17) may aggravate the overlapping and cause the lower incisors to crowd together and incline lingually. On the other hand, not only should correct approximal contact be established, but it must also be maintained. This applies to every contact point and regular dental attention must be continued in order to prevent either loss of tooth substance by interproximal caries or the loss of an entire tooth.

The influence of muscles and soft tissues

The significance of the oro-facial musculature in determining the

labio-lingual positions of the teeth has been discussed in Chapters 3 and 6. It was shown both how the resting position of the soft tissues and the behaviour of the musculature investing the dental arches contribute to a balance of forces which is expressed in the positions the teeth assume. Any change of tooth position will only be stable if an appropriate alteration in the balance of forces is achieved.

Where the behaviour of the oro-facial musculature has been adaptive, it is usual for muscle control to re-adapt itself fairly rapidly to its new environment. The time required for this to occur varies. Six months is not unreasonable. On the other hand, inherent or endogenous behaviour is more difficult to alter and may have to be accepted, the treatment being modified accordingly.

There are other factors which may influence the stability of the teeth after orthodontic movement. The resting relation of the investing musculature and soft tissues to the dental arches is of greatest significance when the incisor overjet has been large and has been reduced so as to bring the upper incisors under a correcting influence of the lower lip. Retention in such cases may be uncertain in the presence of an anterior tongue thrust, thus rendering the prognosis for a stable result very doubtful. The prognosis becomes worse if such a case is accompanied by a lower lip drawn tightly across the lower incisors and perpetuating their lingual inclination. Anlero-posterior separation of the upper from the lower incisors (large overjet) may be corrected and maintained if the upper incisors can be brought under the control of the lower lip but this is less likely to be achieved if the infra-nasal height is large and the lower lip falls short of the upper incisors.

Cases associated with inherent tongue-thrusting behaviour are difficult to handle but it has been noted that the severity of an inherent tongue thrust may become diminished as the child approaches maturity.. Some degree of spontaneous improvement may be expected, therefore, in some of these cases.

During tooth movement the investing soft tissues around the tooth respond very much more slowly to pressure and tension than does the bone. It is found, therefore, that these tissues tend to pile up in advance of the moving tooth. In cases where rotations have been performed it is found that the soft tissues are distorted where they receive the fibres of the periodontal membrane. Similarly the transeptal fibres of the periodontal membrane respond slowly to the rotation. In order to overcome this apparent elasticity which readily causes relapse when the appliance is removed, the operation of pericision may be performed. This involves the sectioning of the periodontal fibres attached to the

cervical two millimetres of the root. It is usually undertaken under local anaesthetic with a small, pointed and very sharp blade (Fig. 198).

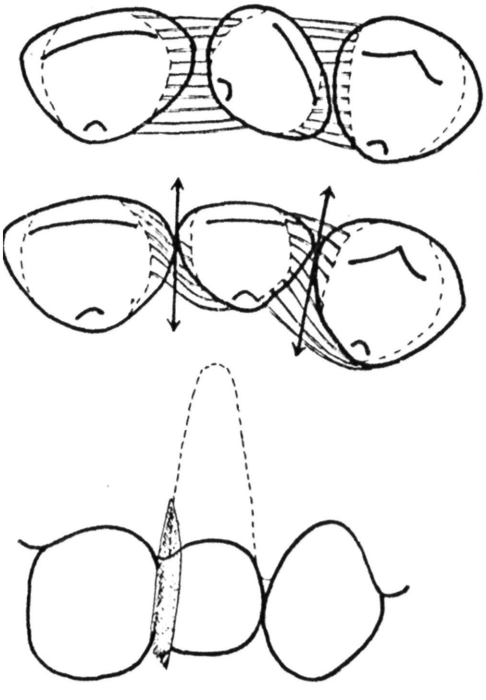


Fig. 198. Drawing to show how correction of a rotated incisor causes rotation of transeptal fibres of the periodontal membrane. As this is likely to cause a return to the original position, it may be necessary to section the fibres with a small scalpel. This operation is known as pericision.

Retention Appliances

By the time all tooth movement is completed and the teeth are apparently well aligned, the young patient is usually anxious to abandon orthodontic appliances. (This anxiety is the more insistent just because the teeth appear to be well aligned). The treatment cannot yet be regarded as complete but the patient will have difficulty in appreciating the danger of relapse. If a retention appliance is deemed necessary it is important that it should be simple in nature in order not to overtax the child. Whatever retention appliance is used, it should only be abandoned gradually, and under careful supervision, by reducing progressively the number of hours it is worn each day. This ensures greater stability of result and enables the operator to observe an incipient relapse before too much harm is done.

Retention appliances may be either removable or fixed and here follows a brief description of those commonly used:

(i) *Upper retention appliance:* An upper appliance, sometimes called

a Hawley Retainer is often used consisting of a plastic base with molar cribs, a labial bow and a suitably shaped inclined incisor bite plane. It is of particular use after the distal movement of canines, premolars or molars. It is also useful after the lingual movement of upper incisors (Fig. 199). The plastic base prevents the lingual movement of teeth and

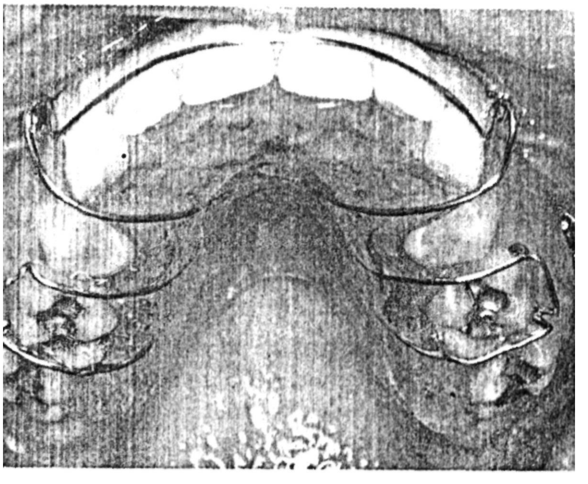


Fig. 199. Removable upper retention appliance used after treatment is completed (Hawley Retainer).

the cribs prevent movement of the molars. The labial bow and the inclined plane reinforce the anchorage, the former also aiding the retention in alignment of the upper incisors,

(ii) *Lower retention appliance:* As in the case of the upper, this consists of a plastic base with molar cribs and a short labial bow. Such a retainer can hold the teeth in the lower arch and prevent the lingual movement of the lower incisors or migration of the lower molars.

In both the upper and lower arches it is sometimes possible to use as a retainer the appliance which has actively corrected the malocclusion. This is done by rendering the springs in the appliance passive so that they exert no further pressure but hold the teeth in their new position. Appliances incorporating screws are particularly suitable to use as retainers, providing the bulk of the screw is not causing inconvenience to the patient. He is merely instructed to stop turning the screw but to wear as before. These instructions should be accompanied by the advice given to all wearers of retention appliances, viz.: 'It must be worn,

Otherwise the teeth will go back to the position they were in at the start of treatment and all the effort will have been in vain.'

(iii) *The Activator as a retainer:* The Activator (Chapter 10) is useful as a retaining appliance after the relationship of the dental arches has been corrected. It may be used with the facets uncut and untrimmed or only trimmed to a minimum degree. Not only can the Activator be used to retain the arches in their new relation but it also provides a strong intermaxillary anchorage to prevent unfavourable movement of the teeth. As a functional appliance it encourages a favourable muscular activity and, used at night, it does not cause embarrassment to the wearer.

(iv) *Retention by the fixed appliance:* If a fixed appliance has been used to provide active tooth movement, it may be employed for retention by rendering it passive. Occasionally a fixed appliance may be constructed solely for the purpose of retention. Molar bands and a rigid labial or

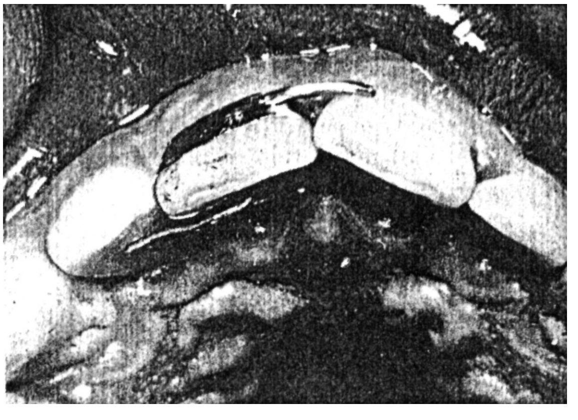


Fig. 200. Band and spur fitted to prevent relapse after correction of mcsio-lingual rotation of the upper right central incisor.

lingual bow may be sufficient and both may be used together on the one appliance. After rotation of an incisor, two spurs may be added to a band on the affected tooth, each engaging one of the neighbouring teeth and such an appliance represents the simplest form of fixed retainer (Fig. 2(X)). Fixed retainers have the advantage of simplicity and they occupy a minimum of space in the mouth.

CONCLUSION

Mention has already been made of the aims of orthodontic treatment,

namely in the words of A. F. Jackson,' 'to establish structural balance, functional efficiency and aesthetic harmony'. Although malocclusion exists, the dental arches may already be in a state of equilibrium. The Iccth will be in a position and relation to one another determined by the balance of forces of occlusion as described in Chapter 3. Though this balance is stable, it may still be abnormal. The movement of teeth during treatment may upset this balance, making it necessary to re-establish a new state of structural balance. Failure to achieve this objective causes the condition to relapse after treatment, the teeth tending to return to their original positions.

It must be reiterated that, where possible, the cause of the anomaly should be removed. This may not always be possible, either because the cause is not understood or because there are no means of controlling it.

There are, however, many environmental causes of malocclusion which can be eradicated. Many of these are habit behaviours which affect the correct balance of forces of occlusion. These, even though they may not be primary factors in the aetiology of the malocclusion, will certainly obstruct any tendency to self-correction. Sucking habits may be controlled and possibly corrected successfully. Adaptive behaviour during swallowing and at rest may often respond to correction of the malocclusion.

There are some patterns of behaviour which appear to be more finnly established and remain even after correction of the malocclusion. In such instances the treatment may have to be. modified and the number of teeth reduced with their relation to each other adapted to their muscular environment.

Marked abnormalities of the facial skeleton may cause a malrclation of the two dental arches which can only rarely be corrected by orthodontic treatment alone. In the absence of surgery some malocclusion may have to be accepted as untreatable.

Successful retention of orthodontic cases depends on correct diagnosis and treatment. This establishes a structural balance of all the forces of occlusion. There is histological and clinical evidence to show that, for a period of at least six months, bone is particularly responsive to pressure after teeth have been moved by orthodontic treatment. Therefore a period of retention is usually necessary.

' Jackson, A. F. (1947). *Trans. B.S.S.O.,* p. 103.

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