A STUDY OF THE RELATIONSHIP OF THE ECTOPIC MAXILLARY CANINE WHICH HAS BEEN DISPLACED PALATALLY TO THE MORPHOLOGY OF THE ADJACENT LATERAL INCISOR

BY

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THESIS SUBMITTED TO THE UNIVERSITY OF GLASGOW

IN PART FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE (MEDICAL SCIENCE)

DEPARTMENT OF ORTHODONTICS

GLASGOW DENTAL HOSPITAL AND SCHOOL

UNIVERSITY OF GLASGOW 1989

ACKNOWLEDGEMENTS

I am indebted to Professor J.K. Luffingham, the supervisor for my project, for the encouragement in the completing of this thesis.

For statistical advice of a theoretical nature, I am indebted to Professor John Waterhouse, and of a practical nature to Dr. D. Kinane. I am further deeply indebted to Mr. D. Stirrups not only for help with the Statgraphics Computer programme, but also for his production of the graphs by the Statgraphics system.

I would like to express my thanks to Dr. M. Watt for the loan of a collection of extracted teeth, and also to Dr. D. Lunt for permission to reproduce her slides of ancient maxillae.

I wish to record my thanks to Mr. J. Davies and staff of the Photographic Department for the reproductions of illustrations, and photographic prints.

My grateful thanks is extended to Mrs. June Russell who typed the Tables and has been unfailingly helpful in very many ways.

I am most grateful also to Mrs. Christine Provan who typed this manuscript despite my regrettable handwriting and for her advice in general layout.

Finally, my very special thanks goes to my husband, Laurie, for his monumental patience during the production of this thesis.

ABSTRACT

The hypothesis that palatally displaced canines are associated with smaller than average lateral incisors with reduction of the root or tooth length, or with congenital absence of the adjacent lateral incisor was tested on a West of Scotland population.

A retrospective study of the records of orthodontic patients attending Glasgow Dental Hospital was carried out. The palatal position of the canine was confirmed radiographically, or if erupted, on study casts. The tooth length of lateral and central incisors was measured on radiographs; the crown widths of lateral incisors was measured on study casts.

An association was sought between the size of the lateral incisor or its absence, the position of the adjacent maxillary canine, and between crown size and tooth length of the lateral incisors.

A separate study of extracted lateral incisors was undertaken further to test the hypothesis that narrow crowned lateral incisors have shorter roots than those with normally sized crowns.

The conclusions supported the hypothesis that palatally displaced maxillary canines are associated with lateral incisors of smaller than average crown width. There was weak support for the association between palatal canines and absence of the adjacent lateral incisor, or between lateral incisor crown width and tooth length.

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Figs. 3-6 Have been reproduced from "Development of the Human Dentition : An Atlas".

Linden, F.P.G.M. van der

Duterloo H.S. 1976

3. INTRODUCTION

Palatal displacement of one or both maxillary canines has been reported as affecting 1-2% of the population.

Treatment is often time consuming for the patient if the canine is to be correctly aligned by orthodontic means. The displacement of the canine may be such that orthodontic treatment is contra-indicated, and removal of the tooth is necessary.

The condition is frequently not discovered by the patient until the mid-teens or later when the canine is fully developed and orthodontic correction more complicated. It would be desirable if the aetiology of the condition could be recognised in relation to lateral incisor morphology; patients at risk could more easily be recognised at an early age when interceptive measures may be indicated. Orthodontic treatment is more acceptable in the younger age range, and treatment planning easier before the dentition is fully established.

As the aetiology of palatal displacement of the canine is likely to be multifactorial, the lateral incisor morphology cannot be examined in isolation. Other factors will be examined, but the principal objective will be the study of lateral incisor morphology, or congenital absence of the lateral incisor, associated with the palatal maxillary canine.

LITERATURE REVIEW

4. LITERATURE REVIEW

4.1 Early evidence of palatal displacement of the canine

Palatal displacement of the maxillary canine is not a phenomenon of modern man. Mead (1930) was reported by Thilander et al. (1968) as finding not a single example in maxillae of "4927 old crania of various races", nor had the impaction been reported but infrequently in the literature.

However, evidence of such palatal displacement has been demonstrated on an old cranium, viz. a skull from the Chaloctithic period, derived from a site at Lembalakkous, four miles from Paphos, in Cyprus. This skull belongs to a period between the Stone and Bronze ages, approximately 3000 B.C.

It is illustrated in Figure 1 and shows the tip of the right maxillary canine on the palatal side of the arch and the socket of what one may assume was a retained deciduous canine.

In Fig. 2 a more recent skull from Birsay, in Orkney, illustrates palatal displacement of the canine in a skull of the Scottish Dark Age (6th - 10th century A.D.).

These two examples of early evidence of canine impaction were supplied by Dr. D. Lunt from original material from her personal collection.

4.2 Skull dissections

Dissection of skulls of subjects of known age can supply information about tooth and jaw development, and has been used as a method of gaining knowledge over the centuries.

Fig. 1 Palatally displaced maxillary canine
(Chaloctithic Period, 3,000 Years B.C.)

Fig. 2 Palatally displaced maxillary canine
(Scottish Dark Age, 6th - 10th Century A.D.)

This method of necessity only provided one stage of development for each individual subject. However, a series of jaw dissections arranged in order of chronological or dental age cast more light on the calcification and path of eruption of the maxillary canine, (hereinafter referred to as the canine).

4.3 Radiography

After the use of radiography became available at the end of the last century, it became possible to study the detailed development of calcified structures. A longitudinal study of individual subjects provided a more accurate method of investigation of the early development of a single tooth, such as the maxillary canine.

A variety of radiographic views were developed, but each could only give a two dimensional view of a three dimensional object. Multiple views from different perspectives overcame this problem, at least to some extent.

Longitudinal studies by Björk (1963), using implants in the jaws, facilitated understanding of jaw growth. Repeated cephalometric radiographs (antero-posterior & lateral) at six monthly or yearly intervals allowed further knowledge of growth and tooth eruption to be gained in selected subjects.

Radiographic techniques which have since been developed are reviewed separately in 4.9.

4.4 Normal development of the permanent maxillary canine

Formation of the maxillary canine begins immediately below the orbit. Subsequent increase in the maxillary sinus separates the developing canine from the floor of the orbit. Calcification of the crown begins at 4-6 months, and the crown is two-thirds calcified by approximately 3 years of age. At this stage it lies above the first deciduous molar (Scott et al. 1974).

In Fig. 3, the age of the subject is 4 years (Linden et al. 1976). The permanent canine lies deep in the maxilla, palatal to the root of the deciduous canine, the root of which is not yet fully formed. The permanent canine crown is in close association with the developing lateral incisor and first premolar. (Scott and Symons 1974).

Broadbent (1941) described the crown where completely calcified as having moved little from its site of origin, although bone growth has carried the erupted deciduous dentition to an occlusal level now well below that of the glenoid fossa.

By 6 years of age the crown of the permanent canine is almost fully calcified and lies deeper in the maxilla than all the other teeth. (Fig. 4) (Linden et al. 1976). By 7 years, the maxillary sinus has further increased in size. The developing canine lies adjacent to the naso-lacrymal duct. It is small wonder that Broadbent (1941) describes the eruptive path of the canine as fraught with hazard between the ages of 8 and 12, and especially in an underdeveloped face (e.g. dwarfism).

At age 9 years, the permanent canine should be labial to the lateral incisor root, and a 'canine bulge' may be visible or palpable by 9 - 10 years. (Leivesley, 1984).
Fig. 5 (Linden et al. 1976).

Dissections of 3 skulls of 9 year old subjects, illustrate the continued development of the canine. Linden et al. (1976) drew attention to the significance of the width of the nasal aperture. If it is wide, there is a greater than normal distance between the

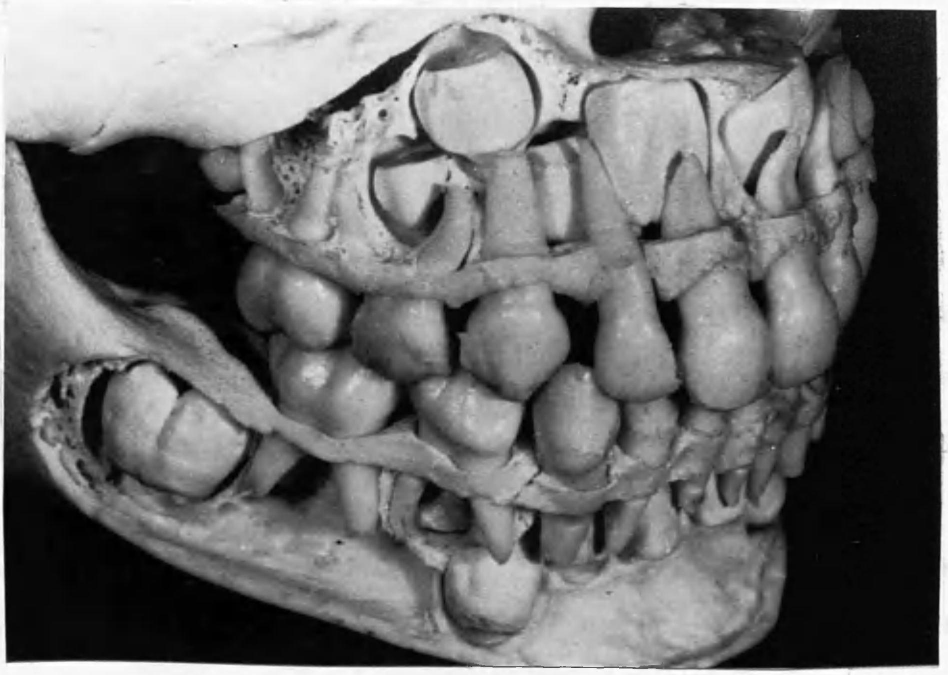


Fig. 3 Jaw Dissection Age 4 years
(Linden et al. 1976)

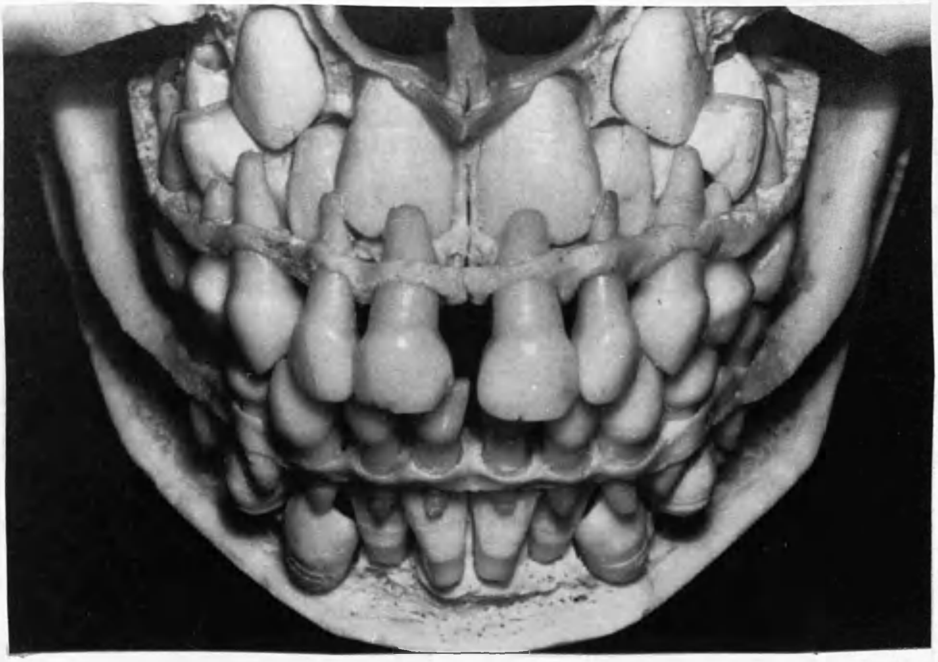


Fig. 4 Jaw Dissection Age 6 years
(Linden et al. 1976)

developing canines. Conversely, if the nasal aperture is narrow, the lateral incisor roots are squashed between those of the central incisors and the permanent canine crown (Fig. 5, D).

In Fig. 5, F, it will be seen that the (R) permanent canine is trapped palatal to the root of the lateral incisor, with apparently no resorption of the root of the deciduous canine. On the (L), the canine is normally positioned, labial to the lateral incisor root, and about two-thirds of the deciduous canine root is resorbed. The prevalence of deciduous canine retention was reported as high in the case of canine impactions (Thilander et al 1968). Linden et al (1976) comment on Fig. 5, E, (the lateral view of Fig. 5, F,) that there is lack of resorption of both the deciduous canine and deciduous molars despite evidence of active eruption of the successors. Active eruption was recognised by the distance between the root ends and the fundi. Is there a predisposition to slow resorption of the roots of deciduous teeth in some subjects, with consequent retardation of eruption of the successors?

Finally, canine eruptions may occur about 11 - 12 years, (Linden et al. 1976) although Ericson et al. (1986) thought the variation in eruption time could be as much as 4 - 5 years, depending upon somatic maturity. Eruption is generally 6 months later in boys than girls. (Linden et al 1976). In the illustration of erupting canines in an 11½ - 12 year old, in Fig. 6 (Linden et al 1976) it is interesting to note another palatally displaced canine (on the left), whereas the canine on the right is in the line of the arch.

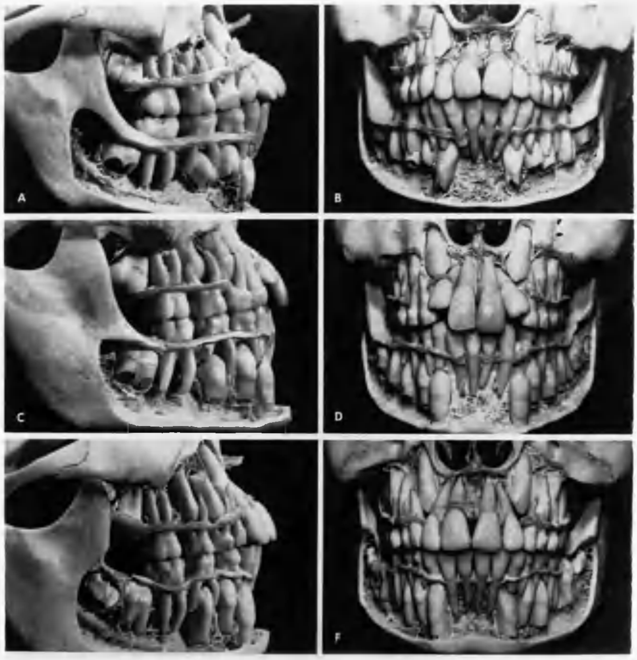


Fig. 5 Jaw dissections from 3 skulls Age 9 years
(Linden et al 1976)

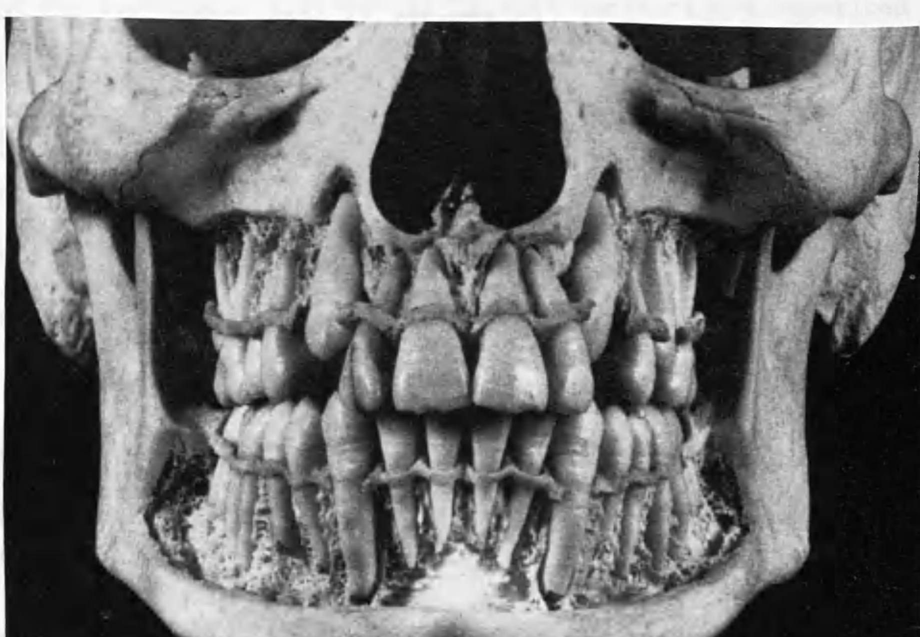


Fig. 6 Jaw Dissection Age 11½ - 12 years
(Linden et al 1976)

4.5 Recognition of ectopic canine development

If a canine bulge on the buccal aspect of the alveolar bone cannot be palpated by 8 years, an abnormal path of eruption may be suspected (Rayne, 1969). This age was amended to 9 - 10 years by Leivesley (1984). The dental maturity of the child is of more importance than the chronological age. The age range of 8 - 10 years for recognition of the canine position was not confirmed in a longitudinal study by Ericson et al (1986). They found the dental and chronological ages may differ by up to 5 years. A canine is not necessarily ectopic if not erupted by 11 years.

The variation of age of eruption of the canine may extend from 11 - 15 years, and be 'normal' for the individual child. Therefore, the canine bulge may not be available as an indicator of normal development of the canine in children who mature late. (Ericson et al. 1986)

A characteristic tilt of the lateral incisors was described by Moss (1972) as a valuable indicator of the position of the unerupted canine, and agreed by Williams (1981). A contrary opinion was expressed by Ericson et al. (1986). In their longitudinal study of canine eruption they found tipping alone provided an inadequate diagnostic criterion of an eruptive disturbance of the canine.

The mesio-distal inclination of the upper incisors depends partly on the space available between the canine crowns, related to the width of the nasal opening (Linden et al. 1976). Resorption of the lateral incisor or central incisor root is a possible hazard of the unerupted canine. Knight (1987) reported on this effect of buccally placed canines close to the apex of the lateral incisor root, this part being most vulnerable.

Ericson et al. (1988) suggested a means of determining if resorption of incisor roots was occurring, due to an ectopic palatal canine. Where the crown of the canine has advanced mesially and has passed the mid-point of the lateral incisor root, overlapping on conventional periapical radiographs and orthopantomograms makes it difficult to detect whether or not resorption has occurred. Ericson et al. (1988) describe high resolution computed tomography as a means of diagnosing both the position and extent of root resorption due to the ectopic canine position.

Conclusions: Clinical signs such as distally tilted lateral incisors should not be considered in isolation, in identifying the position of an unerupted canine, although a distally and labially tilted lateral is likely to indicate a buccal canine crown labial to the lateral incisor apex.

The presence of the canine bulge indicates the canine position, but the absence of the bulge must be related to dental maturity. Canine eruption is common at 11 - 12 years, but can occur later and be 'normal' for the individual. Radiographic investigation is advisable, not on a routine and regular monitoring basis, but at the appropriate time as indicated above, when palatal displacement is suspected.

4.6 Prevalence of palatal displacement of the canine

Dachi et al. (1961) found a prevalence of impacted canines of 0.51% in males, and 1.17% in females, with a definite tendency towards unilateral impaction in a survey of 4,000 routine radiographs. Bass (1967) reviewing 9102 orthodontic patients reported a prevalence of

1.65% unerupted canines which were treated by extraction or exposure, the male : female ratio being 31.3 : 68.7% respectively.

The prevalence of canine impaction in Swedish school children varied with age. 31.2% of girls and 42.7% of boys had unerupted canines at age 11½ years. At the last examination age of 17½ years 1.6% of girls, and 2.1% of boys still lacked one or both canines. Previous studies of prevalence were also quoted by Thilander et al. (1968) ranging from 1.4% to 6.7%, the latter being derived from an orthodontic population (Pederson et al 1940; quoted by Thilander from a Danish publication). Rayne (1969) reported a prevalence of 1.5%.

In Belfast, a review of radiographs of 7,000 consecutive cases attending the School of Dentistry revealed a prevalence of 2.56% of unerupted maxillary canines (by implication, palatally displaced) (McKay, 1978). Radiographic examination of orthodontic patients revealed 1.5 - 2.0% of impacted maxillary canines in the proportion 3:1 in females:males respectively. Impactions were fifty times as often palatal as labial. (Kuftinec et al. 1984)

In a longitudinal study of Swedish schoolchildren, only 1.7% over the age of 17 years had totally ectopic canines, mostly palatal. (Ericson et al. 1986). This agrees closely with the previous Swedish survey of Thilander et al. (1968).

The prevalence of palatal canines in a random sample of an Israeli population comprising 2240 schoolchildren of 14 - 18 years was 1.49% of males, and 1.58% of females (Brin et al. 1986).

There is fairly general agreement that the prevalence of canine impaction is approximately 1 - 2%, with the exception of 6.7% quoted as occurring in a Danish orthodontic population.

4.7 Aetiology of impacted maxillary canines

The term 'impacted' has been variously used by different authors. It is proposed to use the definition of an "impacted tooth" as given by Thilander et al. (1968), viz. "a tooth whose eruption is considerably delayed and for which there is no clinical or radiographic evidence that further eruption may not take place".

Factors which may influence an abnormal path of eruption

4.7.1 Development of the maxilla; arch form

Dewel (1949) and Lappin (1951) claimed there was no space shortage in arches with palatal canines in many cases.

Hitchin (1951) on the other hand believed that lack of space in an inadequately developed dental arch caused impaction of the canines. Kettle (1958) agreed, that a narrow upper arch deficient in intercanine width was a factor. Kettle also noted the significance of retroclined maxillary incisors in Class II division 2 malocclusions where the labial position of the lateral incisor root removed it from its correct relative position to the developing canine, thus depriving it of guidance.

Narrowness in the basal bone of the maxilla i.e. a narrow nasal aperture, can result in disturbance of incisor lateral alignment and crowding of the region occupied by incisor roots and the developing canine, (Linden et al. 1976). This could interfere with the correct path of eruption of the canine.

Takahama et al. (1982) claimed with somewhat small numbers, that there was a significantly higher occurrence of maxillary canine impaction in fathers of children with cleft lip or palate. They concluded that maxillary canine impaction was perhaps a microform of cleft lip or palate. Jacoby (1983) disagreed with the theory that lack of space in the maxilla caused impaction.

In dissections of the maxilla, and at operations, buried canines were often seen not actually to be near adjacent teeth. Jacoby did not find radiographs to be a reliable guide as to space or lack of space. He found repeated orthopantomograms provided different proportional dimensions, and could therefore be unreliable. His hypothesis was that excessive space in the maxillary bone favoured the palatal direction of eruption of the canine.

Excessive bone growth in the canine area, or hypodevelopment of the lateral incisors or stimulated eruption of the lateral incisor or first premolar, each could provide the excessive space required to allow the canine to continue on its course and so move palatally.

As the term "arch length deficiency" often does not fit the situation, Jacoby (1983) preferred the concept "excessive space in the maxillary bone" to describe the predisposing cause.

There is no apparent general agreement on space/lack of space, but excessive space within the maxilla at an early stage of canine development, and shortage of space in alveolar bone at a later stage if the canine is already palatally displaced would summarise the foregoing views as to possible contributory factors in palatal canine displacement.

4.7.2 Developmental inclination of the canine

Hovell (1966) believed that the palatal position of the canine was due to maldirection of eruption; i.e. if the canine is inclined mesially in its early stages of development, root growth would result

result in horizontal displacement. Thilander et al. (1968) agreed with this observation, further stating that of all the local aetiological factors, the position of the tooth was most important.

Leivesley (1984) in a paper discussing methods of minimising the problems of impacted canines included among the aetiological factors he listed, an ectopic direction of eruption. However, he thought that in favourable circumstances the required guidance from the lateral incisor root could occur where adequate space existed.

Bishara et al. (1986) included in the list of causes of impaction the rotation of the tooth bud of the canine.

Coupland (1984) warned of slightly more favourable image of the position and angulation of the canine on an orthopantomogram than on an a-p cephalogram, and the need to compensate accordingly.

The inclination of the developing canine crown in its crypt and thereafter is difficult to demonstrate by radiographic means before its more mesial than normal angulation is well developed.

4.7.3 The retained deciduous canine

Dewel (1949) was of the opinion that the deciduous canine might fail to resorb because the permanent canine was not close to it. Lappin (1951) and Newcomb (1959) both cited non-resorption of the deciduous canine root as the cause of palatal deflection of the permanent canine. Newcomb advocated removal of the deciduous canine and the cutting of a channel in the alveolar bone to provide an easy route for its successor. This would allow its self-correction from the palatal side of the arch.

Miller (1963) was concerned that resorption of the deciduous canine might occur obliquely which in unfavourable circumstances would aggravate the permanent canine position. Thilander et al. (1968) disagreed. They thought that a persistent deciduous canine was a result of palatal displacement of its successor, not a cause.

Kettle (1958) included in a list of local factors predisposing to canine deflection the late resorption of the deciduous canine root. He noted that besides being tardy, if the resorption was not uniform it could deflect the canine mesially, and therefore palatal to the lateral incisor root.

Williams (1981) advised that if the cuspid bulge, and radiographic evidence of impaction of the canine were present the deciduous canine should be removed in uncrowded Class I dentitions. Leivesley (1984) also advises extraction of the canine if resorption is not proceeding normally.

Becker et al (1984) expect that the canine, if given the space or "only the interference of deciduous teeth" will tend to improve its position and break through on the buccal side.

Accordingly to Gibilisco (1985), if the primary canine is permitted to remain for any great length of time, the bone overlying the crown of the unerupted permanent canine tends to become sclerotic. When this occurs, the permanent tooth may fail to erupt, even after the deciduous tooth has been extracted.

There is little agreement as to which comes first, the lack of root resorption of the deciduous canine, or the close proximity of the permanent canine crown to the root of its predecessor. There is more general agreement that if resorption is not proceeding normally, the deciduous canine should be removed, especially in well aligned arches with adequate space.

4.7.4 Crowding/spacing

Lack of space for eruption is not a primary cause of palatal deflection of the canine (Dewel 1949; Lappin 1951; Jacoby 1983). Loss of deciduous molars may, of course, lead to shortage of space for the last tooth to erupt in the area (2nd premolar or canine). Kettle (1958). Thilander et al. (1968) reported that crowding was more often associated with palatal canines. All but one of the non-palatal canines had erupted where there was space, even just sufficient space. In the case of the impacted canines, in all cases the crowding was localized at the site of the canine.

Excess space was always due to absence of a lateral incisor or extraction of a premolar. Jacoby (1983) recorded that 85% of palatal canines had sufficient space to erupt. Some were associated with small or absent lateral incisors. 15% of canines had some arch length discrepancy. Ericson et al. (1986) made no mention of crowding in their longitudinal study.

The conclusion is that, as with any unerupted tooth, space for canine eruption must be maintained if deciduous teeth have been lost. Crowding may cause buccal displacement, but an already palatally displaced canine is likely to be late in erupting, the condition aggravated by shortage of space. Dewel (1949) considered the palatal bone is less responsive to dental eruptive processes than alveolar bone. Spacing in the canine region was generally due to small or absent laterals or extracted first premolars.

4.7.5 Malocclusion category associated with palatal canines

Dewel (1949) and Lappin (1951) noted frequent impactions of canines in uncrowded arches with normal acclusion.

Dental arches with retroclined upper incisors and deep overbite - i.e. Class II division 2 malocclusion is commonly found. (Kettle 1958). Bass (1967) in a survey of an orthodontic population, with palatal canines, reported malocclusion categories as follows: Class I - 63.7%; Class II division 1 - 12.4%; Class II division 2 - 2.7%; Class II indefinite - 14.2%; Class III - 7.0%. He explained the low frequency of Class II division 1 malocclusions as being due to the typical proclination of the upper incisors, with consequently more palatally placed apices as providing less opportunity for the developing canine to slip palatally.

Jacoby (1983) believed Class II division 2 cases showed excessive growth of the maxillary bone favouring palatal displacement of the canine.

Few studies of palatally displaced canines mention the malocclusion category.

While Class II division 2 malocclusion incisor alignment may predispose to canine displacement palatally, and proclined upper incisors may have the opposite effect, further study of malocclusion categories related to palatal canine impaction could usefully be studied.

4.7.6 Familial trait associated with palatal canines and associated laterals

"Family resemblances of tooth arrangement are well known. Heredity has long been indicated as a chief cause of malocclusion". Moyers (1988). The most clear cut examples he gives are for absence of teeth and some gross craniofacial syndromes.

A relative is similarly affected in many cases (Lappin 1951). Takahama et al. (1982) examined radiographs of 2,000 orthodontic patients' parents (3367 parents). They listed the proportion of parents with canine impaction, concluding that canine impaction was higher among fathers who had children with cleft lip or palate.

Woodworth et al. (1985) in their investigation of bilateral absence of lateral incisors conjectured that a developmental disturbance similar to that seen in cleft lip and palate might represent the cause. While a clinical impression of a family predisposition to palatally displaced canines has been noted in passing, no statistical evidence has been included.

Conclusion: the family trait as an aetiological factor in palatal displacement of the canine appears to be a subjective judgement rather than a statistically proved factor.

4.7.7 The association between the morphology of the lateral incisor, or its congenital absence, and the adjacent maxillary canine.

Miller (1963) reported on frequent congenital absence of lateral incisors associated with palatal canines. He suggested that the absence of the lateral incisor, or the lack of root length, allows the canine to continue on a mesial and palatal course and meet the root of the central incisor, or if the lateral is present, lie palatal to it. However, he believed that a small or rudimentary lateral could have adequate root length to provide guidance for the canine. The cases he cited showed many variable positions of the canine where lateral incisors were absent, and in some subjects, different paths of eruption occurred on opposite sides of the same arch under apparently similar conditions.

Bass (1967) reported a high proportion of impacted canines in subjects with congenitally missing teeth, including lateral incisors.

He advanced the theory that there may be an abnormality in the dental lamina as the aetiological factor. He thought the malposition of the canine arose from the same disturbance of the dental lamina that led to lack of development of lateral incisors and other teeth.

Becker et al. (1981) considered the developmental cause of palatal displacement of the canine to be absence of guidance of the lateral incisor root. However, at a later stage during a more advanced period of development when the canine is moving down into a narrower portion of the alveolar process, the presence of the root of a permanent tooth at this stage can act in the opposite way, preventing the buccal and distal correction of the canine path of eruption. This occurs if the lateral incisor root develops late, having allowed the canine to continue on its medial course; its late development then traps the canine crown on the palatal side of the lateral incisor root.

Becker (1984) referring to the graduate thesis of Tsur (Jerusalem, 1982) quotes fourteen publications relating palatal canines to congenitally missing lateral incisors, late formation of the dentition, small lateral incisors, peg-shaped laterals and short rooted laterals.

Jacoby (1983) discovered evidence that agenesis of the lateral incisor, or its being peg-shaped with, it is assumed, a short root, provided extra space in the maxilla which allowed the canine to wander palatally.

Becker (1984) in a letter, gave the following excerpts from his thesis. Out of 88 patients (62 female, 26 male) only 8, which were all female, had congenital absence of the lateral incisor adjacent to a palatal canine. Only in half the cases was the adjacent lateral incisor of normal size; 17% were peg-shaped. In 2 cases a missing lateral incisor on the non-affected side of the arch was paired with a smaller than average lateral on the affected side.

Becker et al. (1984) investigated the root lengths of lateral incisors adjacent to palatal canines. They found a 'definite link' between the incidence of canine displacement with both small lateral incisor crown size and short lateral incisor roots. There was a definite link between lateral incisor crown size and tooth or root length. They also state that since roots of small and peg-shaped lateral incisors tend to be shorter than roots of laterals with normal crowns, the reduced mesio-distal crown widths reflect the short root. The short root is likely to be the critical factor together with lateness in development, depriving the canine of guidance required in the early stages of development.

Brin et al. (1986) conducted a study of a random population of 2240 children, aged 14 - 18 years. Recording (R) and (L) sides of the arch separately yielded data of 4480 cases. They reported a highly significant relationship (42.7%) between anomalous or absent lateral incisors and palatally displaced canines. This confirms the earlier work of Becker et al (1981, 1984) where they reported 47.7% of subjects with a palatal canine had a small, peg-shaped or absent lateral incisor.

Conclusion: There would appear to be an association between anomalous or absent lateral incisors and palatal canines. A relationship between crown width, root or tooth length of lateral incisors as proposed, and between reduced tooth length and palatal canines merits further investigation, and testing on another population.

4.8 Conclusions

Having traced the normal development of the maxillary canine, and discussed the recognition of ectopic eruption of the canine related to age and somatic maturity, the various actiological factors which could affect the palatal displacement of the canine have been reviewed.

While more than one aetiological factor can combine to influence the development of the maxillary canine, the most interesting and promising single field of study would be a follow-up of the evaluation by Becker, Zilberman and Tsur, 1984. They investigated palatally displaced canines in relation to the morphology of the lateral incisor. They found significantly shorter roots of lateral incisors adjacent to palatal canines.

4.9 Radiography : a diagnostic aid

Choice of radiograph

Radiography is an invaluable diagnostic aid in determining the position of an unerupted maxillary canine which is not visible or palpable.

However, it is important to be economical in the use of radiographs to avoid unnecessary exposure to radiation, (Ericson et al. 1986). This is especially important in the case of young children, as the effect of radiation is greater in juveniles than in adults (Williams et al. 1974). There has been un upward trend in radiographic examinations. Between 1957 and 1977 the number has risen by a factor of 6. (Kendal et al. 1981).

Different types of radiographs, or various combinations of radiographs are in current use. Southall et al. (1987) are critical of the clinician using the techniques with which he is most familiar at the cost of an increased dose of radiation to the patient. They further claim that the application of the parallax technique in rotational tomography would seem to provide more data than is generally appreciated. They suggest a single intra-oral radiograph (an oblique occlusal or periapical view) is all that is required if a good quality orthopantomogram is already available.

4.9.1 The orthopantomogram (OPT) and antero-posterior (a-p) skull radiograph

Coupland (1984) compared the localisation of misplaced maxillary canines on OPT and a-p skull radiographs. He found the position of the canines was similar but not identical. The canine inclination on about 60% of the OPT's was more favourable by approximately 7.5 degrees compared with the a-p skull view, and the crown appeared to be slightly further from the midline and nearer its own position in the arch in about 50% of cases. It therefore appeared more favourable than the reality.

4.9.2 The lateral skull view (cephalogram)

The disadvantage associated with the cephalogram is the superimposition of bilateral images which limits the accuracy in distinguishing the relationship between the canine and the roots of the adjacent incisors. When bilateral palatal displacement of the canines occurs, the difficulty of precise definition of the tooth outlines is increased.

4.9.3 Vertex occlusal view

Southall et al (1987) reported that 23% of those replying to their questionnaire used the vertex occlusal film, usually in conjunction with an OPT. The authors did not advocate the use of this radiograph because of the heavy exposure to radiation.

4.9.4 Parallax method

Two periapical films taken of the same object (the canine) but with a horizontal tube shift, allows one to assess the position of the canine in relation to the line of the arch. If the object (the canine) 'moves' in the same direction as the X-Ray tube, the canine is palatal.

Radiation exposure can be further reduced by taking an OPT radiograph and one other view, e.g. oblique occlusal view, and applying the principle of parallax (Southall et al. 1987). They reported that many respondents to their questionnaire did not think interpretation of the palatal canine position was possible on an OPT and oblique occlusal film. Southall et al. (1987) think it is interpretable but the reliability of the method has not been tested.

A general purpose OPT which most orthodontic patients have can be supplemented by one other film (oblique occlusal) or by two periapical views with the tube shifted horizontally for the second view. The principle of parallex can be applied in either case.

There is seldom a requirement for an a-p skull, or vertex occlusal radiograph; a cephalogram for other clinical reasons may be taken but it is generally difficult to interpret accurately for the position of palatal canines.

4.10 Tooth length assessment

A statistical correlation of individual tooth size distortions on the orthopantomogram was compiled by Rejebian (1979). He examined tooth length of 80 extracted premolars and compared the tooth length of the same teeth on pretreatment radiographs.

The magnification error was greater in the maxilla than the mandible. Provided a callibration of magnification distortion is carried out for the particular equipment, and a standardized method is used with care in positioning the patient, an average magnification factor could be produced. The callibration would require a radiograph and a tooth subsequently extracted for actual measurements. While a standardized technique can be carefully used, there are other variables outwith the operator's control, e.g. arch form, tooth alignment, overjet.

Rejebian (1979) measuring to the nearest 0.5mm using a Boley gauge with narrowed points, found that magnification distortion occurred in both vertical and horizontal dimensions, being greater in the maxilla than the mandible. The vertical measurements were on premolars only. Incisor magnification error was not measured.

While the principal purpose of this investigation was the measurement of mesio distal widths of unerupted teeth for determination of arch width discrepancy, correlating magnification distortion with erupted teeth on the OPT and on study casts, the tooth length was studied only in relation to extracted premolars. The vertical magnification distortion could not be applied directly to maxillary incisors, which are unlikely always to be at the same angulation as the premolars used for callibration purposes, or indeed be at the same angulation relative to each other.

Larheim et al. (1984) investigated the measurement of tooth length, including maxillary incisors on the orthopantomograph 5, to discover the reproducibility of successive OPT's carefully taken using a standardized technique. They reported non-measurability of tooth lengths in 14 - 17%. It was considered necessary to mark 13 - 17%, mostly apically in the maxilla. This in itself indicates doubt in identification of reference points. The sharply depicted layer is thinner in the anterior region. The variation in overjet will affect the quality in a standardized radiographic technique. Larheim (1984) claimed the uninterpretability to be not unexpected due to lack of sharpness of the image. However, there was only a small variability in tooth length measurements on successive OPT's of the same patient for whom reference points were identifiable. Larheim concluded that the OPT could be used for tooth length measurement provided the patient had been properly positioned.

It is possible to measure tooth length of incisors on an OPT with the patient in a standardized position if the overjet is within normal limits. The levels of accuracy quoted indicated that in measurements of repeated exposures, up to 7.5% of the differences of measurement on 3 repeated exposures exceeded 2 mm. When differences larger than 2 mm. were excluded (difficulty in identifying reference points) the standard deviation reduced to 0.5 mm. (Larheim et al. 1984)

It therefore is appropriate to measure to the nearest 0.5 mm.

4.10.1 Long cone paralleling technique

Eggen (1969) quoted by Larheim, found a greater accuracy in tooth length measurement on periapical radiographs using the long cone paralleling technique (0.26 mm. error). This technique, developed by the McCormacks and Fitzgerald is described in Oral Radiology. It avoids distortion by placing the film parallel to the long axis of the tooth. The paralleling technique employs a long cone to increase focal spot-to-object distance. Thus only the most central X-ray beams reach the tooth, thus reducing image magnification and increasing image sharpness and resolution.

4.10.2 Bisecting angle technique

This technique was evolved because it was found impossible to place the X-ray film as close and as parallel to the tooth as desired without bending the film.

It is difficult in the maxillary incisor region to place the film close to the incisors without being near the crown and at a distance from the apex. The central X-ray is directed perpendicular to a plane which bisects the long axis of the tooth and the film (Goaz P.W., White S.C.) (Oral Radiology (1987).

Sjölien and Zachrisson (1973) always preferred to measure tooth length on radiographs taken by the long-cone paralleling technique, this method being a prerequisite in their study of apical resorption. They found the standard bisecting angle technique resulted in great variability, confirming previous studies.

4.11 Conclusions

Vertical measurements are possible on orthopantomograms, but measurement error of 2.0 mm may have to be accepted or if excluded accepting a reduced number of data. Callibration of a particular machine would be possible for incisor measurement using the extracted tooth technique only if incisors without apical pathology were measured after extraction and compared with tooth length measurements on the pretreatment OPT. Variation of incisor overjet would continue to be a problem because of foreshortening of the image. The long-cone paralleling technique provides the best method for tooth length assessment but is best suited for comparison purposes of successive films of the same teeth than for absolute measurements of tooth length for comparison purposes with different subjects, and incisors with overjet variations.

4.12 Reproducibility

Larheim et al. (1979) in their investigation of tooth length measurement used the paralleling technique and a callibrated radiographic measuring film.

The black lines of the grid provided a good contrast against the white image of the tooth. The foreshortening of the tooth was 0.14 mm. However, the authors point out that the main source of measurement error is recognition of reference points.

4.13 Detailed review of the method of assessment of tooth lengths in the investigation of Becker et al. (1984)

4.13.1 Reference points

The mesial and distal extremities of the amelo-cemental junction were marked on an acetate sheet over the radiograph of the lateral incisor and adjacent central incisor. These two points were joined by a straight line (a - b). Tangents to the apex and the most incisal point of the crown were drawn parallel to the line a - b. The measurements of tooth and root lengths were made on lines perpendicular to the line a - b from the tangents to apex and incisal points.

Measurements were made with calipers accurate to 0.05 mm.

Although differences of absolute measurements of tooth or root length of the incisors were present on different radiographic views of the same teeth (OPT and periapical views) the ratio between the lengths of lateral incisors and the adjacent central incisors was found to be consistent.

The authors concluded that it was possible to measure tooth or root length on either a periapical or OPT radiograph provided the ratio of tooth lengths, or root lengths of lateral and central incisors was used.

4.13.2 Definitions of lateral incisor categories

(SL) small:	crown size equal to or smaller than the opposite mandibular lateral incisor.
(PL) peg-shaped:	the widest mesio-distal crown width is at the gingival margin.
(AL) absent:	congenitally absent.
(NL) normal.	

(Becker et al. 1981)

4.14 Conclusions

It is not possible to obtain absolutely accurate measurements of tooth dimensions on radiographs, even under the most ideal conditions when one expert radiographer with strictly defined methods, conditions, and patient positioning takes all the radiographs.

Although there is less distortion in the vertical dimension than in the lateral dimension, even measurements of the length of teeth were in a third of cases described by one observer as of doubtful value, and lack of interpretability reduced the acceptable measurements even further.

It is important to limit the use of radiographs to those subjects where there is a definite clinical requirement; it is also essential to be economical in the number of radiographs taken of any one individual; where the use of parallax can help define the problem of a palatal maxillary canine, an orthopantomogram and one other view should suffice.

It is necessary, therefore, to consider a method to eliminate the need to use absolute measurements. The paper by Becker, 1984, with Zilberman & Tsur claimed to overcome this difficulty by using a ratio of lateral incisor tooth/root length to the tooth/root length respectively of the adjacent central incisor.

This method, the authors claim, eliminates the problem of different actual measurements of the same teeth taken from different types of radiograph. It should be possible, they claim, to use periapical or an orthopantomogram, interchangeably.

4.15 Editorial comment (Thurow 1986)

Nevertheless,

"Individual variation is the stuff orthodontics is made of. The 'average' patient is a myth. Even the individual subjects who provided our 'norms' did not fit these norms. Each orthodontic patient is a one-of-a-kind sample of one."

5. OBJECTIVES

The objectives of this study are to investigate the actiological factors relating to palatal displacement of the canine. In particular,the investigation will seek to discover if there exists:

1) an association between small lateral incisors and palatal displacement of the adjacent canine.

2) an association between small crown size of lateral incisors and shorter than average tooth length.

3) an association between congenitally absent lateral incisors and palatal canines.

In addition, the distribution of malocclusion categories of subjects with palatal canines will be compared with the distribution in other relevant populations to establish if palatal displacement of the canine is more frequently associated with a particular category of malocclusion.

6. CLINICAL MATERIAL

6.1 Records of patients attending Glasgow Dental Hospital were examined with the expectation of acquiring data for this study. These patients were derived from a West of Scotland population who had been referred for orthodontic treatment.

Names and unit numbers of all subjects recorded as having palatally displaced canines were obtained from the computerised records of patients attending Glasgow Dental Hospital Orthodontic Department from 1980 - 1985 inclusive.

The source of data proved to be inadequate for the following reasons:

i) In many cases the canines had been surgically removed, and the records culled.

ii) The canines had erupted either buccally or in the line of the arch subsequent to the original estimate of their position. In a number of cases the removal of the deciduous canines had been advised which could have favoured improvement in the canine position.

iii) The study models were no longer available, having been kept for a year after completion of treatment and then discarded.

The second method of data collection was started. This involved the systematic examination of orthodontic model boxes from 1 - 6,000, of patients undergoing orthodontic treatment at Glasgow Dental Hospital. Any cases showing absence of either one or both maxillary canines from the dental arch, and with no buccal bulge indicating its buccal position were selected for further investigation.

This did not involve the examination of all 6,000 boxes, as not all the numbers were in current use. All boxes which were held in the model storage area in the orthodontic department were, however, included.

The relevant case notes were obtained to check the radiographic and clinical records. Cases were discarded where the canine position was not confirmed as being palatally displaced, or where radiographs were not available.

200 records were accumulated with one or more palatally displaced canines, the only criteria for selection being that at least one undamaged set of original study casts was available, and corresponding radiographs taken within 6 - 9 months of the date of the study casts.

No subject was included where the palatal displacement of the canine was in doubt. That is, where there was adequate space for the canine and the radiographs indicated a minimal displacement, and the patient was under 15 years. (Ericson, Kurol 1986)

Eighteen of the original number were subsequently discarded due to a variety of reasons. These included duplication due to patients being recorded twice; radiographs misplaced from records subsequent to selection; or records culled after completion of treatment between selection and the start of data recording.

Not every number between 1 - 6000 was available; i.e. boxes reallocated after culling of records were not all in use. Some records were not available due to their withdrawal for treatment sessions or other purposes at the time of search.

As measurements from casts and radiographs were made, this information was immediately recorded on an individual card for each subject and transferred to a large chart later. The cards were stored alphabetically for purposes of retrieval; it also prevented the same patient being recorded on two occasions when occasionally records had been duplicated.

As there were 145 cases of unilateral displacement, and 37 cases of bilateral palatal displacement, this gave a total of 219 affected sides. The remaining 145 non-affected sides acted as controls. On the affected side, the distribution of canines was recorded separately as on (R) and (L) side of the arch, or bilaterally.

The symbol "u" denoted unerupted, and "er" denoted erupted.

The width of lateral incisor adjacent to a palatally displaced canine was recorded as "width of $\frac{2}{-}$ on the affected side." Similarly, the width of the lateral incisor on the control side was recorded in separate columns as "width of $\frac{2}{-}$ on the non-affected side." The widths varied between 3.5 mm and 8.0 mm. A separate column for each half-millmetre width between 3.5 and 8.0 mm (10 columns in all) was provided for both affected and non-affected sides with an additional column marked "A" for congenitally absent lateral incisors.

"P" denoted a peg-shaped lateral, and "S" denoted a small lateral incisor.

The definition of "small" was that given by Becker et al. (1981), i.e. it is small if the mesio-distal crown width is equal to or less than the opposite lateral incisor in the lower arch. A peg-shaped lateral was defined as one having the widest mesio-distal width at the gingival margin. Crowding was distinguished between anterior or buccal crowding and cases where only the canine had insufficient space for alignment.

6.2 Data from patients records

The final number of records and study casts for investigation was 182.

The following information from the patients' case notes was recorded:

i Name and chart number

ii [Unit number
[Model box number

iii Date of birth. Ethnic origin

iv Date of referral : age at this time

v Sex of patient.

A separate card was provided for each patient. The surname followed by the forename, with the unit number and box number were recorded at the top of the card, for ease of filing, and were arranged alphabetically. The cards were also numbered consecutively to match their entry number on large charts, where all the relevant information was recorded horizontally on one line. This horizontal line was divided vertically, so that information could be collected in vertical columns for ease of retrieval. The information on the large chart was in the following order, from left to right and comprised:

i [Chart number
[Surname, forename

ii Unit number, box number

iii Date of Birth. ethnic origin

iv [date of first referral
[Age of patient at time of referral

v Sex of patient

vi Malocclusion type

vii Position of the maxillary canines

viii Tooth length of the maxillary incisors measured on radiographs

ix Crown width of the maxillary incisors measured on study models

x Previous early extraction of deciduous molars (if recorded)

xi Retention of the deciduous canine

xii Congenitally missing teeth

xiii Resorption of incisor roots

xiv Buccal/anterior arch crowding; canine crowding

xv Photographs (if taken)

xvi Crown width of lower lateral incisors when relevant.

6.3 Radiographs

The types of radiographs in the case records varied, depending to some extent on the route of referral. The Oral Surgery Department, for example, did not often request a panoramic radiograph, some clinicians preferring a vertex occlusal view plus one other.

Only those subjects who had an orthopantomogram were included in the final selection; all patients also had at least one other view in order to localise the palatal canine when it was unerupted. A cephalogram had been taken in a number of cases where it was deemed to be clinically necessary.

Lateral head films had generally only been taken in cases where a skeletal anomaly existed, or where incisor angulations required alteration. They were not used to diagnose the position of the canine. Because of superimposition of bilateral images on the lateral head film, especially in cases where both canines are palatally displaced, accurate tracing is difficult, if not impossible.

6.4 Study casts of good quality, cast in artificial stone were available for each subject. They were undamaged, and correctly articulated to correspond with the malocclusion category recorded in the case notes.

6.5 Materials for comparison of measurements

Materials for comparison of measurements of tooth lengths of lateral incisors and adjacent central incisors on two different types of radiograph, viz, orthopantomogram and periapical radiograph.

This was required to test the claim by Becker et al (1984) that either radiograph could be used to measure lateral/central incisor ratios of tooth length. Only 11 subjects had both types of radiograph which were of sufficient clarity to identify the reference points. As 5 of the subjects had bilaterally identifiable reference points, the total number of paired incisors was 16. These were considered as 16 subjects.

6.6 Material for recording lateral crown width and tooth length of the lateral incisor and adjacent central incisor on affected and non-affected sides of the same arch

60 subjects were selected on the basis that they had an orthopantomogram, both lateral incisors were present, and they had a unilateral palatal displacement of the canine. The other side of the arch was the control side.

Difficulty in consistent recognition of reference points, particularly the root apex resulted in 17 subjects being discarded, leaving 43 subjects.

6.7 Extracted lateral incisors

A total of 106 extracted lateral incisors was supplied by Dr. M. Watt, Oral Biology Department, Glasgow Dental Hospital.

These teeth which were destined as teaching material for sectioning or cavity preparation, were derived from a West of Scotland population. They were collected from general dental practitioners from Glasgow and the surrounding area. The teeth, on extraction, were immediately placed in screw top jars supplied from the Dental Hospital. They were immersed in a solution of 10% formalin, in neutral buffered saline. These teeth were therefore not dried out specimens. The morphology of the lateral incisors was checked by the Lecturer in Dental Anatomy to ensure that their classification as lateral incisors was correct.

No teeth with incomplete apices or fractured roots or crown were included, nor any with mesial or distal caries which would have affected mesio-distal width measurements.

The purpose in selecting these lateral incisors was to measure the tooth and root length and relate these measurements to the mesiodistal width of the crown. This was done in order to establish if a link existed between crown width and tooth length.

7. METHOD

The following measurements and calculations were used

7.1 The number of male and female subjects

7.2 The number of subjects with unilateral and bilateral palatal canines

7.3 The number of palatal canines on (R) and (L) of the arch

The proportional distribution was calculated in each case.

7.4 The distribution of unerupted:erupted palatal canines

The palatal displacement was confirmed by radiograph. It was recorded as unerupted if no portion was visible on the study cast. It was recorded as erupted if any portion of the crown was visible on the study cast. There was no example of an absent canine on the affected or non-affected side of the arch.

7.5 Distribution of malocclusion categories

Class I

Class II division 1

Class II division 2

Class II indefinite

Class III

7.6 Measurement of crown width of lateral incisors on study casts

Measurements were made from the study casts of 182 subjects. Dividers were used to measure the mesio-distal crown width at its widest point, perpendicular to the long axis of the tooth. The width was calculated to the nearest 0.5 mm. Reproducibility, as before, required an identical measurement to be recorded on two subsequent occasions with an interval between of at least two weeks. The lower lateral incisor mesio-distal crown width was also measured if the opposite maxillary lateral incisor was 6.0 mm wide or less. This was done in order to fulfil the criterion for describing the maxillary lateral incisor as "small".

Where the maxillary lateral was of less than average width but not by definition "small", it was recorded as "not small" to save remeasuring the lower lateral incisor width at a later date.

7.7 Bilateral displacement of canines

This group which is assumed to be a severer form of the condition than the unilateral incidence was examined as a separate category. This allows comparison with the unilateral palatal canine group which was also examined as a discrete category.

7.8 Lateral incisor categories

The distribution of lateral incisor categories in male and female patients on affected/non-affected sides.

The results were analysed statistically using the chi-square test on the numbers recorded.

The distribution of small and peg-shaped lateral incisors on affected and non-affected sides was analysed.

7.9 Measurement of root length of lateral incisors on radiographs

The method described by Becker et al. (1984) was described in 4.13.

The mesial and distal extremities of the amelo-cemental junction were identified (a-b). Root length was measured on a perpendicular line from the apex to a-b. An attempt was made to use the same method. It proved difficult to identify the mesial and distal extremities of the amelo-cemental junction in all but a few radiographs. This lack of clarity was due both to the quality of the radiograph and the position of the teeth, which were often overlapping or rotated. As all root lengths could not be measured it was decided to measure tooth lengths, which were interchangeable for the purpose of this invesitgation.

7.10 Measurements of tooth length on radiographs

7.10.1 The orthopantomogram

Dividers were used directly on the radiographs. Tooth length was measured from the apex to the most incisal portion of the crown. It was calculated to the nearest 0.5 mm as advocated by Rejebian (1979) and by Larheim et al. (1984) who found an attempt at a greater degree of accuracy reduced reproducibility.

Measurements were repeated after an interval of at least two weeks. Unless they matched exactly, they were discarded. Measurements were repeated after similar intervals of more than two weeks, until identical measurements were obtained on two subsequent occasions.

It was considered that in view of the small discrepancies in tooth length which were being investigated, the margin of error should not be increased by any variation of measurement. Practice sessions before the actual calculations of tooth lengths included in this study were necessary, especially after a gap in time between measuring sessions. The method of measurement of Becker et al. (1984), using an acetate sheet over the radiograph and marking the reference points of apex and most incisal point of the crown was tried. It added an extra dimension for error in my hands, and measurements were less reproducible. This method was abandoned in favour of direct measurements on the radiographs.

Pin-holes to identify reference points were not used. If a point requires to be so marked to produce an accurate repeated measurement, there is some inherent doubt about its recognition.

7.10.2 The periapical radiograph

Measurements were carried out in a similar manner on all periapical films on which reference points were identifiable. Dividers were used; measurements were calculated to the nearest 0.5 mm. The apex and most incisal point of the crown were measured to give tooth length.

Calculations were repeated after an interval of at least two weeks and only identical measurements on two subsequent occasions were accepted.

In the case of both orthopantomograms and periapical films, a number were uninterpretable, mainly due to difficulty in identifying the root apex.

7.10.3 Ratios of tooth length of lateral incisors and the adjacent central incisor

Records of measurements were abstracted of all patients who had a lateral incisor adjacent to a central incisor and an interpretable panoramic and periapical film. This provided a total of only 11 subjects, 5 of whom had measured radiographs for both sides of the arch. This provided 16 'subjects' for the study.

Comparisons were made of absolute tooth lengths of lateral and central incisors measured on both types of radiograph. Ratios and percentages of tooth length of the lateral incisor to the adjacent incisor were calculated. The differences between the means of tooth length were calculated statistically. The standard error of difference between percentages was calculated statistically.

7.11 Measurements of crown width of lateral incisors and tooth lengths of the same lateral incisor and the adjacent central incisor

The records of the 43 subjects selected because they had interpretable orthopantomograms, bilateral presence of lateral incisors, and unilateral palatal canines were abstracted from the total of measured subjects.

The following calculations were made:

7.11.1 Tooth length of central incisors on affected and non-affected sides. This measurement was made, not in the expectation of a relationship between central incisor tooth length and palatal canines, but to establish if in fact no difference existed in tooth length on the affected/non-affected sides, prior to calculation lateral/central incisor ratios on the two sides.

7.11.2 Lateral incisor tooth lengths on affected/non-affected sides.

7.11.3 The ratio of lateral incisor/central incisor tooth lengths on affected/non-affected sides.

7.11.4 The crown widths of lateral incisors on affected and non-affected side.

The results were analysed statistically by computer using the paired t-test.

7.12 Measurement of extracted lateral incisors.

Tooth length and crown width

Tooth length was measured by dividers, from the apex to the most incisal point of the crown. The root length was measured from the greatest curvature of the amelo-cemental junction on the labial aspect of the crown to the tip of the apex.

The crown width was measured at the widest mesio distal dimension, perpendicular to the long axis of the tooth.

All calculations were made to the nearest 0.5 mm. All measurements were repeated after an interval of at least two weeks; the few which did not coincide with the previous calculations were repeated, and accepted when they matched exactly on two subsequent occasions, separated by the same interval of time.

The relationship between crown widths and tooth length was analysed statistically by computer.

7.13 Absence of lateral incisor

This was recorded, when the absence was confirmed by radiograph. If it were associated with a palatally displaced canine, this was recorded.

The proportions on affected/non-affected sides were calculated.

7.14 Error of method

7.141 Radiographic measurements

It is recognised that magnification distortion occurs on radiographs. It is less in the vertical dimension than in the horizontal and will differ according to the type of radiograph and procedures followed in patient positioning.

Calibration by measuring tooth length of extracted premolars and comparing the length measured on a pretreatment radiograph cannot be extrapolated for tooth length in other regions of the arch, e.g. the incisor region (Larheim et al 1984). The opportunity to measure the length of extracted incisors without apical pathology against pretreatment radiographs occurs rarely.

7.142 Orthopantomogram

In a retrospective study, the orthopantomograms will have been taken by several different radiographers, but standard procedures and patient positioning should reduce variation of technique. Even repeated procedures of one radiographer for the same patient are not identical (Larheim et al. 1984). Calibration of the orthopantomogram was not attempted.

7.14.3 Periapical radiographs

In Glasgow Dental Hospital, the bisecting angle technique is used for patients referred to the Department of Radiography from the Orthodontic Department for periapical radiographs. If, however, a patient is referred from any other department, the radiographer uses the long-cone paralleling technique. It is not unknown for a patient to be examined in another department prior to attending the orthodontic department. There is no consistency in the taking of periapical films depending as it does on the route of referral.

In order to overcome the effects of different amounts of magnification distortion, the method of Becker et al (1984) will be tested. They claim that the tooth length of the lateral incisor calculated as a ratio of the central incisor root length eliminates the effect of magnification distortion to a great extent since both teeth are equally affected. This claim will be tested.

Lastly, the angulation of incisors varies both from the normal overjet, and between pairs of incisors (lateral and adjacent central). Callibration of periapical radiographs was not attempted for these reasons.

Measurements were calculated to the nearest 0.5 mm on radiographs and on dental casts. This was as advised by Rejebian (1979). Larheim et al. (1984) found when he excluded tooth length measurement differences exceeding 2 mm the standard deviation based on repeated measurements decreased to about 0.5 mm (measurement error 0.4 mm) or 2% of the mean radiographic tooth length. It was decided therefore to measure to the nearest 0.5 mm, but demand exact coincidence of measurements repeated after an interval of at least two weeks. This improved reproducibility but at the cost of rejection of measurements of a number of subjects.

Pin holes were not used to identify reference points as this suggests a lack of interpretability of the radiograph if such marking is necessary.

7.15 Statistical Analysis

The paired sample t - test was computed for Tables 8.18, 8.19.

The Chi-square analysis for Tables 8.7., 8.8 (converted back to numbers) 8.10., 8.11.

The standard error of difference between means for Tables 8.15., 8.16., 8.17.

Regression analysis Table 8.33

Levels of significance were recorded viz $p < 0.05$

$p < 0.01$

$p < 0.001$

TABLE 8.1. Distribution of subjects with palatally placed canines according to their sex.

SUBJECTS		
Males	55	30.2%
Females	127	69.8%
Total	182	100%

UNILATERAL AND BILATERAL DISTRIBUTION OF PALATAL CANINES

TABLE 8.2.

NUMBER OF PALATAL CANINES		% OF TOTAL
Unilateral	145	79.7
Bilateral	37	20.3
	182	100

Distribution of palatal canines on (R) or (L) side of arch.

TABLE 8.3.

UNILATERAL PALATAL CANINES				
	(R)		(L)	
Males	46		53	
Females	20		26	
	66	(45.5%)	79	(54.5%)

Distribution of palatal canines, unerupted or erupted

TABLE 8.4

Palatal canine	Unerupted	per cent	Erupted	per cent	TOTAL	per cent
Unilateral	99	(68.3)	46	(31.7)	145	100
Bilateral	50	(67.6)	24	(32.4)	74	100
TOTAL	149		70		219	

Distribution of malocclusion in subjects with palatal canines

TABLE 8.5.

Malocclusion Class	Glasgow No. of subjects	Glasgow Percentage
I	102	56.0
II division 1	17	9.4
II division 2	45	24.7
II indefinite	7	3.9
III	11	6.0
TOTAL	182	99.9

TABLE 8.6.

Distribution of crown widths of lateral incisors categorised by malocclusion type.

	Affected side											Non-affected side										
CLASS I	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	Abs.	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	Abs.
Normal	-	-	-	-	3	6	19	30	15	5	-	-	-	-	-	4	7	13	24	7	4	-
Small	-	-	-	7	6	12	1	-	-	-	-	-	-	-	2	1	11	2	-	-	-	-
Peg	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1	0	0	9	9	18	20	30	15	5	14	0	0	0	2	5	18	15	24	7	4	7
CLASS II^1 (b)																						
Normal	-	-	-	-	-	1	3	7	1	2	-	-	-	-	-	-	3	3	4	3	-	-
Small	-	-	-	1	3	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Peg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	0	0	0	1	3	1	4	7	1	2	0	0	0	0	0	1	3	3	4	3	0	0
CLASS II^2 (c)																						
Normal	-	-	-	-	-	1	10	9	7	1	-	-	-	-	-	-	6	4	11	2	-	-
Small	-	-	1	6	4	5	2	-	-	-	-	-	-	-	1	2	4	2	-	-	-	-
Peg	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	0	1	1	6	4	6	12	9	7	1	4	0	0	0	1	2	10	6	11	2	0	7
CLASS II ind. (d)																						
Normal	-	-	-	-	-	1	3	3	-	2	-	-	-	-	-	-	-	2	2	1	-	-
Small	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	0	0	0	0	0	1	3	3	0	2	0	0	0	0	0	0	0	2	2	1	0	0
CLASS III																						
Normal	-	-	-	-	-	3	-	3	3	-	-	-	-	-	-	-	-	-	3	1	-	-
Small	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Peg	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	0	1	3	0	1	3	0	3	3	0	0	0	0	0	0	0	3	0	3	1	1	0

Distribution of crown widths of lateral incisors
on affected and non-affected sides.

TABLE 8.7.

	Affected side											Non-affected side										
	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	Abs.	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	Abs.
Normal	-	-	-	-	3	12	35	52	26	-	-	-	-	-	-	4	16	22	44	14	-	-
Small	-	1	2	14	14	17	4	-	-	-	-	-	-	-	3	4	19	4	-	-	-	-
Peg	1	-	2	2	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1	2	4	16	17	29	39	52	26	10	18	0	0	0	3	8	35	26	44	14	5	14

Combined totals from Table 6 (a - e) $X^2 = 18.3$ D.F. = 10

Percentage of lateral incisors according to crown width on affected and non-affected sides.

TABLE 8.8.

CROWN 2 WIDTH mm.	Affected side per cent	Non-affected side per cent
3.5	0.5	0
4.0	0.9	0
4.5	1.7	0
5.0	7.5	2.0
5.5	8.0	5.4
6.0	13.6	23.5
6.5	18.2	17.4
7.0	24.3	29.5
7.5	12.2	9.4
8.0	4.7	3.4
Abs.	8.4	9.4
	100	100

Distribution of crown widths of lateral incisors associated with palatal canines bilaterally.

TABLE 8.9.

Bilaterally affected					Non-affected
WIDTH 2 mm.	NO.OF TEETH	%	SMALL 2	PEG 2	
3.5	1	1.4		1	0
4.0	2	2.7		2	0
4.5	3	4.0	1	2	0
5.0	4	5.4	3		3
5.5	8	(10.8)	5		8
6.0	7	(9.5)	2		35
6.5	8	(10.8)			26
7.0	15	(20.2)			44
7.5	12	(16.2)			14
8.0	7	(9.5)			5
Absent	7	(9.5)			14
	74	100	11	5	149

The crown width is further sub-divided into small or peg-shaped categories.

Distribution of lateral incisor categories in male and female subjects.

TABLE 8.10.

AFFECTED SIDE

LATERAL INCISOR	MALES		FEMALES			
	NO.OF TEETH	PER CENT	NO.OF TEETH	PER CENT	NO.OF TEETH	PER CENT
NL	38	56.8	99	65.1	137	62.5
SL	20	29.8	36	23.7	56	25.6
PL	2	2.9	5	3.3	7	3.2
AL	7	10.5	12	7.9	19	8.7
TOTAL	67	100	152	100	219	100

Distribution of normal, small, peg-shaped or absent lateral incisors.

$X^2 = 1.54$ D.F. = 3 $P < 0.50$

Distribution of lateral incisor categories in male and female subjects.

TABLE 8.11.

NON-AFFECTED SIDE

LATERAL INCISOR	MALES		FEMALES			
	NO.OF TEETH	PER CENT	NO.OF TEETH	PER CENT	NO.OF TEETH	PER CENT
NL	29	67.4	73	71.6	102	70.3
SL	10	23.3	18	17.6	28	19.3
PL	0	0	0	0	0	0
AL	4	9.3	11	10.8	15	10.4
	43	100	102	100	145	100

$X^2 = 0.57$ D.F. = 2 $P < 0.50$

Distribution of small and peg-shaped lateral incisors on affected and non-affected sides.

TABLE 8.12.

CROWN Width mm.	Number of small lateral incisors Affected side		Non-affected side
3.5	1	(1P)	
4.0	2	(2P)	
4.5	4	(3P)	
5.0	16	(2P)	3
5.5	12		4
6.0	17		19
6.5	4		2
TOTAL	56		28

Measurements of tooth lengths of lateral incisors and adjacent central incisors on orthopantomograms.

TABLE 8.13.

PANORAMIC RADIOGRAPH		
SUBJECT	TOOTH LENGTH LATERAL INCISOR mm	TOOTH LENGTH CENTRAL INCISOR mm
1	29.0	31.0
2	28.5	29.0
3	29.0	30.0
4	27.5	31.5
5	31.5	35.0
6	24.5	28.0
7	30.0	31.5
8	29.0	31.0
9	30.0	31.0
10	30.0	30.0
11	26.5	28.0
12	28.0	29.0
13	30.5	31.0
14	32.5	35.0
15	25.0	35.0
16	26.0	29.0
Sum	457.5	495.0
Mean tooth length	28.59	30.93
S.D.	2.25	2.31

Measurements of tooth lengths of lateral incisors and adjacent central incisors on periapical radiographs.

TABLE 8.14.

PERIAPICAL RADIOGRAPH		
SUBJECT	TOOTH LENGTH LATERAL INCISOR mm	TOOTH LENGTH CENTRAL INCISOR mm
1	17.0	19.0
2	24.0	27.0
3	19.0	19.0
3	18.5	22.5
5	22.0	27.0
6	17.5	21.5
7	17.5	24.0
8	20.0	20.0
9	22.5	24.0
10	17.5	19.0
11	22.5	20.0
12	21.0	22.0
13	20.0	22.5
14	22.0	24.5
15	13.0	18.5
16	26.5	26.0
Sum	320.5	356.5
Mean tooth length	20.03	22.28
S.D.	3.26	2.90

Mean tooth lengths of central and lateral incisors measured on panoramic radiographs.

TABLE 8.15.

PANORAMIC RADIOGRAPH				
Tooth	No.of data	Mean tooth length (mm)	S.D.	Mean Ratio
1	16	30.93	2.31	0.93
2	16	28.59	2.25	

Mean tooth lengths of central and lateral incisors measured in periapical radiographs.

TABLE 8.16.

PERIAPICAL RADIOGRAPH				
Tooth	No.of data	Mean tooth length (mm)	S.D.	Mean Ratio
1	16	22.8	2.90	0.90
2	16	20.03	3.26	

Mean tooth lengths of central and lateral incisors measured on periapical radiographs. (Glasgow).

Comparison of ratios of tooth lengths of lateral and central incisors measured on panoramic and periapical radiographs.

TABLE 8.17.

	RATIO 2:1	RATIO 2 : 1
SUBJECT	PANORAMIC VIEW	PERIAPICAL VIEW
1	0.94	0.89
2	0.98	0.89
3	0.97	1.0
4	0.87	0.82
5	0.90	0.81
6	0.88	0.81
7	0.95	0.73
8	0.94	1.0
9	0.97	0.94
10	1.0	0.92
11	0.95	1.1
12	0.97	0.95
13	0.98	0.88
14	0.93	0.90
15	0.71	0.70
16	0.90	1.0

Mean	0.92	.89
S.D. =	0.069	0.10

$0.01 < P > 0.05$

Distribution of crown width of lateral incisors, their tooth length and the tooth length of the adjacent central incisor.

TABLE 8.18.

AFFECTED SIDE

	CROWN WIDTH (mm)	TOOTH LENGTH (mm)		
	2	2	1	2 : 1 Ratios
1	7.5	28.5	31.0	0.92
2	7.5	26.5	25.0	2.06
3	7.5	32.0	31.0	1.03
4	7.5	30.0	32.0	0.94
5	7.5	30.0	31.5	0.95
6	7.5	29.5	29.5	1.00
7	7.0	28.5	30.0	0.95
8	7.0	29.5	30.0	0.98
9	7.0	29.5	29.5	1.00
10	7.0	20.5	21.0	0.98
11	7.0	22.5	30.0	0.75
12	7.0	27.5	27.0	1.02
13	7.0	29.0	31.0	0.94
14	6.5	30.0	28.0	1.07
15	6.5	30.5	32.0	0.95
16	6.5	28.5	29.0	0.98
17	6.5	24.0	25.5	0.94
18	6.5	26.5	29.0	0.91
19	6.0	27.5	30.0	0.92
20	6.0	30.0	33.0	0.91
21	6.0	29.0	29.0	1.00
22	6.0	27.0	29.0	0.93
23	5.5	25.0	30.5	0.82
24	5.5	25.0	29.0	0.86
25	5.0	26.5	27.5	0.96
26	5.0	24.5	28.0	0.88
27	5.0	25.0	35.0	0.71
28	5.0	28.0	29.0	0.97
29	6.0	27.0	29.0	0.93
30	6.0	30.0	31.5	0.95
31	6.0	16.5	22.0	0.75
32	6.0	25.0	30.0	0.83
33	6.5	29.0	29.0	1.00
34	6.5	32.5	35.0	0.93
35	6.5	30.5	32.0	0.95
36	6.5	29.0	30.0	0.97
37	6.5	29.0	29.0	1.00
38	7.5	28.0	30.0	0.93
39	7.5	24.0	27.0	0.88
40	7.0	22.0	35.0	0.63
41	7.0	30.0	31.0	0.97
42	7.0	23.0	29.0	0.79
43	7.0	31.0	29.0	1.07

Mean length 2 27.37 S.D. = 3.26

Mean length 1 29.56 S.D. = 2.84

Mean ratio of length 2:1 0.93 S.D. = 0.09

Distribution of crown width of lateral incisors, their tooth length and the tooth length of the adjacent central incisor.

TABLE 8.19.

NON-AFFECTED SIDE

	CROWN WIDTH (mm)	TOOTH LENGTH (mm)		
	2	2	1	2 : 1 Ratio
1	7.0	28.5	31.0	0.92
2	7.0	20.0	22.5	0.88
3	7.0	29.5	32.0	0.92
4	7.5	29.0	32.0	0.91
5	7.5	31.5	33.0	0.95
6	7.0	26.0	28.0	0.93
7	7.5	31.0	30.5	1.02
8	7.0	26.5	28.0	0.95
9	7.0	29.0	28.0	1.04
10	7.0	21.0	21.0	1.00
11	7.0	25.5	29.0	0.88
12	7.0	27.0	27.0	1.00
13	7.0	29.0	31.0	0.94
14	6.5	26.0	28.5	0.91
15	6.5	28.0	21.5	0.88
16	6.5	27.0	29.0	0.93
17	6.5	24.0	27.0	0.88
18	6.0	26.0	28.0	0.93
19	6.5	28.0	30.0	0.93
20	6.0	30.0	32.0	0.94
21	6.0	28.5	30.0	0.95
22	5.5	30.5	29.0	1.05
23	5.0	25.0	30.0	0.83
24	5.0	25.0	28.5	0.88
25	6.0	25.0	26.5	0.94
26	6.0	26.0	29.0	0.90
27	6.0	30.0	34.0	0.88
28	5.5	25.0	27.0	0.93
29	7.0	28.0	28.0	1.00
30	6.5	28.5	29.0	0.98
31	6.0	18.5	22.0	0.84
32	5.0	26.5	29.0	0.91
33	6.5	29.5	31.0	0.95
34	7.5	31.5	35.0	0.90
35	6.0	31.0	33.0	0.94
36	7.0	27.5	33.5	0.82
37	6.5	29.5	31.0	0.95
38	7.5	31.5	31.0	1.02
39	7.5	23.0	27.0	0.85
40	7.0	23.0	32.5	0.71
41	7.0	31.5	31.5	1.00
42	7.0	28.5	29.5	0.97
43	7.0	29.0	31.0	0.94

Mean length 2	27.31	S.D. = 3.11
Mean length 1	29.47	S.D. = 2.96
Mean ratio of lengths 2:1	0.93	S.D. = 0.06

Measurements of crown width of 106 extracted lateral incisors.

TABLE 8.20.

CROWN WIDTH mm.	NUMBER OF TEETH
5.5	2
6.0	16
6.5	17
7.0	46
7.5	16
8.0	8
8.5	1
TOTAL	106

Mean root length associated with crown width of extracted lateral incisors.

TABLE 8.21.

CROWN WIDTH mm.	MEAN ROOT LENGTH mm.
5.5	12.5
6.0	11.81
6.5	12.32
7.0	13.13
7.5	12.78
8.0	12.75
8.5	14.0

The mean root length was calculated for each group according to crown width with the exception of the 8.5 mm width of which there was but one example.

There was no statistical significance between crown width and tooth length of 106 extracted lateral incisors.

Distribution of congenitally absent lateral incisors on affected and non-affected sides.

TABLE 8.22.

CONGENITALLY ABSENT LATERAL INCISORS

No. of Subjects	AFFECTED SIDE WIDTH 2 (mm)	NON-AFFECTED SIDE WIDTH 2 (mm)
1	5.0	A
2	6.5	A
3 *	A + 5.5 (small)	-
4	A	7.5
5 *	A + 7.5	-
6	A	(previously extracted)
7	A	6.0 (small)
8	A	7.0
9	6.0 (small)	A
10	6.5	A
11	5.00 (small)	A
12 *	A + 5.0 (small)	-
13	A	7.5
14 *	A + A	-
15	A	A
16	A	A
17	A	A
18	A	A
19	A	A
20	A	A
21	A	A
22	A	A
23	A	A
TOTAL	19	14

"A" denotes absent.

* Indicates bilateral palatal displacement of the canine : both laterals appear on the affected side.

Distribution of age at date of referral of subjects with palatal canines.

TABLE 8.23.

AGE	8	9	10	11	12	13	14	15	16	17	18	19	20	21-24	25-29	30+	TOTAL
SUBJECTS	1	1	3	9	16	19	36	25	21	9	7	5	8	14	5	3	182

The age range was 8 - 34 years.

Distribution of malocclusion in subjects with palatal canines

TABLE 8.24.

Malocclusion Class	Glasgow No. of subjects	Glasgow Percentage	Shropshire Percentage
I	102	56.0	44
II division 1	17	9.4	27
II division 2	45	24.7	18
II indefinite	7	3.9	7
III	11	6.0	3.3
TOTAL	182	99.9	99.3

Comparison with a Shropshire population. (Foster and Day 1974).

Distribution of subjects with palatal canines (canine group) in malocclusion categories.
All are derived from orthodontic populations.

TABLE 8.25.

Malocclusion Class	(Glasgow) Canine group per cent	(Bass) Canine group per cent (150 patients)	(Bass) Random group
I	56	63.7	47.5
II division 1	9.3	12.4	30.5
II division 2) II indefinite)	28.6	16.9	11.8
III	6.0	7.0	10.2

(Bass, 1967)

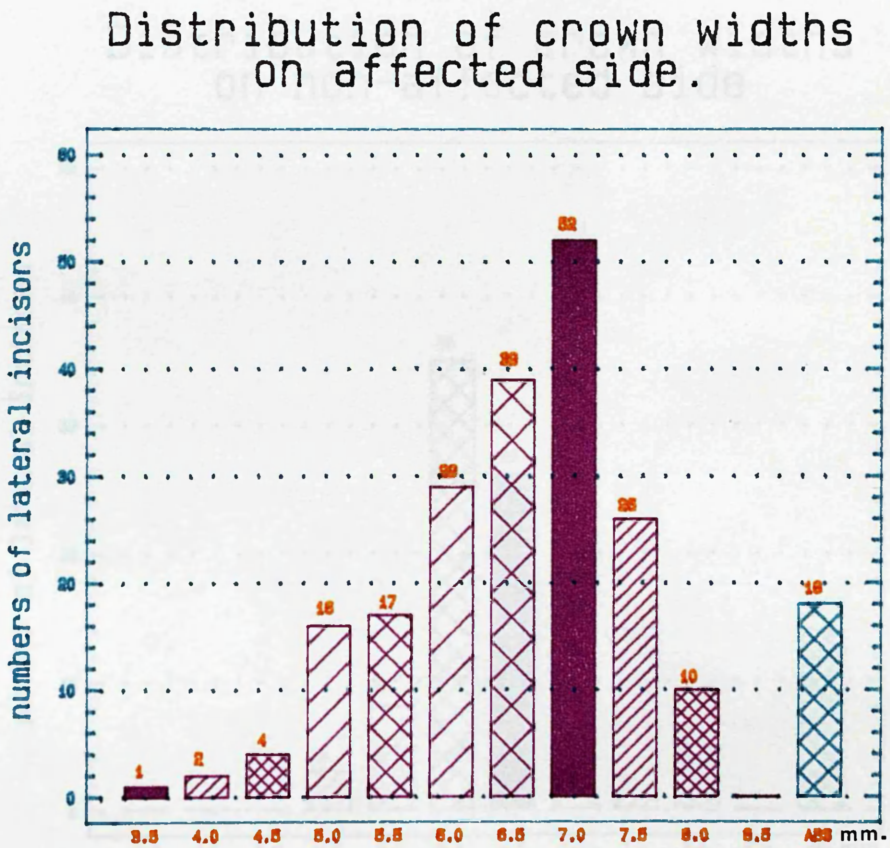
Distribution of malocclusion in two Glasgow populations.

TABLE 8.26.

Malocclusion Class	Glasgow Canine group per cent	Glasgow orthodontic population per cent
I	56	42.5
II division 1	9.3	28.3
II division 2	24.7	12.9
II indefinite	3.9	3.6
III	6.0	10.0

GRAPH 1

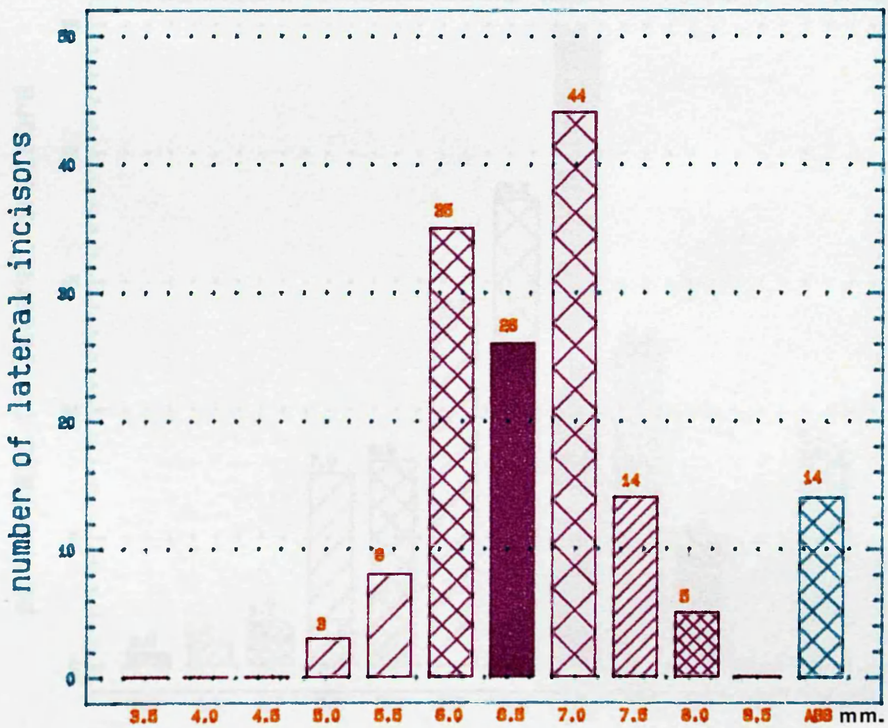
8.27


Distribution of crown widths
on affected side.
numbers of lateral incisors
60
50
40
30
20
10
0
1
2
4
16
17
29
39
52
26
10
18
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
ABS
mm.

GRAPH 2

8.28

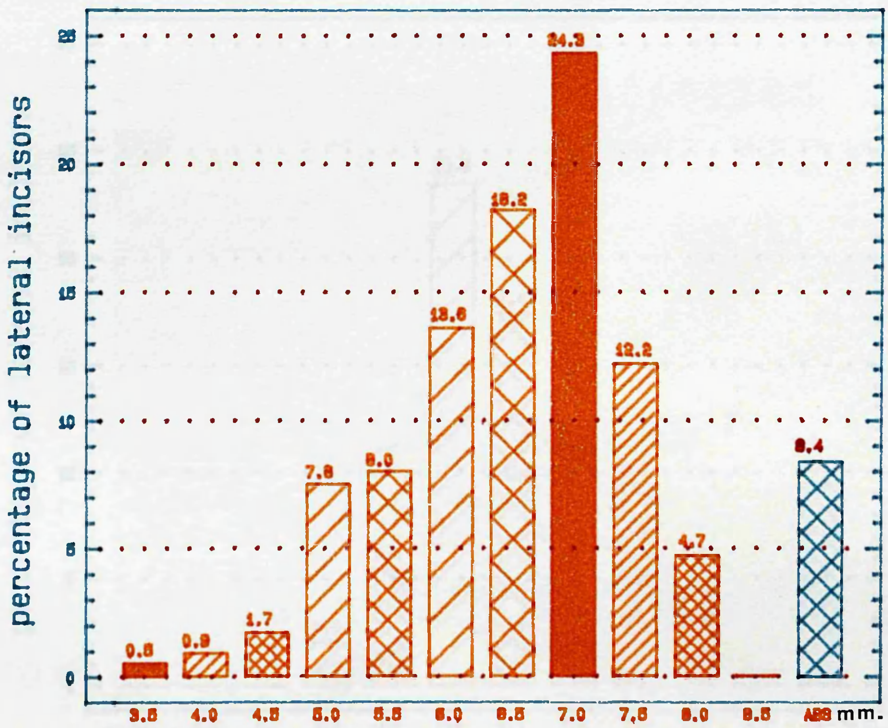
Distribution of crown widths
on non-affected side



GRAPH 3

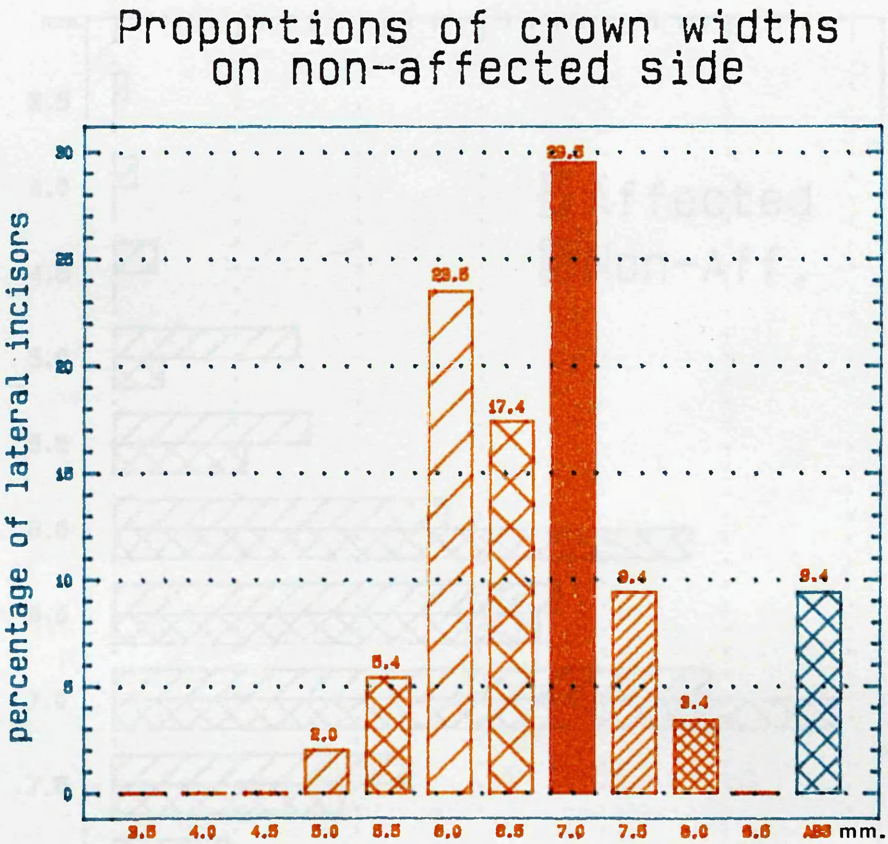
8.29

Proportions of crown widths on affected side.



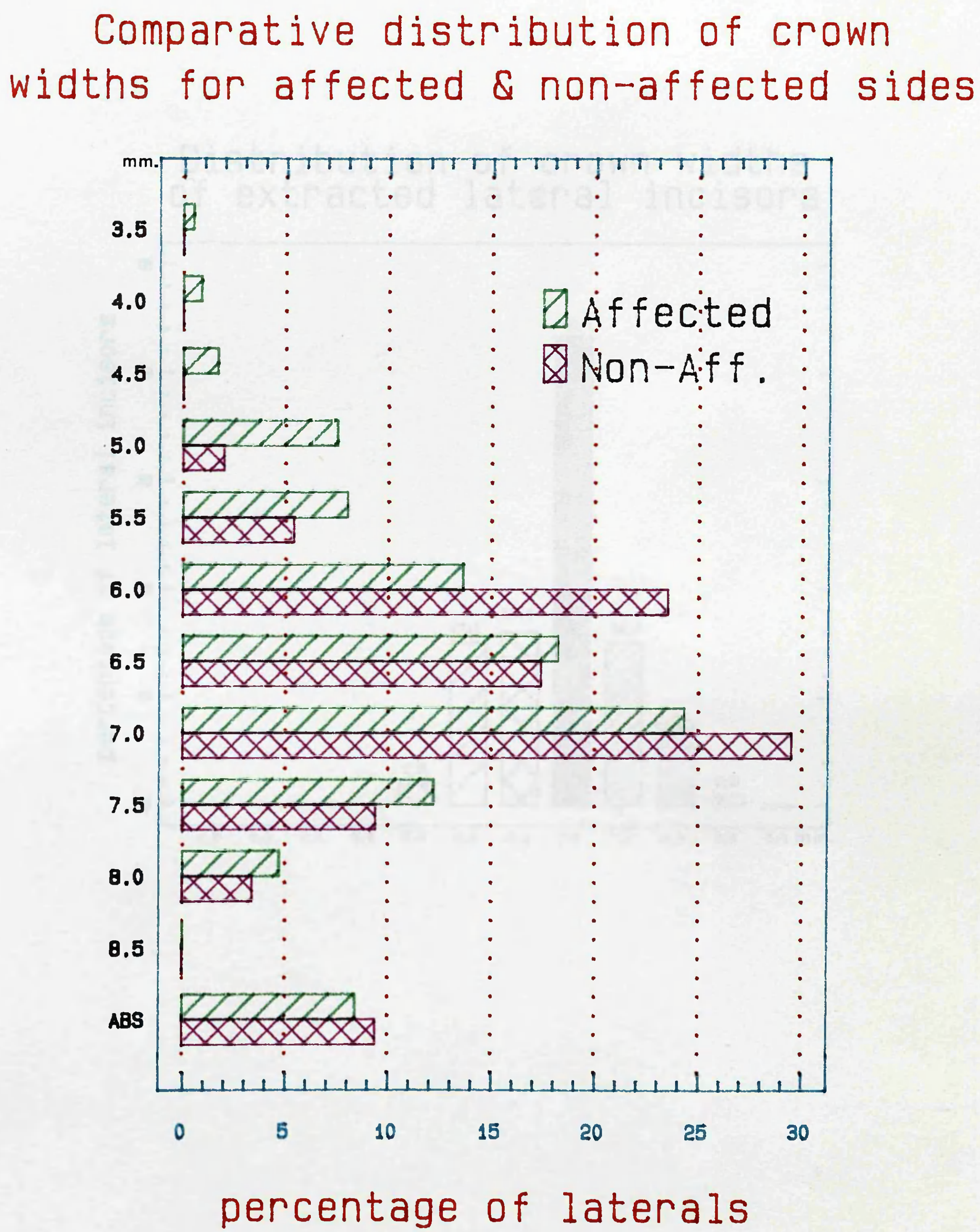
GRAPH 4

8.30


Proportions of crown widths
on non-affected side
percentage of lateral incisors
30
25
20
15
10
5
0
29.5
23.5
17.4
9.4
9.4
5.4
3.4
2.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
ABS
mm.

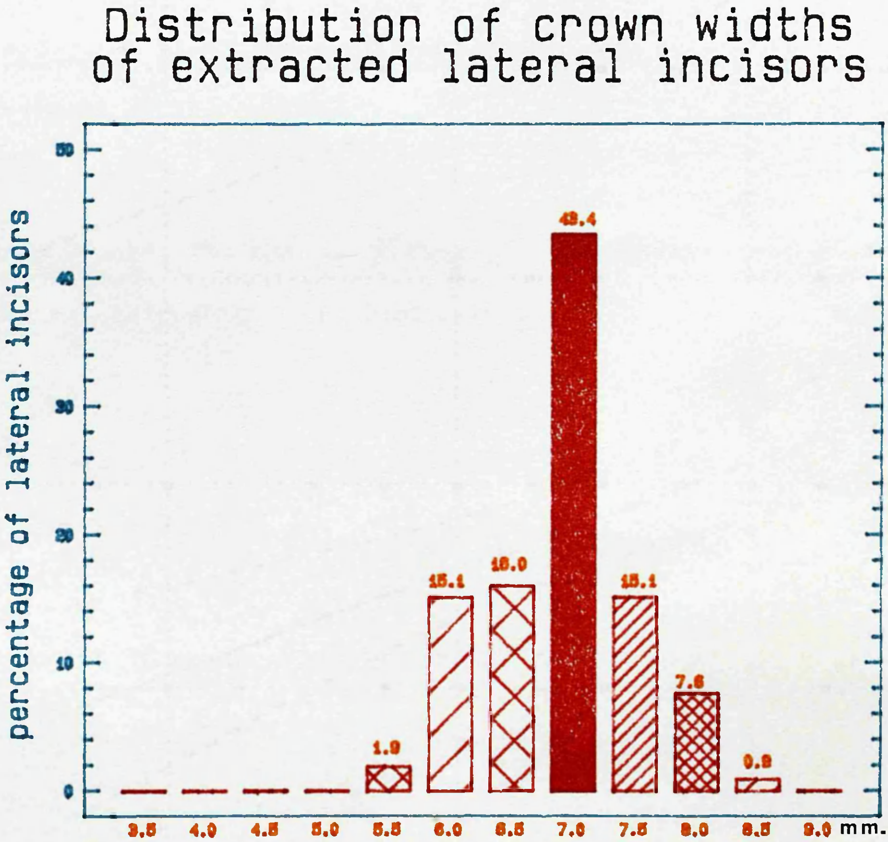
GRAPH 5

8.31


Comparative distribution of crown widths for affected & non-affected sides
mm.
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
ABS
Affected
Non-Aff.
0
5
10
15
20
25
30
percentage of laterals

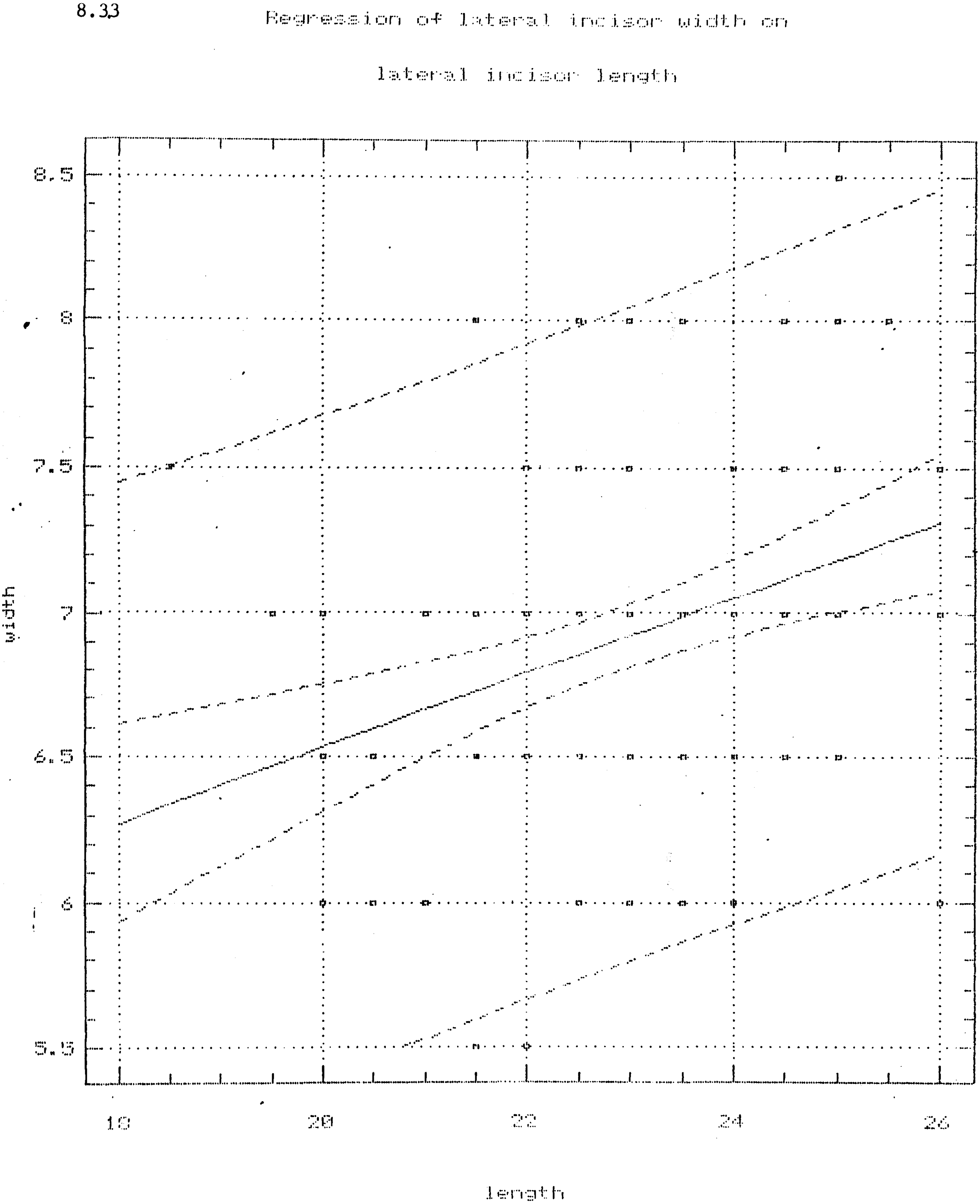
GRAPH 6

8.32


Distribution of crown widths
of extracted lateral incisors
percentage of lateral incisors
0
10
20
30
40
50
1.9
15.1
16.0
43.4
15.1
7.6
0.9
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
mm.

GRAPH 7

8.33



The slope of the regression line for lateral crown width on lateral tooth length of extracted lateral incisors is significantly different from zero.

9. RESULTS

9.1 The categories of subjects according to their sex

(Table 1)

There were 55 males and 127 females. This is a proportion of 30.2% males and 69.8% females.

9.2 The proportion of subjects with unilateral and bilateral displacement of the canine

(Table 2)

Of 182 subjects, 145 had unilateral palatal canines, and 37 had bilateral palatal canines, a proportion of 79.7% unilateral and 20.3% bilateral.

9.3 Distribution of unilateral palatal canines on right and left sides of the arch

(Table 3)

There are 45.5% on the right and 54.5% on the left.

9.4 Distribution of palatal canines, unerupted and erupted

(Table 4)

The proportions of unerupted : erupted are 68.3 : 31.7% respectively for the unilateral palatal canine group, and 67.6 : 32.4% respectively for the bilateral canine group.

The proportions are very similar in both the unilateral and bilateral canine groups.

9.5 Distribution of subjects with palatal canines in categories of malocclusion

(Table 5)

9.5.1	Class I	:	56%
	Class II div.1	:	9.4 %
	Class II div.2	:	24.7%
	Class II indefinite	:	3.9%
	Class III	:	6.0%

9.5.2 For comparison purposes the malocclusion categories of a general British population are shown alongside the Glasgow canine group on Table 24.

9.5.3 Tables of the distribution of subjects with palatal canines (canine group) from two orthodontic populations (Bass) are shown with the canine group (Glasgow) in categories of malocclusion on Table 25.

The difference between the populations was analysed statistically.

Chi-square = 6.773 DF = 3 $0.10<p<0.05$

The populations are dissimilar. The main differences are in the proportion of Class II division 2 subjects and to a lesser extent, Class II division 1 subjects.

9.5.4 Distribution of malocclusion in two Glasgow orthodontic populations are shown for comparison purposes on Table 26.

9.6 Distribution of crown widths of lateral incisors on affected and non-affected sides in malocclusion categories

(Table 6)

Lateral incisors are tabulated by crown width by intervals of 0.5 mm from 3.5 - 8.0 mm, with an additional column for congenitally absent lateral incisors (Abs).

These were separated into affected and non-affected sides indicating the association of the lateral incisor with a palatally displaced canine (affected side) or with a normal canine (non-affected side). The separation into malocclusion categories was continued in order to discern any significant differences in crown widths distribution according to malocclusion type.

9.7 Combined totals of Table 6 (a - b) are drawn in Table 7 (Graphs 1 and 2). The crown widths of lateral incisors on the affected side are shown in Graph 1, and on the non-affected side in Graph 2.

Of 182 subjects, the combined total of 364 lateral incisors has been reduced to 363. It was discovered that one lateral incisor had been removed some years previously due to root resorption. This one tooth was removed from the total of congenitally absent lateral incisors.

The distribution of categories of crown widths of lateral incisors was analysed statistically using the chi-square test.

Result: Chi-square = 17.49 DF = 10

The difference was statistically significant at the level $P<0.05$.

The proportions of crown width categories of lateral incisors are shown on:

Graph 3 (affected side)

Graph 4 (non-affected side)

9.8 Percentage distribution of lateral incisors according to crown width on affected and non-affected sides

(Table 8)

The percentage of each crown width from 3.5 - 8.0 mm and congenitally absent lateral incisors are shown.

3.5 mm indicates the smallest crown width in the sample, and 8.0 mm the largest.

9.9 Distribution of crown widths of lateral incisors associated with bilateral palatal canines

(Table 9)

This was included as the bilateral displacement of canines palatally is assumed to be a severer form of the condition. The distribution of crown widths was compared with that on the non-affected side.

The differences were analysed statistically using the chi-square test.

Chi-square = 29.4   DF = 9

The differences were highly significant at $p < 0.001$ level.

9.10 Distribution of lateral incisor categories in male and female subjects

(Table 10)   affected side

9.11 (Table 11)   non-affected side

The distribution of normal, small, peg-shaped and congenitally absent lateral incisors in male and female subjects was analysed statistically using the chi-square test.

Table 10   (the affected side)

Chi-square = 1.54   DF = 3

There was no statistically significant difference at the $p < 0.50$ level.

Table 11 (the non-affected side)

There was no example of a congenitally absent lateral incisor on the non-affected side.

Chi-square = 0.57   DF = 2

There was no statistically significant difference at the $p < 0.50$ level.

As there was no statistically significant difference in the distribution of lateral incisor categories in male and female subjects, the categories can be combined.

9.12 Distribution of small and peg-shaped lateral incisors on affected and non-affected sides

(Table 12)

Congenitally absent lateral incisors will be considered separately in Table 22.

The distribution of small and peg-shaped lateral incisors on affected and non-affected sides is 56 and 28, a proportion of 2:1 respectively.

All the examples of peg-shaped laterals are on the affected side.

9.13 Measurements of tooth lengths of lateral incisors and the adjacent central incisor

(All measurements are in millimetres, to the nearest 0.5 mm)

(Table 13) Panoramic radiograph

9.14 (Table 14) Periapical radiograph

The subject numbers in Tables 13 and 14 correspond.

Measurements of tooth lengths of the same subjects were taken on two different types of radiograph, viz. panoramic and periapical to test if these views provided comparable data.

9.15
9.16 Mean tooth lengths and standard deviations were calculated for Table 13 and Table 14. They are shown on Tables 15 and 16 respectively.

Differences between means of the tooth lengths of lateral incisors on panoramic and periapical radiographs were analysed statistically using Student's t test. Similarly, the differences between the tooth lengths of the central incisors on panoramic and periapical radiographs were analysed statistically using Student's t test. In both cases the result is highly significant at $p \ll 0.001$ which renders the null hypothesis unlikely. That is, there is a difference between the two populations represented by the panoramic and periapical film groups. The two types of radiograph are therefore not interchangeable for the purpose of measuring tooth lengths.

9.17 Comparison of ratios of tooth lengths of lateral and adjacent central incisors measured on panoramic and periapical radiographs Table 17)

As differences were found between absolute measurements in Tables 13, 14, ratios were calculated of the tooth lengths of the lateral incisors to the adjacent central incisor. The subject numbers 1 - 16 again correspond to the numbers in Tables 13 and 14.

The difference between the means of ratios of tooth length of lateral incisors to central incisors on panoramic and periapical radiographs was analysed statistically using Student's t test.

Result:

The difference is of statistical significance at the level $0.1<p<0.05$. The null hypothesis is unlikely. This does not establish the validity of using ratios of tooth length on either periapical or panoramic radiographs instead of absolute tooth measurements.

9.18 Distribution of crown widths of lateral incisors, their tooth lengths and the tooth lengths of the adjacent central incisors

Table 18 (affected side)

9.19 Table 19 (non-affected side)

The following calculations were made using the statgraphics computer package. The paired sample t test was computed.

1. Tooth lengths of central incisors on affected and non-affected sides.

   Result:

   There was no statistically significant difference at the $p < 0.85$ level.

2. Tooth lengths of lateral incisors on affected and non-affected sides.

   Result:

   There was no statistically significant difference at the $p < 0.54$ level.

3. The ratios of tooth length of lateral incisors to the adjacent central incisor on affected and non-affected sides.

   Result:

   There was no statistically significant result at the $p < 0.94$ level.

4. The widths of lateral incisors on affected and non-affected sides.

   Result:

   There was no statistically significant result at the $p < 0.74$ level. The null hypothesis was likely in each case 1 - 4. i.e. the null hypothesis was not disproved.

9.20 <u>Measurements of crown widths of 106 extracted lateral incisors</u>

(Table 20)

The number of teeth in each crown width category is shown.

9.20 Percentage in each crown width category

Crown Width	Number
5.5	2
6.0	16
6.5	17
7.0	46
7.5	16
8.0	8
8.5	1
	106

The percentage distribution of crown widths is shown in Graph 6.

9.21 The mean root length associated with crown width of extracted lateral incisors

(Table 21)

The association between crown width of the lateral incisor and the mean root length was examined. There was no apparent association of smaller root length associated with smaller crown widths.

The association between crown width of the lateral incisors and the tooth length was analysed statistically by computer, using the regression analysis (Graph 7).

Graph 7.

Result:

The correlation coefficient of 0.3551 between crown widths and tooth length of extracted lateral incisors is well below statistical significance. Only 12.61% of the variation in root length can be explained from the variation in crown width. (R-squared = 0.1261).

9.22 Distribution of congenital absence of lateral incisors associated with palatal canines

(Table 22)

The prevalence of congenitally absent lateral incisors was 33 out of 363 lateral incisors, which represented 9.1% of lateral incisors. However, in 10 subjects, lateral incisors were absent bilaterally. Congenitally absent lateral incisors occurred in 23 out 182 subjects, a prevalence of 12.6% in this population of orthodontic subjects with palatal canines. However, the distribution of the absent laterals was 19 : 14 on affected and non-affected sides, or 57.6 : 42.4% respectively. A difference of only 15.2%.

One subject had bilateral palatal canines and bilateral absence of lateral incisors. There were altogether 4 subjects with bilateral palatal canines, 3 of whom had small or absent laterals on both sides of the arch.

Of the 12 associated laterals, 5 were categorised as small, and one lateral incisor had a crown width of 5.0 mm. but was not defined as small. The other 6 laterals were of normal crown width.

9.23 Distribution of age at date of referral of subjects with palatal canines

(Table 23)

The percentage distribution of ages was:

8 - 11 Years	-	7.7%
12 - 16 Years	-	64.3%
17 - 34 Years	-	28.0%

10. DISCUSSION

10.1 Discussion of material

The West of Scotland population studied was not selected by random numbers from a table supplied for this purpose.(Kirkwood 1988) It is, therefore, not representative of a general population.

Although all subjects who had palatal canines were selected from a population of orthodontic patients currently attending for orthodontic treatment, the sample chosen would be described as accidental.

It was convenient to search through all the available study model boxes in view of the small numbers of subjects expected to have the condition under study, the prevalence of palatal displacement of the canine being between 1% and 2% of the population. (Dachi et al. 1961; Bass, 1967; Kuftinec et al. 1984; (Brin et al. 1986.)

Because this was an orthodontic population there may be a bias in favour of female patients. (Dewel 1949; Bass 1967; Thilander et al. 1968).

Generalisations cannot be made with the parent population. As probability sampling was not employed in selecting the population for this study, care must be taken in comparing results with general as distinct from orthodontic populations.

Numbers of data

182 subjects: study casts were measured

43 subjects: selected as having unilateral palatal displacement of the canines and interpretable orthopantomograms.

11 subjects: selected as having interpretable periapical and panoramic radiographs of the same pair of incisors (lateral and central), providing 16 pairs.

Although these numbers were disappointingly low, it was felt that they were adequate for the studies undertaken. The main reason for rejection was uninterpretability of radiographs, especially identification of the tooth apex. Difficulty of recognition of radiographic reference points has been noted by Rejebian (1979). Larheim et al (1984) reported 17% of non-measurability, and 17% requiring pin-holes as identification for repeated measurements of tooth lengths, a total of 34% of his radiographs which had been specially taken for his prospective study.

For a future prospective study requiring tooth length measurements, the long-cone paralleling technique as favoured by Sjölien and Zachrisson (1973) would offer greater clarity of maxillary incisors if periapical radiographs were among the chosen views.

10.2 Discussion of method

Measurements by dividers require practice for accuracy and consistency. Practice sessions prior to taking measurements for the study were a necessary prelude. The measurements of the study casts presented less difficulty than the radiographs.

A Boley guage was used in his study of tooth size distortions on radiographs by Rejebian (1979). He reduced the measuring legs to 0.2 mm.; he measured in millimetres to the nearest 0.5 mm. I found that with the finer points of the dividers it was easier to obtain reproducible measurements. I also calculated to the nearest 0·5 mm.

10.3 Discussion of reproducibility

Measurements were made to the nearest 0.5 mm as in the investigation by Rejebian (1979) into tooth size distortions.

As very small discrepancies in tooth lengths or ratios of tooth lengths were being investigated, as in the study of Becker et al. (1984) a measurement error of more than 2.12 mm would cancel out the discrepancy being considered. It was decided, therefore, to accept only repeated measurements on two subsequent occasions which exactly coincided.

The original sample of 182 subjects had been reduced to 60 with "interpretable" orthopantomograms. Lack of reproducibility due to inability to identify reference points, on two subsequent occasions after an interval of at least two weeks reduced the number of subjects to 43.

Inability to interpret reference points, even on orthopantomograms specially provided for the purpose in a prospective study by Larheim et al (1984) was reported in 17% of films, and a further 17% required marking of the reference points. It would be unnecessary to mark a reference point if it could be consistently recognised.

The same demand of exact coincidence of measurements of crown widths on study casts was made. This virtually allowed a measurement error within 0.5 mm. Larheim et al. (1984) found that if he excluded those cases with measurement error of 2 mm or over, his measurement error of root length was 0.4 mm, calculated on an orthopantomogram.

He quoted Eggan (1969), from a Swedish publication, as recording a measurement error of only 0.26 mm., when calculating tooth lengths on a periapical film taken by the paralleling technique.

It is concluded that lack of interpretability is inherent in the orthopantomogram. A prospective study of maxillary incisor tooth length would be best served using periapical radiographs taken by the long-cone paralleling technique, as preferred by Sjölien and Zachrisson (1973)

10.4 Prevalence of palatal canines

The prevalence of palatal canines in the population of the West of Scotland is not known. The computerised records were inconclusive, as many "palatal" canines had erupted into the arch since the original diagnosis was made. This agrees with Ericson et al (1986) who reported a prevalence of 29% of impacted canines at age 10 years, but only 5% at 11 years.

Bass (1967) recorded 1.65% of palatal canines in an orthodontic population, Rayne (1969) - 1.5%. Thilander (1968) in a general population - 31-42% at age 11 years, and only 1.6-2.1% at 17½ years. There is general agreement from Kuftinec et al. (1984) - 1.5-2.0%; Ericson et al. (1986) - 1.7% by 17 years, that the prevalence of impacted (palatal) canines is between 1% and 2%.

10.5 Prevalence of palatally displaced canines in male and female subjects

Table 1

The prevalence in males : females of 30.2% : 69.8% closely matches that reported by Dachi et al (1961) - 30.4% : 69.6%;

by Bass (1967) - 31.3% : 68.7%; and Kuftinec et al. (1984) of 1:3 in males : females respectively. These were all orthodontic populations. Rayne (1969) has suggested a bias towards female patients in such populations. He quotes Rose (1966) who claimed 60% of his orthodontic patients were female.

Thilander (1968) examined a general population and reported no difference in distribution of the sexes in cases of impacted canines among children, but in her adult population there was a 1:2 male : female prevalence. Her sample of adults consisted of referred patients, and so were strongly selected.

Brin et al (1984) examined a general Israeli population and recorded male : female prevalence as 1.49% : 1.58%, the difference not being significant.

It is likely that the higher prevalence of palatal canines in females is due to the selected nature of the group as it is composed of orthodontic patients

10.6 Unilateral or bilateral palatal displacement of the canine

Table 2

Displacement of the canine palatally occurred unilaterally in 79.7% and bilaterally in 20.3% of the subjects in this study.

It has been suggested by Becker (1984) that bilateral displacement of the canines palatally is a severer form of the condition. The proportion of bilateral cases reported by Hitchin (1956) and Bass (1967) was 17%, a little less than in the Glasgow example, but Rayne (1969) noted a higher percentage, at 25%.

Thilander (1968) did not think definitive conclusions could be reached regarding prevalence unilaterally or bilaterally. She thought it "more logical" to expect one rather than both canines to be affected.

10.7 Distribution of palatal canines on the right or left side of the arch

Table 3

The prevalence of palatal canines is 45.5% on the right and 54.5% on the left, agreeing closely with Bass (46% and 54% respectively). Rayne reported equal numbers on both sides. The opposite tendency was found by Thilander (1968). It is recorded because of the observations by her that there was a tendency for eruption to occur later on the right, and so impaction would be more common on that side, which was confirmed in her adult group.

It is of little importance, right or left, except in cases where the eruption does not occur within 6 - 9 months of the opposite maxillary canine. Further investigation of its position should be carried out.

10.8 Eruption status of the palatal canines

Table 4

The proportions of unerupted : erupted canines of 68% : 32% applied almost equally (within 1%) to unilateral and bilateral canines.

Thilander (1968) in her study of a general population recorded 1.8% of canines still unerupted by 17.8 years. In her adult group, 50% of palatal canines were still unerupted. She thought the most important local factors were the palatal direction of eruption, and severe crowding.

In the absence of a canine bulge in the area of the deciduous canine being palpable by 8 years, Rayne (1969) thought an abnormal path of eruption might be suspected. This age was amended to 9 - 10 years by Leivesley (1984). After 10 years, further radiographic investigation is advised. However, the age range of 8 - 10 years for recognition of the canine position was not confirmed by Ericson et al. (1986). They found dental and chronological ages differed by up to 5 years. A canine is not necessarily ectopic if unerupted by 11 years. The age at which eruption of the canine occurs may vary between 11 and 15 years, and can still be considered 'normal' for the individual child within this age range.

The canine bulge may not reveal itself as an indicator of normal development of the canine in children who mature late (Ericson et al. 1986).

A characteristic distal tilt of the lateral incisors was described by Moss (1972) as a valuable indicator of the position of the unerupted canine. This was agreed by Williams (1981).

The mesio-distal inclination of the upper incisors depends partly upon the space available between the canine crowns related to the width of the nasal opening. Crowding alone may cause lateral incisor tilting (Linden et al. 1976).

Ericson et al. (1986) in their longitudinal study of canine eruption, found tipping alone to be an inadequate diagnostic criterion of an eruptive disturbance of the canine.

Mention will be made of root resorption of incisor roots by ectopic canines at this point. Only one example of resorption of a lateral incisor root occurred in this study. Knight (1987) reported on resorption caused by buccally displaced canines, but noted that previous authors had associated root resorption principally with palatally displaced canines.

Ericson et al. (1988) advise the use of high resolution computed tomography in the diagnosis and location of incisor root resorption due to palatally displaced canines, a condition which could not be identified by the use of conventional radiographs in many cases until too far advanced.

10.9 Distribution of malocclusion in subjects with palatal canines

Table 5

10.9.1 The Glasgow sample was compared with a general British population, the Shropshire survey of 11 - 12 year old children (Foster and Day 1974) (Table 24). There is a marked difference in the distribution of the Class II division 1 category, with only 9.3% in the Glasgow group, and 27% in the Shropshire survey. It has been suggested that the more proclined lateral incisors, typical of the Class II division 1 incisor position, with the relatively palatal position of the apex favours the correct eruption of the canine (Bass 1967).

24.7% of the canine group are in the Class II division 2 category, but only 18% of the general (Shropshire) population. The relatively large proportion of the palatal canine group in the Class II division 2 category confirms the view of Kettle (1958) who claimed that the labial position of the apices was an important factor in deflecting the canine palatally.

Excessive space within the maxilla could be found in some subjects with Class II division 2 malocclusions even where there was anterior crowding and this could be a contributory factor in palatal displacement, in allowing the canine space in which to "wander". (Jacoby 1983).

10.9.2 Comparison of two canine groups and a random group all derived from orthodontic populations

Table 25

In order to avoid bias in comparing an orthodontic population with a general population comparisons were made with another canine group derived from an orthodontic population (Bass 1967). The Class II indefinite category was combined with the category most similar - i.e. having vertical incisors , as the usual relative proportions of Class II division 2 and Class II indefinite were reversed in the Bass canine group, and the criteria for selection were unknown.

The difference of distribution of malocclusion categories between the Glasgow canine group and the canine group (Bass) was analysed statistically. There is a difference between the populations but below the level of significance. This is accounted for by small differences between the malocclusion categories except for Class III.

Bass (1967) recorded a highly significant difference between his canine group and the random group of orthodontic patients. A similar difference of distribution of Class II division 1 and Class II division 2/indefinite categories between the canine group and the noncanine group confirms distribution difference between the Glasgow canine group and a general population. There is a significantly smaller proportion of Class II division 1 in the canine group, and a larger proportion of Class II division 2/indefinite in the canine group.

Differences of distribution of malocclusion occur in populations derived from different countries; the ethnic composition may be dissimilar. Even within the Israeli population Brin et al (1986) discovered an alteration in ethnic ocmposition over a period of 12 years.

10.9.3 It was decided, therefore, to compare the Glasgow canine group with another Glasgow population (Table 26) (Jenkins et al. 1982). This was derived from patients attending the Orthodontic Department of Glasgow Dental Hospital between 1978 and 1980. The Glasgow canine group were derived from an orthodontic population attending between 1980 and 1985. The criteria for determining categories of malocclusion were similar.

The difference between the two populations is shown in Table 26. This confirms the previous findings of a marked reduction in the proportion of Class II division 1, and a marked increase in the proportion of Class II division II malocclusions in the palatal canine group.

These conclusions are not in agreement with these of Brin et al (1986) who found that the percentage of individuals with palatally positioned canines presented a similar distribution of malocclusion when he compared his population with an American one, with the exception of Class I. (72.6% : 63.5%). This increase in the Class I category agrees with Dewel (1949) and Lappin (1951) who recorded frequent impactions of canines in subjects with uncrowded arches and normal occlusion otherwise.

It is difficult to compare populations where the criteria of selection are not defined and may differ. Bass (1967) excluded the cases which had an impacted canine as the sole malocclusion. These cases were included in the Glasgow canine population and in that of Brin et al. (1986). Nor were the criteria for selection of Class II indefinite cases defined, the usual proportions of Class II dividion II and Class II indefinite were reversed in the Bass (1967) canine group.

Despite this, the conclusion is that there is more of a risk of palatal displacement of the canine in subjects with a Class II division 2/indefinite malocclusion, and a reduced risk for the Class II division 1 patients with proclined incisors.

10.10 The distribution of crown widths of lateral incisors on affected and non-affected sides (182 subjects)

Tables 6, 7 Graphs 1 and 2

(1) The difference between crown widths of lateral incisors on affected and non-affected sides was significant at the 5% level. The probability level was minimally increased to $0.05<p<0.02$ when the absent lateral incisors were excluded from the calculation.

It is concluded that there is a weak association between crown width of the lateral incisor and palatal canines.

This lends little support to the claims by Miller (1963), Becker et al. (1981), Becker (1982) referring to graduate thesis of Tsur (Jerusalem 1982) that there is an association between the crown widths of lateral incisors and palatal canines.

This study would not support the claim of Brin et al (1986) that there is a highly significant association between anomalous or absent lateral incisors and palatally displaced canines, and that "the chance of finding a palatally positioned canine adjacent to a normal lateral incisor is minimal."

(2) The proportions of crown widths of lateral incisors on affected and non-affected sides are shown in Table 8 and Graphs 3 and 4.

The proportions differ mainly in the distribution of the crown widths in the 3.5 - 5.0 mm range. There are no examples of crown widths of 3.5 - 4.5 mm on the non-affected side, and a smaller proportion of the 5.0 mm and 5.5 mm widths.

10.11 Distribution of crown widths of lateral incisors associated with bilateral palatal canines

Table 9

The association of palatal canines with anomalous lateral incisors may be further investigated by reference to cases of bilateral canine displacement. This was thought to be a severer form of the condition than unilateral displacement (Becker 1984).

Crown widths of bilateral cases on the affected and non-affected sides showed a highly significant difference.

Even if the 3.5 - 4.5 mm range is excluded since there are no examples of this crown width range on the non-affected side, the difference between the bilateral and non-affected sample remains highly significant. This was accounted for by the concentration of small, peg-shaped and smaller than average lateral incisors in the bilateral canine group of the 7 lateral incisors of crown width 3.5 - 4.5 mm.

No references have been discovered in the literature referring to the prevalence of anomalous lateral incisors in subjects with bilateral palatal displacement of the canines. The conclusion from this study is that the significantly higher proportion of anomalous lateral incisors in this group would tend to confirm the opinion of Becker et al. (1984) that the bilateral condition is a severer form of the condition.

10.12.1 Distribution of categories of lateral incisors in male and female subjects

Tables 10 and 11

There was no statistically significant difference in the distribution of normal, small or peg-shaped lateral incisors between male and female subjects. This agrees with the report of Brin et al (1986) who found, as in this study, that there was a slightly higher occurrence of small and absent lateral incisors in females, but it was not statistically significant. In the Glasgow study there were no examples of peg-shaped lateral incisors in the male group but 3.3% in the female group. This does not agree with Brin et al (1984) who recorded a distribution of 1.8% overall, equally distributed between the sexes.

Brin et al. (1984) quoted a much higher prevalence of missing (Eidelman et al. 1973), small (Alvesalo et al. 1969) and peg-shaped lateral incisors (Chosak et al. 1985) among females. These results are not in accord with the present study with the exception of the peg-shaped laterals.

It was useful to have a definition of a 'small' lateral, relating it to the width of the lower lateral incisor, and to have a definition of 'peg-shaped', (Becker et al 1981) so that comparisons with other studies are realistic.

10.12.2 The distribution of "small" and peg-shaped lateral incisors on affected and non-affected sides Table 12

When lateral incisors were classified according to the criteria of Becker et al. (1981) as 'small', a larger number of teeth were included; the peg-shaped teeth being more easily identified remained in the same proportion. There was a marked difference of distribution, the small and peg-shaped lateral incisors occurring in a proportion of 2:1 on affected : non-affected sides.

This classification of the lateral incisor as "small" according to the definition of Becker et al. (1981) serves to support the hypothesis that an association exists between "small" and peg-shaped lateral incisors and palatal canines.

The reasons for this association are not clear. Miller (1963) on one hand was of the opinion that small lateral incisors were at times associated with palatal canines but he nevertheless thought that the root length even of a peg-shaped tooth would be adequate to guide the developing canine.

Brin et al. (1984) on the contrary reported that there is a "definite link" between a short incisor root and the incidence of palatal displacement of the adjacent canine; a "definite link" between lateral incisor crown size and root size; a "definite link" between small lateral crown size and the incidence of palatal canines. Tooth length could be substituted for root length in his calculations.

10.13 Tooth length measurement

Since absolute measurements of tooth length on panoramic and periapical radioraphs were found to differ, comparison of tooth lengths could not be made when they were measured on different types of radiograph. (Tables 13 and 14)

Mean tooth lengths are shown for lateral and central incisors on both periapical and panoramic radiographs on Tables 15 and 16. The difference between the means of lateral incisors, and between the means of central incisors was highly significant: the panoramic and periapical radiographs are not interchangeable for the purposes of tooth length measurement. The method of Becker et al. (1984) was followed in order to overcome this difficulty.

Becker et al. (1984) calculated the ratio of tooth length of the lateral incisor to the adjacent central incisor and found this to be consistent on either radiographic view. The ratios of lateral and central incisor tooth lengths of this study are shown on Table 17.

The difference between ratios of tooth length on the two types of radiograph was tested statistically. It was established that a difference existed between the ratios of tooth lengths measured on panoramic or periapical radiographs. This is contrary to the results reported by Becker et al. (1984). The two types of radiograph are not interchangeable.

It was decided to concentrate on the measurement of tooth length on one type of radiograph only. The choice was the orthopantomogram.

The periapical views taken by the bisecting-angle technique were more variable than those taken by the paralleling technique (Larheim et al 1984), and it was the bisecting-angle technique which had been used for the majority of available periapical radiographs in this study. The choice of the orthopantomogram was not ideal.

Rejebian (1979) reviewed the problems of identification of reference points, as did Larheim et al (1984), who reported uninterpretability of a proportion of films. 43 radiographs were finally selected because root apex and incisal edge of both central and lateral incisors could be accurately identified on more than one occasion. The subjects also had a unilateral palatal canine and the other side of the arch provided the contrast.

10.14 The distribution of crown widths and tooth lengths are shown in Tables 18 and 19.

10.14.1 There was no statistically significant difference in tooth lengths of central incisors on the affected and non-affected sides. This confirms the results of Becker et al (1984). Although no difference was expected, as there is no association between palatal canines and root length of central incisors, it suggests that if a connection exists between lateral incisor tooth length and palatal canines it may be identified from the ratios of the tooth length of the lateral incisors and the adjacent central incisor.

10.14.2 There was no statistically significant difference between tooth lengths of lateral incisors on affected and non-affected sides.

10.14.3 The ratios of tooth lengths of lateral incisors to the adjacent central incisors were compared on the affected and non-affected sides. There was no statistical difference. This differs from the study of Becker et al. (1984) who found an average relative deficiency of 2.12 mm in lateral incisor length on the affected side and 1.40 mm deficiency in root length. The ratio between root length of lateral and central incisors was "essentially the same" in unilateral and bilateral cases (Becker et al 1984).

10.14.4 The widths of lateral incisors on the affected and non-affected sides were compared. There was no statistical difference.

These results do not support the hypothesis of Becker et al (1984) that an association exists between tooth length of lateral incisors and palatal canines; little support is provided from data of the whole sample that crown width of lateral incisors is associated with palatal displacement of the canine, with the exception of small and peg-shaped lateral incisors in cases of bilateral palatal canine impaction.

The discrepancy in tooth or root length between lateral incisors on the affected and non-affected sides (2.12 mm and 1.40 mm respectively) in the study of Becker et al. (1984) was small, and measurements were made on radiographs which were not ideal, since superimposition in the anterior region reduces clarity in many films.

<u>10.15 Measurement of extracted lateral incisors</u> was undertaken.

This provided data on an association between crown width and tooth length in conditions where measurements of tooth length were easily made. (Table 20). The percentage distribution in crown width categories is shown in Graph 6.

The mean tooth lengths were calculated for each crown width except for the 8.5 mm width of which there was but one example. No pattern of tooth-length to crown-width emerged. The crown widths were computed against tooth lengths. The correlation coefficient between crown width and tooth length was well below statistical significance. Only 12.61% of variation of tooth length can be explained from variation in crown width.

There is no evidence from the data of 106 extracted lateral incisors to support Becker et al (1984) that a "definite link" exists between crown size and tooth length.

10.16 Congenitally absent lateral incisors

(Table 22)

There was a prevalence of 12.6% of congenitally absent lateral incisors in the orthodontic population with palatal canines in this study. The occurrence was only 15% more frequent on the affected side of the arch than in the non-affected side. This provides but weak support for the claims of Kettle (1958) and Miller (1963), Rayne (1969), Jacoby (1984), Leivesley (1984) that congenital absence of the laterals was a predisposing cause of palatal displacement of the canines. Bass (1967) claimed that congenital absence of teeth generally was more frequent in his 'canine group', even when lateral incisors (the proportion unspecified) were excluded. This was not supported in this study, in which only 2 congenitally absent teeth, both second premolars were recorded.

Nor was there agreement with Becker (1984) who reported an 8% prevalence, all in female subjects. The distribution in this study was 1 : 2 in males and females respectively.

Brin et al (1986) reported a prevalence of 5.5% of absent lateral incisors in a general population (an increase of 3.4% in prevalence from a survey of another Israeli population of 12 years previously by Eidelman, quoted by Brin et al. (1984)

Congenital absence of the lateral incisor would appear to be only one of several factors predisposing to palatal displacement of the canine. There is a tendency for an absent lateral incisor to be associated with another absent lateral or an anomalous lateral incisor in approximately two-thirds of the subjects with absent laterals, but there is no support for the theory that the condition (congenital absence of lateral incisors) is a major actiological factor in palatal displacement of the canine.

10.17 Age of subject at date of referral for advice or treatment of palatal canines

(Table 23)

The age range was 8 - 34 years in this study. Kettle (1958) claimed that the majority of patients in his practice were referred between the ages of 12 and 15 years, but he thought the ideal age to start treatment was between 9 and 12 years, before the condition was more advanced, and more difficult to treat. If the patients in his study are divided into groups by age, 7.7% are aged 8 - 11 years; 64.3% are 12 - 16 years, and 28% are 17 - 34 years. Ericson et al (1986) claimed that the numbers of children with unerupted canines dropped dramatically from age 11 years to 17 years. Chronological age had to be allied to somatic maturity in assessing when a canine was 'late' in erupting. All the patients in orthodontic populations are at the mercy of the referring dentist as as far as the age when first seeking specialist advice is concerned.

While the peak age range in this study approximately matches that of Kettle (1958), for many patients it is later than the ideal, and for 28% of over 17 years, considerably later. Space may be lost due to buccal drift in the adult group (Thilander 1968) and treatment may involve premolar extraction.

However, age distribution in this study is better than that of Rayne (1969) who reported that "half the patients were more than 20 years of age, and of these 48% were edentulous".

11. CONCLUSIONS

11.1 The relative magnitude of distortion of the orthopantomogram in use in Glasgow Dental Hospital

Calibration using extracted premolars and pre-extraction radiographs of the same teeth to compare tooth lengths and relative magnification distortion cannot be repeated in the incisor region other than on a very few occasions when an incisor requires extraction. Nor would the extracted incisor be useful for the purpose if there were apical pathology involving resorption, an open apex or crown fracture involving the incisal edge.

Calibration in the horizontal field can more easily be accomplished, measuring crown widths of the same teeth on study casts and on the orthopantomogram, but horizontal magnification is greater than in the vertical plane, and the magnification factor in one plane would not apply to the other.

It was not possible to obtain a callibration of magnification error in the orthopantomogram in use in Glasgow Dental Hospital.

The following methods have been used, or may be used in the future to overcome the problem of magnification distortion of linear measurements.

i) In a retrospective study, the conversion of absolute tooth lengths of the lateral and adjacent central incisor into a ratio minimises the tooth length distortion which both teeth, in theory, suffer equally. Comparison of tooth lengths or ratios will not be valid if one of the paired incisors (i.e. lateral incisor and the adjacent central) has a markedly different overjet. The distortion of tooth length will be unequal unless the long axis of both the incisors is parallel.

ii) The use of a radiographic method which provides as near as is possible an X-ray beam which is perpendicular to the long axis of the whole length of the tooth. Periapical films taken by the long cone paralleling technique would supply this requirement with least linear distortion and enhanced clarity.

iii) In a prospective study, the use of a grid incorporated in the periapical film would allow an accurate calculation of vertical distortion when measuring incisor tooth lengths.

The Class II division 2 malocclusion, it its severer form would still provide a problem with the different labio-lingual angulations usually associated with lateral and central incisors in this condition, as would any marked deviation from a normal overjet.

11.2 Correlation between crown width and tooth length of maxillary lateral incisors.

This was tested on extracted lateral incisors, but the correlation was weak (R=0.12 61), and it was concluded that there is very weak support for the hypothesis of Becker et al. (1984), that an association exists between lateral incisor crown width and tooth (or root) length.

Criticism can be made of the range and distribution of crown widths as the extracted lateral incisor sample differed somewhat from the distribution of crown widths on the non-affected side. The range differed further from that of the affected side, having no examples of crown width of less than 5.5 mm. One has more confidence in the measurement of tooth lengths on extracted incisors than on radiographs. A future study could match the distribution of crown widths of extracted lateral incisors to the control group. The source of the extracted lateral incisors, i.e. the dental practitioners would require notification of the need to retain and preserve even the most rudimentary lateral incisor which required extraction for orthodontic reasons.

11.3,4 Crown widths and tooth lengths of maxillary lateral incisors in subjects with palatally displaced canines. Similar measurements for a control group matched for malocclusion type and age

The most accurate method of matching malocclusion type and age was to select a sample which had unilateral palatal displacement of the canine, the opposite side of the arch acting as the control side. Comparison of tooth lengths, ratios of tooth lengths, and crown widths on affected and non-affected (control) sides did not support the hypothesis of Becker et al (1984) that there is an association between the crown width and tooth length of lateral incisors adjacent to a palatal canine.

11.5 Subjects with smaller than average maxillary lateral incisors are more at risk of palatal displacement of the maxillary canine

This was proved to be so. There were few smaller than average lateral incisors in the non-affected sample, the smallest recorded width being 5.0 mm. A more positive correlation occurs between crown width and palatal displacement of the canine when a selected group was examined. When "small" lateral incisors as defined by Becker were included irrespective of actual crown width category by size, along with peg-shaped laterals, an association between crown width and palatal canines was demonstrated. This positive correlation was further confirmed by examining the bilateral canine samplewhere there was a relatively larger distribution of "small" and peg-shaped lateral incisors.

11.6 Correlation between congenitally absent lateral incisors and palatal displacement of the canine

Only weak support for this association was proved. 20 out of the total of 33 congenitally absent lateral incisors were bilaterally missing, yet only 1 subject had bilateral palatal canines which does not support the contention that the absent lateral incisor is a major predisposing cause of palatal displacement of the canine.

11.7 Smaller than average maxillary lateral incisors are later in development than normal lateral incisors

The date of development of the lateral incisor could not be ascertained in this retrospective study in an age range of 8 - 34 years. The one subject in the 8 year old category had absence of both lateral incisors; there was no abnormal late development inthe youngest categories. When is a lateral incisor late? This would be difficult to estimate in view of the range of ages within which development is considered "normal" for the individual. The dental maturity of the child, relating development of both lateral incisor and permanent canine would have to be assessed as a routine when monitoring young patients.

11.8 Malocclusion type

It was in malocclusion type that one of the most marked differences occurred between the 'canine group' and the control groups derived both from orthodontic and general populations.

There was a marked increase in the number of Class II division 2/indefinite malocclusions in subjects with palatal canines, and a marked reduction in subjects with Class II division 1 malocclusion.

There was also a small increase in Class I malocclusions, which included subjects whose malocclusion consisted only of a malpositioned (palatal) canine.

It would appear that the subject most at risk of palatal displacement of the canine would have a Class II division 2 malocclusion with "small" or peg-shaped lateral incisors.

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