Longitudinal Study Of Growth Of Maxillary Width*

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In John Hunter's *Natural History of the Human Teeth,* 1771, appeared the first statement relating to the subject of this study. It read:

> "The jaw still increases in all points till twelve months after birth, when the bodies of all of the six teeth are pretty well formed; but it never increases in length between the symphysis and the sixth tooth; and from this time, too, the alveolar process, which makes the anterior part of the arches of both jaws, never becomes a section of a larger circle, whence the lower part of a child's face is flatter or not so projecting forwards as in the adult."

This observation made little imprint on the dental profession until serious efforts were made to regulate the dental arches of patients, beginning with the middle of the 19th century. Because these early efforts consisted largely of expanding the arches to gain room for crowded teeth, little attention was paid to intertooth or interjaw relations. When the concept of normal occlusion began to influence treatment procedures following Angle's pronouncement of his classification, factors other than teeth came under scrutiny. Cases that had been greatly expanded frequently relapsed. Then Hunter's statement was remembered and frequently quoted.

The literature would seem to indicate that there has long been a tendency to assume that the dimensions of the dental arches, the maxillary and mandibular bases which support them, and the alveolar arches which connect the two were directly interdependent. This is shown by the repeated efforts of investigators to draw inferences about the supporting bases from measurements of the tooth arches. Similar inferences have been drawn from measurements of the alveolar arches taken at the necks of the teeth. Examples of these efforts are as follows.

Sir Charles Tomes, 1892, measured the width of the maxilla by taking measurements from the middle of the grinding surfaces of the teeth and came to the conclusion that there was an increase in width of the maxilla between the ages of 4 and 15, only, and this was approximately one millimeter.

E. A. Bogue, 1913, assumed that the ten permanent teeth erupt in almost the same positions as their predecessors of the deciduous arch and that alignment of the deciduous arch would insure alignment of the permanent arch. He considered the positions of the temporary teeth as being infallible indices to impending irregularities of the permanent teeth. In 1919 he stated that there is a distinct relationship between the size of the deciduous teeth and their successors.

Sir Frank Colyer, 1920, took measurements at the gum margin at the outer surface of the necks of the teeth and found a definite increase in width

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of the arch up to age 11 and a change in the arc of a circle made by them.

Friel, 1927, gave a descriptive analysis of the teeth and noted that, after the complete eruption of the deciduous teeth and before the complete eruption of the permanent teeth, there was a slight forward growth of the anterior portion of the deciduous maxillary arch but mainly lateral growth of the entire arch to accommodate the permanent incisors.

Hellman, 1927, made measurements of the minimum maxillary arch width (bicanine) between the palatal margins of the canine alveoli, and maximum alveolar arch width between the widest points on the buccal side of the alveolar process. His findings indicated that the mean minimum maxillary alveolar arch width continued to increase until stage V (when the 3rd molars are erupting) and the maximum mean increase continued until stage IV or V.

Brash, 1928, stated that the last deciduous molars and the first permanent molars owe their increasing separation in the maxilla mainly to the oblique buccal direction of the alveolar bone.

C. Smith and M. Young, 1932, using calipers to measure the width of the dental arches at the necks of the molars found that the dental arches increased in transverse diameter in the 8-14 year interval although they did not increase in length.

M. S. Goldstein and F. L. Stanton, 1935, measured the alveolar arches and noted a broadening of the arches and a relative shortening.

J. T. Cohen, 1940, made measurements from the tips of the cusps of the canines and through those of the first permanent molars. These measurements were taken on 28 children ranging in age from $3\frac{1}{2}$ to $13\frac{1}{2}$ years. Fifteen were boys and 13 were girls. He concluded that the greatest amount of growth in width occurred during the eruption of the incisor teeth. His table showed growth of males through the $13\frac{1}{2}$ year age except for the 1st permanent molars which stopped at 13. The females showed a tendency to stop increasing in width at 13 with the molars stopping at $10\frac{1}{2}$.

R. H. W. Strang, 1949, said that the growth of the jaws anterior to the first permanent molars was completed at 5 to 7 years of age and could not thereafter be stimulated to renewed activity.

G. A. Woods, Jr., 1950, made measurements on lateral and frontal headplates of 28 individuals. His finding on measurements made of bimolar width was that the first molars increased in width rapidly until they came into occlusion and thereafter their increase was at a much slower rate.

L. J. Baume, 1950, found a frontal and lateral growth of the alveolar arch during the time of eruption of permanent incisors and that the increase in intercanine width was greater in the nonspaced than in the spaced deciduous arch.

D. C. Walters, 1951, studied the stability of the dental arch after orthodontic expansion. He took bilateral measurements from the tips of the buccal cusps of the teeth before and at the end of active treatment, and several years after removal of retention devices. Of great interest were some cases, expanded by treatment, which continued to expand during and after retention.

G. V. Barrow and J. R. White, 1952, measured the dental arches of 51 children. They found that between the ages of 5 and 10 years there was an increase of about 1.5 mm in the dental arch between the second primary molars with a decrease occurring in only 7 of the 51. On measurements between the first permanent molars they found a 1.8 mm increase in the maxilla between ages 7 and 11, but an average decrease from 11 to 15 years. This decrease was explained on the basis of a forward drifting of the first molar after loss of the deciduous molars.

J. H. Sillman, 1953, said that after the eruption of the deciduous teeth there is relatively no change in the size of spaces existing at that time. He noted that the dental arches changed in form as well as their absolute dimensions from birth to the time that the second molars had erupted.

C. F. A. Moorrees, 1959, noticed that the maxillary permanent teeth anterior to the first molars are usually larger than their predecessors (total crown diameter) but might be the same size or smaller. Increase in intercanine distance of the permanent over the deciduous canines was attributed to growth of the alveolar bone and maxilla by apposition and possibly to tooth movement. Moorrees also observed a loss of space just before emergence of the permanent incisors. He claimed that no physiologic spacing occurred in the deciduous incisors, i.e., there was no increase in spacing after three years of age.

Axel F. Lundstrom, 1925, noted that there is a difference in the arcs made by the apices of the teeth and that of the crowns of the teeth. He recognized the fact that the skeletal area, which he called the apical base, is a factor to be considered when dealing with malocclusions. He claimed that the size and form of the apical base were determined by factors that were independent of the positions of the teeth and that a dental arch might develop in harmony or disharmony with the apical base. Since the crowns of teeth do not change, the changes in the apical base must cause changes in the denture. He noted those cases where the tooth arches were expanded and a subsequent growth of the skeletal area was found. He pointed out that expansion of the denture did not necessarily mean that it would be followed by growth of the apical base but that when this did take place, it must indicate that there was a tendency for the apical base to increase in size independently. Nevertheless, he stated that the prognosis of successful treatment of a case of malocclusion depended to a large extent on the size of the apical base.

A. E. Howes, 1947, stated that normal lateral development of the apical base in the premolar region took place at an early age, that is, before the shedding of the deciduous side teeth.

A. G. Brodie, 1958, stated that jaw growth and tooth eruption were not strictly correlated. There could be tooth eruption before the jaws were ready to accept them resulting in crowding. With precocious growth there could be spacing. He pointed out that the teeth were fully formed before they started to erupt, and the fact that the jaws had not grown enough to accommodate them at that time was not a sign that they would not eventually be large enough to accommodate them. This same author has indicated that while the apices of the teeth were probably under the control of the apical base, their crowns and, to a lesser extent the alveolar process, were subject to the forces of the tongue, lips and cheeks.

H. Berger, 1961, attempted to use the basilar cephalogram as another approach to studying changes in the dental arches.

The above studies reveal that there is considerable range of opinion regarding the growth of the maxilla anterior to the first permanent molars after three years of life. They also reveal that the opinions held by investigators of this problem are based on data derived from measurements of either the tooth arch or the alveolar arch at its boundaries. No studies have been directed at the so-called "apical base" as an independent entity. This has been due to lack of a method for determining its size and form in the individual.

The present work was undertaken to attempt to develop a method that would permit longitudinal appraisal of the base of the maxillary denture; second, to determine, on the basis of available longitudinal material, the changes that took place in the so-called "apical base"; and third, to test for correlations among the apical base, the alveolar arch and the tooth arch.

Methods and Material

The major difficulty of the study was the same one that has faced the investigators of the problem in the past, viz., the determination of the size of the apical base. A possible attack was offered by the work of Downs (1944) who had x-rayed plaster models and had found that the films he obtained gave a quite clear delineation of what he thought was the apical base. This study was purely qualitative, no attention being paid to absolute values. Since it was the purpose of the present study to attempt to determine whether change took place in the apical base during growth, and since the longitudinal material to be studied was in the form of plaster casts, it was necessary to ascertain whether the plaster cast of an individual accurately represented the skeletal area to be measured.

A random sample of 25 individuals, ranging in age from 8 to 27 years, was divided into two groups, adults and children, on the basis of their dentitions. The mean chronological ages were 20.2 years for adults and 10.8 years for children. The following procedures were carried out on all individuals of both groups.

Alginate impressions were made with particular attention to the height and details of the labial and buccal flanges. The models were poured immediately thereafter. The base was trimmed parallel to the occlusion of the teeth on a plane passing through the most posterior point of the incisal fossa, generally called Downs' point "A". The back of the model was trimmed at right angles to the base plane on a transverse line which passed through the mesial contacts of the first permanent molars. The area enclosed by this line and the periphery of the model was tentatively accepted as the apical base.

For the x-ray determination of the area of the apical base in the living, a special device was fabricated. This consisted of an acrylic collar that could be accurately positioned on the long tube of an x-ray head. Two parallel rods extended first laterally and then downward parallel to longitudinal engraved lines on the cone (Figure 1).

After placing an occlusal film in the mouth, which the patient held by closing lightly upon it, the cone and x-ray head were brought into position. A light, stiff, steel wire was placed transversely in the mouth at the interproximal space between the fourth and fifth teeth, whether deciduous or permanent. The rods on the cone were then brought into contact with the two ends projecting from the sides of the mouth. The long engraved lines on the cone and the bars from the collar, which lay in the same plane, were used to bring the cone to a right angle with the film. The midsagittal plane was determined from the interproximal contact of the maxillary centrals and the median raphe of the palate. The target to film distance was kept at 23.5 inches.

It was recognized that there was a

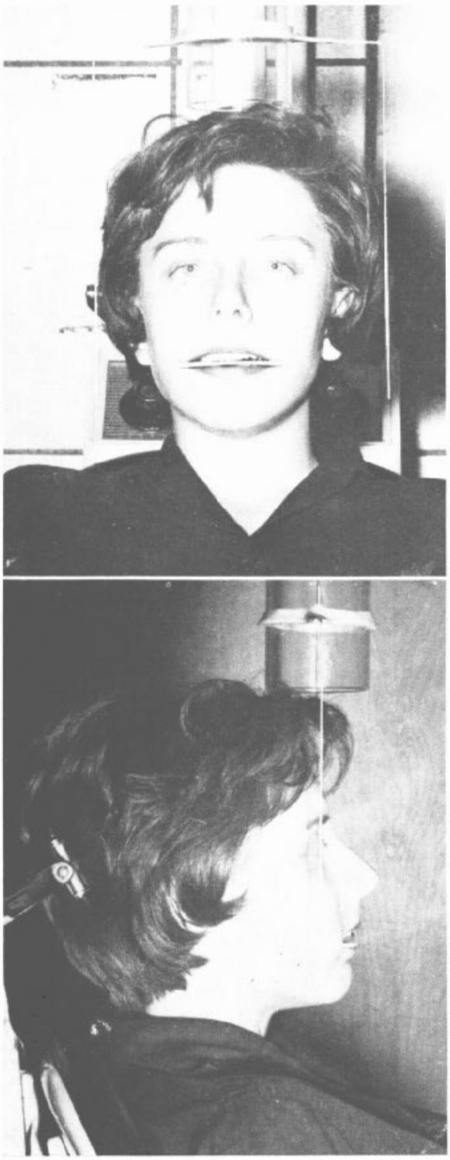


Fig. 1 Photograph of device used with long cone to position the patient for x-rays.

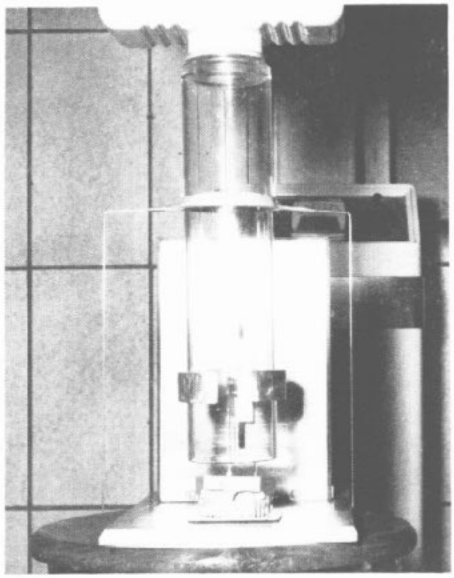


Fig. 2 Photograph of aluminum positioner used in x-raying models.

possible source of error in the positioning of the cone and x-ray head, particularly in the determination of the right angle relation between the film and cone. To test the seriousness of this, the cone and x-ray head were rotated 15° in both forward and backward directions, maintaining contact between the collar rods and the transverse wire between the teeth. As might be expected, these rotations caused elongation or foreshortening of the shadow cast by the apical base. When the rotation amounted to only a few degrees, the error was reduced to one that could not be detected by ordinary tracing methods. Since interest was focused on width dimensions principally, this error was considered to be immaterial.

The x-ray technique as applied to the plaster cast was tested next by placing the model, teeth down, on an aluminum platform (Figure 2). This device was equipped with a clamp that permitted positioning of the tube and x-ray head in the same relation to the model and film as that which had been obtained on the patient. Following the development of the film, the assumed outline of the apical base was traced and laid aside.

The model was now trimmed as already described so that its base represented the assumed apical base. The model was placed base down on a sheet of matte acetate and its outline scribed with a sharp pencil. When this drawing was laid over the tracing with the base line superposed, the two coincided almost exactly (Figure 3). When, however, the tracing of the x-ray of the model, or the outline drawn around its base, was similarly oriented over the tracing derived from the x-ray of the patient, it was noted that the x-ray image, although parallel in outline, was somewhat smaller. This was not surprising because the x-ray of the patient represented the outline of the bony maxilla only. The difference between the two was taken as the area occupied by its soft tissue covering.

When the samples of adults and children had been subjected separately to the procedures outlined above, it was found that the mean value of the soft tissue in the children exceeded that of the adults by 94 sq. mm. as determined by compensating polar planimeter (Keuffel and Esser N4242). This bore out the statements by Aprile (1945) and Wentz, Maier and Orban (1952) that the epithelium and connective tissue of the gingiva are thinner in the adult than in the child.

Having determined that the technique of taking measurements of the apical base from the x-rays of plaster casts was reasonably accurate, attention was directed toward gathering data from models of patients on whom longitudinal records were available.

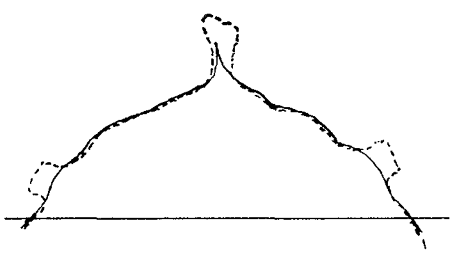


Fig. 3 Tracing of a roentgenogram of the apical base anterior to the first permanent molar (———) superposed over the circumscribed area of a trimmed model (---------).

Forty-six longitudinal series of records were available for this study. These consisted of models which were carefully checked to be certain that the labial and buccal flange areas were in good condition. All models had been made from plaster impressions. Three of the series were siblings taken over a period of ten years, beginning at age 6 or 8 and continuing to age 17 or 18. Forty-one of the series were a part of a growth study, the first records of which were made at a mean age of 8, plus or minus one year. The second records of the same sample were made at 16, plus or minus one year.

Two series were of congenital anodontia. One set of records started at 6 years of age and continued through 16 years. On the other case, records were available at 5 and 7 years. In making measurements on these sets of models, Black's standard measurements for the sizes of the teeth involved, viz., the cuspids, deciduous molars and premolars, were used. The corner of the arch at the cuspid area was used to estimate the position of the cuspid. The sum of the width of the deciduous teeth (cuspid, first and second molars) was measured on the basal area from the most anterior part of the cuspid eminence area or corner of the apical base in a posterior direction with the termination being taken as a distal contact of the deciduous second molar. When converting to the secondary dentition phase, only half of the width of the cuspid was used, plus the width of the premolars. The sum of these teeth was measured on the basal area beginning at the same cuspid area anteriorly and continuing posteriorly with the dis-

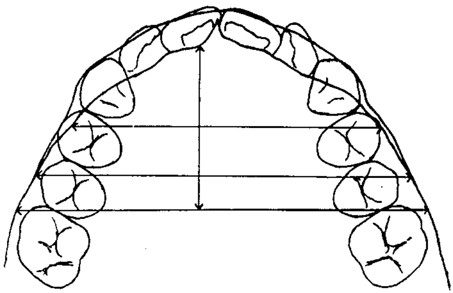


Fig. 4 Linear measurements of the apical base taken in this study.

tal portion being called the distal of the second premolar. Only half of the crown width of the permanent cuspid was used due to the distal inclination of the root of the tooth; the crown does not come as close to being within the confines of the outline of the apical base as is seen in the more upright deciduous teeth.

A total of 142 models were x-rayed in this part of the study. The x-ray technique used here was the same as described above but using a 20-inch target film distance. All models were positioned to center the central ray on the junction of a line running between the contacts of the first molar and the second premolar with the midpalatine raphe.

The following procedure was used in order to demarcate the area anterior to the first molar. A line was drawn across the x-ray at the junction of the mesial contact of the permanent first molar with the distal contact of the second premolar or deciduous second molar. In cases where the first permanent molars had not erupted, an estimate was made of this junction by checking it on later models in which the tooth was in place. The outlines of the first and second premolars were bisected mesiodistally and the points marked where a frontal plane would intersect the dental and alveolar arches and the apical base (Figure 4).

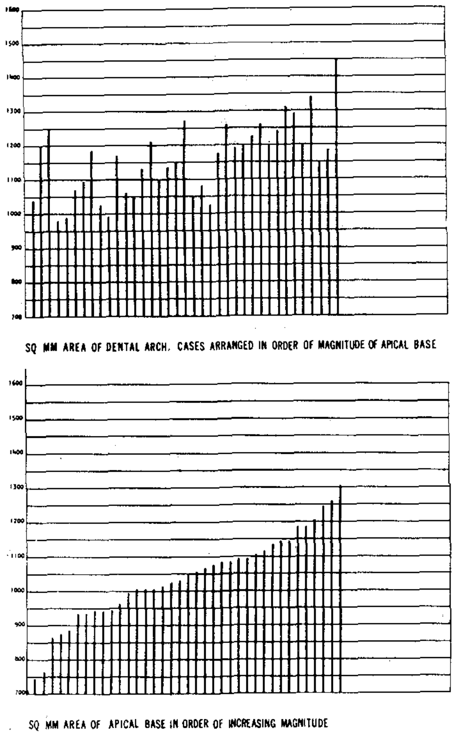
Planimeter measurements were made of the area of the apical base and of the alveolar arch. Each measurement was made three times and on separate occasions, and the average of the three measurements was used. Ninety-four square millimeters were added to measurements of the apical base where only the secondary dentition was present in order to compensate for the greater thickness of the soft tissue covering of the base during the deciduous dentition stage.

A Boley gauge and standard millimeter ruler were used for measurements of the width of the apical base at the junction of the first permanent molar and second premolar and at the midpoint of the mesiodistal diameter of the first and second premolars. The length of the apical base was measured parallel to the midpalatine raphe from the line representing the junction of the second premolar and first molar to the most anterior part of the apical base, excluding the area of the anterior nasal spine (Figure 4).

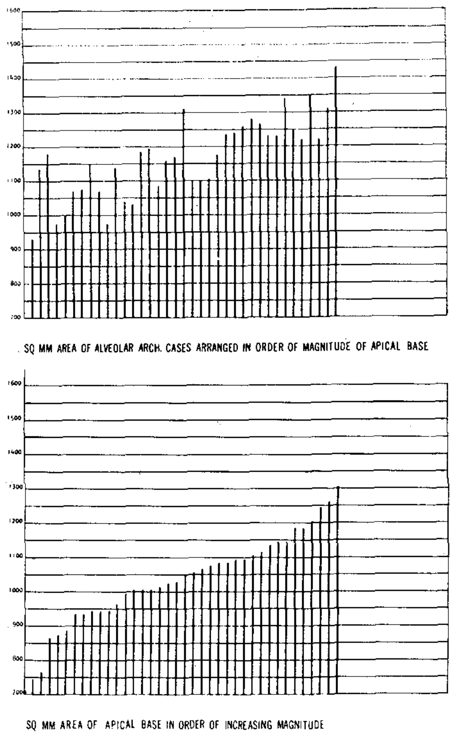
Measurements were taken of the alveolar arch length in a similar manner.

The length of the dental arch was measured along the midpalatine raphe from the junction of the second premolar and first molar to the labial surface of the central incisor. The width was measured on the models from the middle of the buccal surfaces of the teeth near the necks on one side to the same spot on the corresponding tooth on the other side. Measurements were taken of the first and second premolars or deciduous molars and first permanent molars.

Two measurements of the circumference of the dental arch were taken. The ideal circumference was measured tooth-by-tooth and with dividers. Such measurements were totalled to obtain the circumference. The actual circumference was taken by means of a .016



Graph 1 Graphic representation of area of apical base (below) and of dental arch (above).



Graph 2 Graphic representation of area of apical base (below) and of alveolar arch (above).

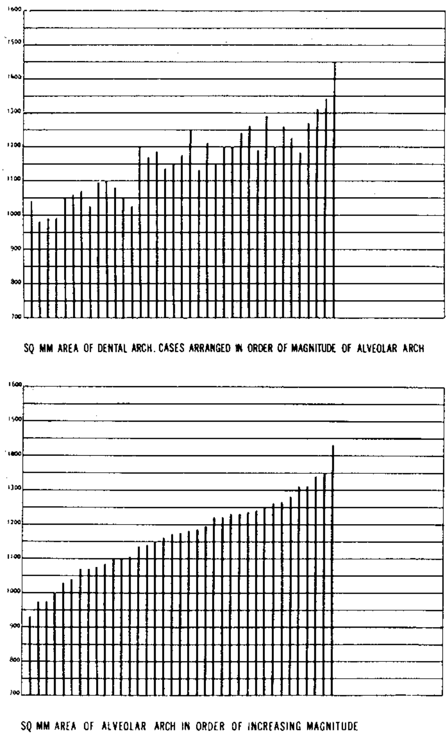
steel wire in the same manner as that used by Moorrees (1959). The wire was notched with pliers, the mesial bend of this notch being fixed at the distal side of the second premolar. The wire was run along the occlusal surface of the buccal teeth crossing the contact area and along the incisal edges of the cuspids and incisors. Utility wax was used to secure it in position. The wire was marked on the opposite side at the distal contact of the premolar, allowed to straighten and then measured. Actual arch length measurements were taken only on cases with a full complement of teeth.

Management of Data

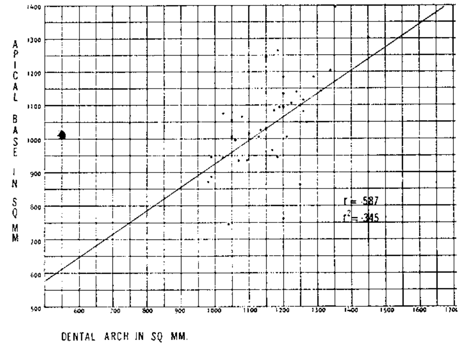
Since the objective of the investigation was to determine whether there was correlation between the size of the apical base, the alveolar arch and the dental arch, and if so, to determine its degree, the data were first arranged in graphic form (Graphs 1-3).

The areas of the apical bases were laid out in order of increasing magnitude to provide a basis for comparison. Against these, the areas of the dental arches and those of the alveolar arch were laid out maintaining the same order of cases as used for the apical base (Graphs 1-2).

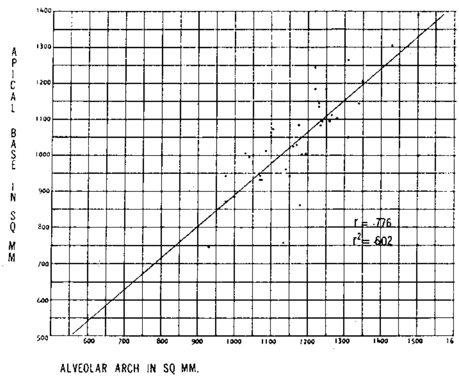
To make graphic the degree of correlation between the dental arch and the alveolar arch the cases were laid out in the order of increasing magnitude of the area of the alveolar arch; the area of the dental arch was laid out in the same order of cases (Graph 3).



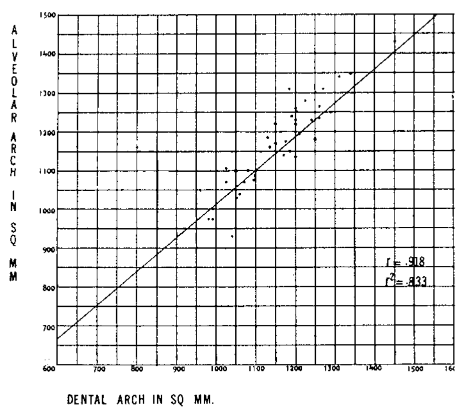
Graph 3 Graphic representation of area of the alveolar arch (below) and of dental arch (above).



Graph 4 Scattergram of the area of the apical base plotted against the area of the dental arch.



Graph 5 Scattergram of the area of the apical base plotted against the area of the alveolar arch.



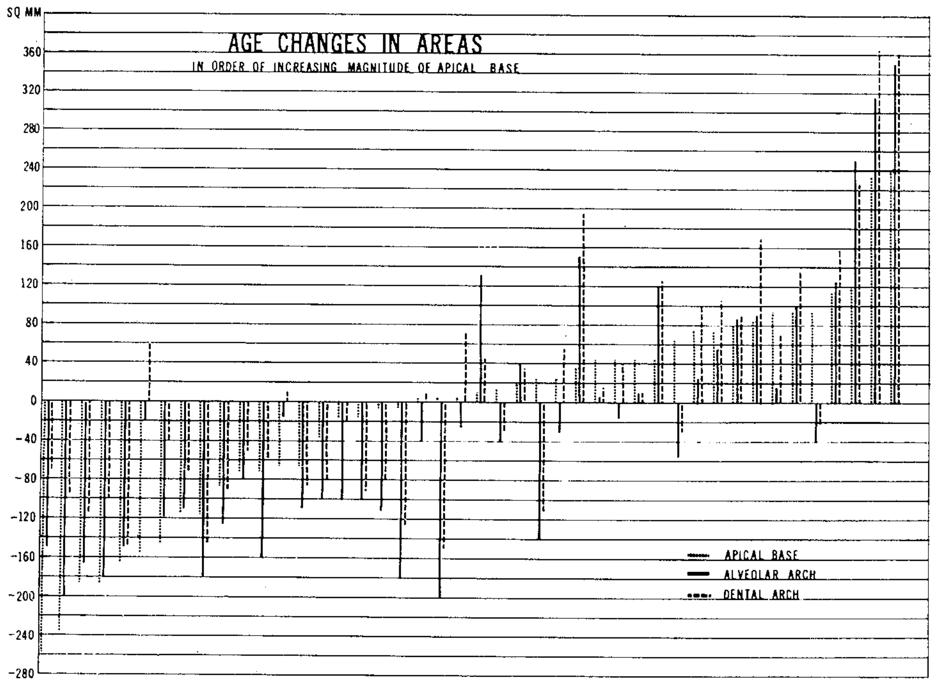
Graph 6 Scattergram of the area of the dental arch plotted against the area of the alveolar arch.

To reduce the data to more commonly employed statistical methods, they were laid out as scattergrams (Graphs 4, 5, 6), and their coefficients of correlation (r) were derived. Because of the size of the sample it was considered advisable to further reduce the possibility of chance by deriving the measurement of certainty (r^2) of the data.

Findings

A. *Apical Base—Area Determinations*

1. Of the 46 cases studied longitudinally 25 (54%) showed an increase in the apical base of from 4 to 240 sq. mm. Four cases remained unchanged and 17 (37%) decreased 6 to 256 sq. mm. When divided according to sex, of 21 females, 8 showed increases of from 4 to 240 sq. mm.



Graph 7 Growth change in the apical base, alveolar arch and dental arch. Note the independence of the three variables when considered within the individual.

Three showed no change and 10 exhibited decreases of from 6 to 256 sq. mm. Of the 25 males in the sample, 17 showed increases of from 4 to 234 sq. mm. One remained unchanged and 7 showed a decrease of from 16 to 186 sq. mm. Thus the females showed both the greatest increases and the greatest decreases.

2. On 30 of the 46 individuals there were available for study at least two sets of models taken after eight years of age. Six of these 14 (47%) showed increases, 4 (13%) showed little change and 12 (40%) showed decreases.

3. In those cases on which models were available covering the entire period of the changing dentition, it was noted that the apical base increased until just before the exfoliation of the deciduous molars. During and following the loss of these teeth there was generally a decrease in the size of the apical base. With the eruption of the permanent teeth the majority of cases showed increases in the apical base although some appeared to remain unchanged.

4. Both cases of anodontia exhibited growth. In one case there were no records beyond 7 years. The other case exhibited growth after the 11th year of life. This was shown by a great increase in area between 11 and 16 years. It did not follow the same pattern of increase as was seen in the mixed dentition cases but a fairly regular pattern of increase in area.

5. Comparing the area of the alveolar arch with that of the skeletal base did not reveal any definite correlation between the two except that when there was a significant reduction in the area of the skeletal base, there was a reduction in the area of the alveolar arch (Graphs 1, 4, 7).

The author saw a few slight reductions in the skeletal base without reductions in the alveolar arch. This was especially so in the transitional stage from the mixed to the permanent dentition. The reduction of the skeletal base did not show a definite correlation with the reduction in the alveolar arch. Otherwise the alveolar arch exhibited reductions, increases or relatively no changes, both without changes and with increases in area by the skeletal base. Sequence of eruption of the teeth seemed to have some effect on the pattern of remodelling of the skeletal base.

6. There was a tendency for the jugal process or key ridge to be located over the second deciduous molar in the child dentition and over the first molar of the permanent dentition. The location of the key ridge over the first molar ranged from above the mesial root to the distal root and, in one or two instances, it was slightly distal to the distal root. There was no significant relationship between the position of the key ridge and the increase, decrease, or constancy of the size of the skeletal base anterior to the first molar.

7. The dental arch did not show a direct correlation to the skeletal base (Graphs 2, 5, and 7).

B. *Alveolar Arch—Area Determinations*

1. The area of the alveolar arch exhibited a positive relationship to the teeth. This was seen in its increase in size as more space was made to allow the incisors to erupt in proper positions. Following this there was a continuous increase through the mixed dentition, then a reduction after exfoliation of the first and second deciduous molars.

2. Considerable variation was seen in the relative sizes of the alveolar arch and the dental arch. In some, the alveolar area was of greater size than the dental area while in others the reverse was true (Graphs 3 and 5).

3. Of further interest was the not infrequent observation of lapped contacts in dental arches exhibiting spaces in other areas. Measurement of these cases revealed that there was frequently sufficient alveolar arch length to accommodate the teeth in their correct positions.

A. *Skeletal Base — Linear Measurements*

1. The width of the apical base at the junction of the second premolar and first permanent molar continued to increase in size until the ages of 12 or 13 years in females and 14 to 16 years in males. In cases where growth was not experienced, the levelling began around ten years of age. The more dramatic changes in width of the apical base were noted in the first premolar area which almost always showed a narrowing of the base in the remodelling process of change from a deciduous to a permanent dentition. The skeletal area in the second premolar area remained relatively unchanged after about ten years of age. In cases where the area decreased, there were some instances of a reduction in width of the skeletal base at the junction of the second premolar and first molar.

2. The length of the skeletal base showed a tendency to increase through the period of the mixed dentition; it then showed a reduction in the first few years of the permanent dentition.

3. There was a definite change in the shape of the skeletal base supporting the permanent dentition from that of the deciduous dentition. The base usually became shorter and wider forming an arc of a larger circle.

4. Measurements of the width of the first premolar crowns and skeletal base at the middle of the same teeth did not reveal a positive relationship.

The increases and decreases in width occurred more nearly together in the second premolar area.

5. In the deciduous dentition, the skeletal base was wider than the crowns of the first and second molars but with the eruption of the permanent dentition, the skeletal base width varied in terms of its relationship to the coronal width of the premolars, being wider, the same, or narrower. There was a greater tendency for it to be narrower at the first premolar area.

6. The width of the skeletal base, at the premolar area of the permanent teeth, compared with that supporting the deciduous dentition became larger, smaller, or remained the same.

B. *Alveolar and Dental Arches—Linear Measurements*

1. The first bimolar width correlated with other studies and showed a levelling at the 13th to 16th years. The mean compared favorably with the mean of Smyth and Young, and Woods. The mean of this group was 55.33 for males, while that of Smyth and Young's study was 56.66 and Woods was 56.75 at 13.5 and 13 years, respectively. The mean of the group for females was 55.35; Smyth and Young's was 55.99 and Woods' was 55.20.

2. Several cases (8) showed little or no increase after the ninth year. Four cases showed a decrease in width between ages 8.5 and 16 years.

3. The bimolar width and the length from the first permanent molar to the central incisor correlated with previous studies. The arch became wider and shorter, i.e., an arc of a larger circle. The shortening in length was noticed toward the latter part of the mixed dentition period or during the first year or two of the secondary dentition.

4. Of ten cases with models of the full deciduous dentition and full permanent dentition, the sum total of the mesiodistal crown diameter of the ten permanent anterior teeth was larger than that of their predecessors. The difference in size varied from 2.5 to 14.5 mm with a mean of 6.5 mm difference in the size of the two dental arches. The coefficient of correlation was not significant at the 5% confidence level.

5. Physiologic spacing was noticed in some of the cases.

6. A further indication of the independence between the dental arch and the apical base was shown by the behavior of the cases in which there was spacing of the dental arch which closed, and those cases in which the actual dental arch length became smaller than the ideal dental arch length. Both conditions witness a shortening of the actual arch length. The behavior of the apical base in these cases was divided almost equally between those that increased and those that decreased.

Discussion

An analysis of the three sets of area measurements determined in this study, viz., apical base, alveolar arch and tooth arch, shows quite clearly that each has a considerable range of variation. Furthermore, the correlation between any two of them is such as to preclude the possibility of predicting the value of one from measurements of either of the others.

The problem is made still more complex by the finding that the relations existing between them do not remain constant with growth as is the case of different parts of the skeletal system. Bearing one set of relations or ratios in the deciduous dentitions they may change completely in the permanent dentition. Some insight into the reasons for this may be gained by a careful scrutiny of the two sets of teeth.

The teeth of the primary dentition stand in more vertical positions than do their successors. The roots of the incisors are longer in relation to the size of their crowns while those of the molars occupy considerably more space than the teeth that will succeed them. The height of the alveolar process is markedly less in the child than in the adult. The apical base of the deciduous dentition more closely parallels the size and shape of the deciduous alveolar and tooth arch than those of the permanent dentition, as was pointed out by Lundstrom.

During the stage of the mixed dentition there is usually an increase in width of the dental and alveolar arches across the anterior region as the larger permanent incisors erupt. Added to this are the mesiodistal diameters of the deciduous molars which are usually greater than those of their successors. Thus the arch length is generally greater at this time that at any other whether measured sagittally or circumferentially. This bears out the common observation that the denture appears more protrusive at this time than at any other.

During this same period of time the apical base is growing, but at a slower rate. Further than this the timing of its growth may be delayed beyond that of the eruption of the teeth so that these organs may assume positions which reflect a lack of synchrony. Broadbent has called such a lack of synchrony "ugly duckling" stages. Subsequent growth of the apical base frequently results in a gaining of more vertical axial alignment of the teeth.

Probably one of the chief factors responsible for the lack of correlation between apical base and tooth arch size lies in the influence of the musculature on tooth positioning. As the second teeth erupt and the alveolar process grows to support them, they come under the influence of the tongue, lips and cheeks. The course of eruption and axial inclination of the teeth seem to be largely determined by forces of this muscular environment. Thus the individual presenting a large tongue will frequently exhibit teeth standing at pronounced labial and buccal axial inclinations with good occlusion although the apical base may be small by contrast. This same condition may well explain those cases in the present study where lapped contacts were found together with spacing of the teeth, even in the same segments of the arch.

At first thought is seems improbable that such an important area as the apical base would decrease in absolute size as the permanent dentition comes into function. The evidence that it seems to do so may be questioned on the following grounds:

The growth of the jaws and eruption of the teeth witness a significant increase in height of the alveolar process plus an increase in height of the second teeth as compared with that of the deciduous set. Both of these factors would yield a plaster model that was higher than one of an earlier age. Since the maxilla slopes outward on the surfaces scrutinized in this study, and since the x-ray delineates the outline of the smallest area, it is entirely possible that the second x-ray does not represent the same level of "cut" as did the earlier one. Only longitudinal studies on the living could satisfactorily settle this question.

Thus it would seem that the study involves three entirely different systems, viz., teeth, skeletal as well as alveolar bone, and muscle. When viewed in this light, the lack of correlation found between the size of the apical base, the alveolar arch and the dental arch is not surprising.

Conclusions

1. The apical base of the maxilla, anterior to the first permanent molars, usually changes its form during growth. It becomes shorter and wider, an arc of a larger circle.
2. The area of the tooth arch is greatest in the late stage of the mixed dentition, after the six anterior teeth are in place and the deciduous molars still remain. Thereafter it diminishes in size until the premolars are erupted.
3. Spacing and lapped contacts can be present in the same arch.
4. The area of the apical base increases with growth in the majority of cases. In those cases in which it appeared to remain unchanged or to decrease, the possibility exists that the method did not permit the determination of the same level of the x-ray "cut" at different ages.
5. In a problem such as the present one, there is danger in according the usual degree of confidence to the results obtained by statistical techniques. Although the three variables, considered as groups, give correlation coefficients that are statistically significant, the scrutiny of individuals within the sample exhibits wide departures from the pattern that might be expected from such correlation values (Graph 7). The correlation between the area of the apical base and that of the dental arch is statistically significant but its measure of certainty (r^2) indicates that of the total variation, only 34.5% may be explained by the association between these two variables. Thus, the size of the apical base is not necessarily the dominant factor in determining the size of the dental arch. A small apical base may not be accompanied by a small dental arch and vice versa.
6. The area of the alveolar arch correlates quite closely with the area of the dental arch but the correlation is not perfect. Cases presenting lapped tooth contacts or interdental spaces show the poorest correlation.
7. The oriented occlusal x-ray film is a valuable adjunct to growth studies.

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