Developmental changes of the maxillary and mandibular dental arches*

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Since most orthodontic patients are growing children, knowledge of growth becomes important in the ascertaining of etiology, in the outlining of treatment procedures, and in the defining of probable consequences of treatment. During the past thirty years research in orthodontics has given considerable attention to the solution of growth problems in the dento-facial complex.

Early work in orthodontics overemphasized the importance of environment, neglecting the role of heredity. Consequently some literature interprets departure from a generalized growth curve as due to the operation of nongenetic forces. Abnormalities in the dentition, malrelation of the arches, and other peculiarities of the dento-facial complex were attributed to environment. According to this point of view, dental irregularities would be caused by habits, mutilation of the dentition and subsequent movement of teeth, or faulty nutrition.

Our data enables us to estimate the influence of growth upon etiology, diagnosis, and treatment of occlusal irregularities. In addition, it provides an opportunity to outline the expectation of growth in the dentition and supporting structures. These findings should be of practical, as well as theoretical, value to the profession.

This paper will present in summary form the findings concerning developmental changes of several regions of the dental arches. Detailed reports on the summarized findings will be presented in the near future.

PROBLEM

The problems of this paper are: (1) to evaluate the changes in occlusal relationships during the period from the completed primary dentition to the eruption of all permanent teeth except the third molars; (2) to ascertain the major changes in maxillary and mandibular arch form during the above periods; 3) to measure the amount of growth occurring within and between the various areas of the primary and permanent dentitions.

MATERIAL AND METHODS

The data consist of 528 sets of serial casts of 51 children enrolled in the University of Michigan Elementary and High Schools at Ann Arbor, Michigan. These casts were made at approximate-

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ly one year intervals and the impressions for them were taken with plaster or compound during the primary dentition and with plaster or hydrocolloid materials during the mixed and permanent dentitions. Plaster impressions were discontinued when the new agar and alginate hydrocolloids came into use.

Individual casts were examined in two ways: (1) by graded observational appraisal of attributes which did not lend themselves to measurement; (2) by serial measurements of many regions of the maxillary and mandibular dental arches. The details of cast examination will be discussed later.

Observations and Discussion

A. Spacing and Crowding of Anterior Teeth

The standard for determining the amount of anterior spacing and/or crowding for an individual case was the incisal width of the permanent mandibular right central incisor. The letter (S) was used to indicate spacing and one (S) represented one-third the width of the mandibular central incisor. The letter (C) was used to indicate crowding and one (C) represented one-third the width of the mandibular central incisor. We recorded only the total spacing or crowding of the six anterior teeth of the cast examined.

The means of spacing and crowding ranged from maxillary spacing equivalent to 4/3 incisor width at 3 years of age to mandibular crowding equivalent to 1/3 incisor width at 15 years of age. In the maxillary arch the mean spacing decreased from 4/3 incisor width at 3 years to 0 by 14 years of age. After 14 years mean crowding started and increased with age. In the mandibular arch the mean spacing decreased from 4/5 incisor width at 3 years to 0 by 7 years of age. After 7 years mean crowding started and steadly increased to 1/3 incisor width by 15 years. In the maxillary arch at 6 years of age none of the cases had crowding but at 14 years 24% showed crowding. In the mandibular arch from 6 to 14 years of age the crowding increased from 14 to 51% of the cases.

Examination of the individual series of cases revealed several findings that are of value to the orthodontic profession: (1) *crowding of permanent anterior teeth was absent when the total primary anterior spacing was equal to or greater than the width of the permanent mandibular right central incisor;* (2) crowding was consistently more pronounced in the mandibular than in the maxillary anterior teeth; (3) *of* 16 *cases having no primary anterior spacing* 5 *resulted in no crowding of the permanent anterior teeth.*

B. Classification of Occlusion

In this report occlusion was classified both in the molar and in the canine regions. The Angle system of classification was used in the molar region and a "so-called" Angle method was used in the canine region. A "Class I" canine relationship was one in which the cusp point of the maxillary canine fell on a line which bisected the embrasure between the mandibular canine and first premolar. In other words, a "Class I" canine relationship was present when the cusp point of the maxillary canine interdigitated perfectly with the mandibular canine and first premolar. A "Class II" canine relationship was one in which the cusp point of the maxillary canine was positioned mesial to the midline of the embrasure and a "Class III" canine relationship was one in which the cusp point of the maxillary canine was positioned distal to the midline of the embrasure between the mandibular canine and first premolar. The observations were graded in terms of quarters of a cusp in both the molar and canine regions.

In this paper all dicussion on the classification of occlusion is in accordance with the regular Angle method except when specific reference is made to classification in the canine region. At five years of age 39% of the 51 cases studied were classed as having normal occlusion, 33% were Class I, 18% were Class II and 9% were Class III. From 5 to 16 years of age the percentage of normals had decreased from 39% to 12%, Class I cases had increased from 33% to 39%, Class II cases had increased from 18% to 36% and Class III cases had increased from 9% to 12%. From this portion of the study the essential findings were: (1) in the transition from the primary to the permanent dentition the percentage of normal cases decreased to one-third of its original value, while the percentage of Class II cases doubled; (2) of the 20 cases classified as normal in the primary dentition 15 or 75% maintained their corerct molar relationship throughout the age range studied: (3) 56% of the 51 cases cases studied maintained the same molar relationship throughout the age range studied; (4) 26% of the 51 cases showed a one-half cusp molar change. This clearly demonstrates that those cases classified as normal in the primary dentition show least change in molar occlusion during the transition from primary to permanent dentition.

At least 50% *of the cases with normal molar relations presented a "Class II" relationship in the canine area. This finding is important because many orthodontists seek to establish and retain a "Normal" canine relationship which in these cases would result in a Class III molar relationship.*

C. Arch Form

The arch form was classified as tapered, trapezoid, squared, ovoid, U-shaped or hyperboloid.

A tapered arch converges from the molars to the central incisors to such an extent that lines passing through the central grooves of molars and premolars intersect a short distance anterior to the central incisors. A trapezoid arch converges in variable degrees from the molars to canines. The anterior teeth are somewhat squared to abruptly rounded from canine tip to canine tip. Ovoid arches curve continuously from the molars on one side to the molars of the opposite side in such a way that two such arches placed back to back describe an oval. U-shaped arches present little difference in diameter between the first premolars and the diameter between the last molars, and the curve from canine to canine is abrupt so that capital "U" is formed. Hyperboloid and squared arches are not represented in this series.

Many writers report finding a very high percentage of ovoid arches in the early primary dentition. We found approximately 5% tapered, 65% trapezoid, but only about 30% ovoid. *The primary arch before eruption of the first permanent molars is very short and to the casual observer appears ovoidal in form, when upon closer examination usually it will be found to be trapezoidal.*

Examination of individual series of casts revealed that the form of the maxillary and mandibular dental arches changed only a little during the period from the primary to the early permanent dentition. In general these changes consisted of an increase in tapered and trapezoidal arches and a decrease in ovoidal ones.

D. Dental Arch Width (Measured at the Canines)

The width of the dental arches in the canine region was obtained by measuring the distance between canine tips in each arch. With the canine tip

as the point of measurement it was possible to collect data from the time of eruption of these teeth. The shape of the canines permitted approximation of the original tip locations even after extensive abrasion.

The essential findings under this heading were: (1) there was little intercanine arch width change from 3 to 5 years of age; (2) *the intercanine width increased very rapidly from* 5 *to* 8 *or* 9 *years of age.* (The amount of change was approximately 4mm. in the maxillary arch and 3mm. in the mandibular arch.) (3) *in most cases the maxillary and mandibular intercanine arch widths steadily decreased in amount varying between* 0.5*mm. and* 1.5*mm. after* 14 *years of age.*

E. Dental Arch Width (Measured at the Second Primary Molars)

The point on a molar tooth from which measurements were taken was the point where the buccal groove crosses the ridge into the central fossa. The width of the dental arches in the molar regions was obtained by measuring the distance from the molar point on one side of the arch to the corresponding molar point on the opposite side of the arch.

In general, from 5 *to* 10 *years of age, the width of the maxillary and mandibular dental arches in the second primary molar region increased approximately* 1.5*mm.* Decreases in arch width occurred in only 7 of the 51 cases studied.

F. Dental Arch Width (Measured at the First Permanent Molars)

From 7 to 11 years of age the average increase in intermolar width was 1.8mm. in the maxillary arch and 1.2mm. in the mandibular arch. From 11 to 15 years of age there was an average decrease in intermolar width of 0.4mm. in the maxillary arch and 0.9mm. in the mandibular arch. *This decrease in intermolar width following the* 11 *year reading was due, in our opinion, to mesial drift of the first permanent molars after the loss of the primary molars.* The arches converge toward the anterior, and the mesial movement of the first permanent molars produced the decrease in intermolar dimension. The greater decrease in the mandibular arch, we believe, was due to the greater mesial movement of the mandibular molars. From 15 to 17 years of age more than half of the cases show a continued decrease in intermolar width.

G. General Discussion on Dental Arch Width

The maxillary and mandibular dental arches increase in width but little from 4 to 17 years of age and, according to our findings, this change has occurred by the end of the transition stage. *Orthodontists, in planning treatment procedures, should expect moderate increase in width of the dental arches particularly in the anterior regions until the permanent canines erupt. After this time they should plan on some decrease in arch width in both the anterior and posterior regions.*

H. Primary Dental Arch Length

The length of the primary dental arch was obtained by measuring the distance from the midportion of the labial surfaces of the primary central incisors to the distal surfaces of the primary second molars. After permanent teeth had replaced primary ones then the measurements were made from the labial surfaces of the permanent central incisors to the distal surfaces of the permanent second premolars.

From 4½ to 6 years of age the average decrease in the length of the maxillary and mandibular dental arches was approximately 0.33mm. This de-

crease was associated with closure of the interproximal spaces of the primary posterior teeth. An increase in the dental arch length during this period occurred in only 6 maxillary arches and 4 mandibular arches. Between 6 and 12 years of age the primary teeth were replaced by permanent ones and the length of the maxillary arch increased 1.0mm., from an average of 28.82mm. to 29.82mm. During the same period from 6 to 12 years of age the length of the mandibular dental arch decreased 1.12mm. from an average of 26.06mm. to 24.94. From 12 to 13½ years of age the length of the maxillary dental arch decreased 0.5mm. and the mandibular dental arch decreased 0.67mm. These further decreases in the length of the dental arches following the replacement of the primary by permanent teeth were associated with closure of interproximal spaces of the permanent posterior teeth.

From 4½ to 13½ years of age the total change in length of this portion of the dental arches was an increase of approximately 0.2mm. in the maxillary arch and a decrease of approximately 2.2mm. in the mandibular arch.

I. Discussion on Dental Arch Length

In many cases the length of the dental arches continued to decrease through 17 or 18 years of age. We found three main causes for this decrease following the replacement of all primary by permanent teeth. They were: (1) *closure of the interproximal spaces of the posterior teeth;* (2) *lingual tipping of the anterior teeth, especially noted in the maxillary incisors;* (3) *normal wear of the proximal contact surfaces of all teeth. Our findings show in general, that the permanent teeth through the years move and wear in many ways resulting in a shortening of the dental arches.*

J. Depth of Bite

The depth of bite was determined by measuring the average overlapping of the labial surfaces of the mandibular central incisors by the maxillary central incisors. The degree of openbite was determined by measuring the average distance from the incisal edges of the maxillary central incisors to the incisal edges of the mandibular central incisors. The preceding measurements on depth of bite and degree of openbite were not recorded unless the maxillary and mandibular central incisors were at least three-fifths erupted.

Many teachers of orthodontics have emphasized that the depth of bite decreases as the permanent bicuspids and second molars erupt. Our findings are not in accord. We found that the depth of bite decreased from a mean of 2.0mm. at 4 years of age to 1.75mm. at 5 years. This decrease of 0.25mm. probably was due to attrition of the primary upper anterior teeth. The depth of bite then increased 1.75mm. to a mean of 3.5 by 11 years and showed only minor variations through 17 years of age. This 1.75mm. increase was mainly due to the larger size of the replacing permanent incisor teeth. *The depth of bite remained very stable after the permanent incisor teeth had erupted sufficiently so that the incisal edges of the lower anteriors came in contact with the lingual surfaces or incisal edges of the upper anteriors.*

Proportionate to the incisor tooth size, the degree of depth of bite was very nearly constant throughout the primary and permanent dentitions. For example, if in the primary dentition the incisal edges of the lower anteriors contact the cinguli of the upper anteriors at the gingival margins the same relationship of incisor teeth usually can be expected in the permanent dentition. In this study the 4 children who had impinging overbites in the primary den-

tition at 6 years of age also had impinging overbites throughout the age range of the permanent dentition. In both the primary and permanent dentitions the depth of bite necessary to produce impingement was largely dependent upon the length of the clinical crowns of the maxillary and mandibular incisor teeth. The depth of bite necessary to produce impingement in the primary dentition ranged from 3.0 to 4.0mm. while in the permanent dentition it ranged from 3.5 to 7.5mm.

Habit practice caused bite opening in only 5 of the 14 habit cases studied. *Our findings show that if an oral habit has been practiced for several months and no tooth displacement is evident* we can be reasonably sure that none will ever occur. In most cases where habit practice had caused tooth movement we found considerable natural correction after the habit had been discontinued, but in nearly one-half of the cases we did not find complete self correction because of the following reasons: (1) frequently there were minor oral habit substitutions; (2) there were those cases in which the habit practice had caused so much protrusion of the upper anteriors that the lower lip naturally rested lingual to these protruded teeth and little natural improvement took place even though the habit was discontinued.

Many cases at 9 *and* 10 *years of age are diagnosed as having impinging overbites. If such cases are closely examined, it usually will be found that the maxillary incisor teeth are not fully erupted and the incisal edges of the lower anteriors are in contact with the gingival tissue which covers the cinguli of the maxillary anterior teeth.* After complete eruption of these maxillary anteriors the mandibular incisors will be in contact with the cinguli of the upper anteriors and the "false impingement" will no longer exist. In "true impingement" the incisal edges of the lower anteriors contact the palatal soft tissue completely lingual to the cinguli of the upper anteriors. In "false impingement" cases the depth of bite usually did not increase after 11 years of age but in cases of "true impingement" it continued to increase throughout the age range studied.

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