The Relationship Between Eruption, Calcification, And Crowding Of Certain Mandibular Teeth

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INTRODUCTION

This is a study of the mandibular permanent canine and premolars to investigate the timing of their eruption and calcification, and to determine whether this has any relation to crowding in the mandibular permanent dentition.

Mean ages of eruption have been reported by Cattell[1], Cohen[2], Klein, Palmer, and Kramer[3], Hurme[4], and many others. A difference between sexes was noted in mean eruption times, but no difference has been found between right and left sides of the dental arch. The sequence of eruption of different teeth was studied by Lo and Moyers[5], and Garn and Lewis[6].

The relation of age and dental calcification was investigated by Nolla[7], and eruption as related to dental calcification was reported by Carlson[8], and Shumaker and El Hadary[9].

MATERIAL

Radiographs and dental casts for a sample of eighty-nine boys, predominantly of mixed European stock of middle socio-economic background, were selected from the files of the Elementary School Growth Study at the University of Michigan on the basis of two criteria.

1. It was necessary that there be annual lateral jaw radiographs of the right side of the mandible. These were taken at yearly intervals plus or minus one month, usually during the month in which the birthday occurred. The age range was from three to eighteen years; there was an average of 6.9 annual radiographs in the series for each individual. The greatest number of series in progress at one time was 86 at age nine. The procedure used for taking the radiographs was standardized, but not cephalometric, and all were taken by Professor Albert G. Richards at the Radiographic Department of the University of Michigan School of Dentistry. The right side of the subject's face was held against the cassette with his nose about one-fourth inch from its surface. The tube was positioned so that the central ray passed below the body of the mandible on the left side and through the body of the mandible on the right side.

2. Also required was a dental cast with all mandibular permanent teeth erupted anterior to and including the first permanent molar. The mean age at which the casts were obtained was fourteen and the latest age was nineteen.

METHOD

From the radiographs two types of data were recorded for the mandibular right canine and premolars. (1) Dental calcification stages, as defined by Nol-

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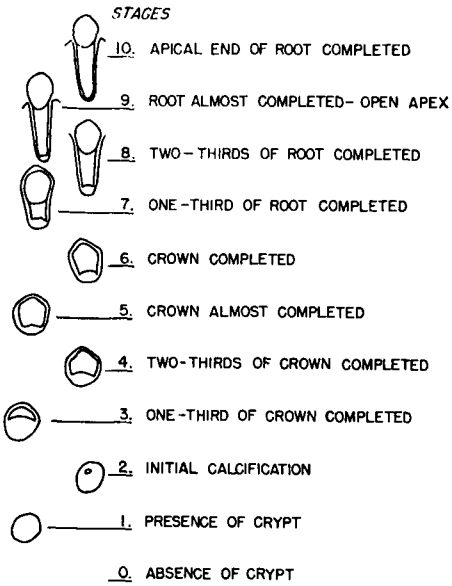

Fig. 1 Calcification stages of the mandibular canine and premolars (after Nolla).

la[7] (Figure 1), were determined to the nearest stage. (2) Using the method of Shumaker and El Hadary[9] (Figure 2), per cent of eruption was determined from each radiograph for each tooth. The limits for the measurements were the inferior border of the mandible, and an arc passing through the cusp tip of the primary canine and the buccal cusp tips of the primary molars. The lines along which the measurements were made passed through the cusp tips of the unerupted permanent teeth and the centers of the crowns of their primary predecessors. Eruption per cent as used was not a perfect measure of eruption because it was affected by growth of the alveolar processes and inferior border of the mandible, and by occlusal attrition. It was used because it was considered the best possible measure of eruption with the available lateral jaw radiographs.

On the casts the following measurements were made, as shown in Figure 3: (1) the mesiodistal width of each permanent tooth anterior to the first permanent molar on the right side of the dental arch; and (2) the distances from the mesial surface of the right first permanent molar to the mesial contact of the right permanent canine, and from there to the mesial contact of the right central incisor. The sum of the two segments of the dental arch minus the sum of the tooth widths, expressed as a positive or negative number to the nearest tenth of a millimeter, was recorded as the right side dental arch space adequacy. Any tooth which appeared to be rotated or out of the line of the arch was recorded as a malposed tooth. All measurements on the radiographs and casts were made to the nearest tenth of a millimeter with a finely pointed vernier caliper.

The measuring procedures used were the result of an error study in which each method of measurement under consideration was performed twice,

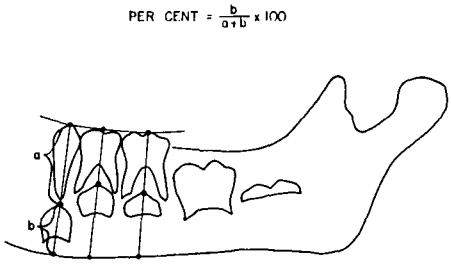

Fig. 2 Per cent of eruption (after Shumaker and El Hadary).

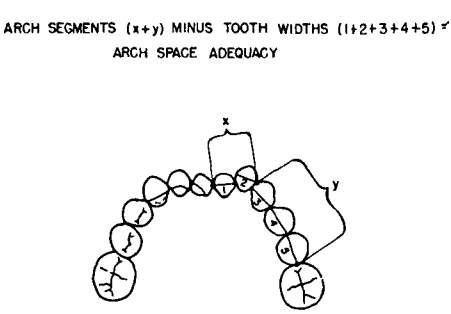

Fig. 3 Right side dental arch space adequacy.

with a one-week interval between measurements, on ten of the record series which had been selected at random. (1) When per cent of eruption was determined from measurements of tracings of the radiographs, the mean error (the mean difference between the first and second measurements) was 1.2 per cent, but when the measurements were performed directly on the radiographs, the mean error was .8 per cent. This difference between means could have occurred by chance only 5 per cent of the time[11]. (2) When right side dental arch circumference was measured, using the two segments as previously described, the mean error was .3 mm, but when circumference was measured from one tooth contact to the next around the arch, the mean error was .7 mm. This difference between means could have occurred by chance only 1 per cent of the time. Though the two segment method was more reliable, it averaged .3 mm smaller. (3) The mean error in reading calcification stages was .2 stage, and (4) the mean error for the sum of the mesiodistal measurements of the five teeth was .6 mm.

Eruption and Calcification

Figure 4 shows the mean eruption per cent and calcification stage with their standard deviations and sample size at each yearly age plus or minus one month; and Figure 5 indicates the mean eruption per cent and monthly age with their standard deviations and sample size at each calcification stage. The mean values show the following. The per cent of eruption begins to increase by stage six, and the canine and first premolar reach stage six about the same time (74 and 75 months, respectively) followed by the second premolar (84 months). At stage six the eruption per cent is least for the canine (50 per cent), next for the second premolar (57 per cent), and greatest for the first premolar (61 per cent). All three teeth near 100 per cent eruption at stage nine, and the canine reaches stage nine first (140 months) followed closely by the first premolar (144 months) and then the second premolar (151 months).

The ages of attaining 100 per cent eruption are about one year greater than the eruption ages found in previous studies, which had designated a

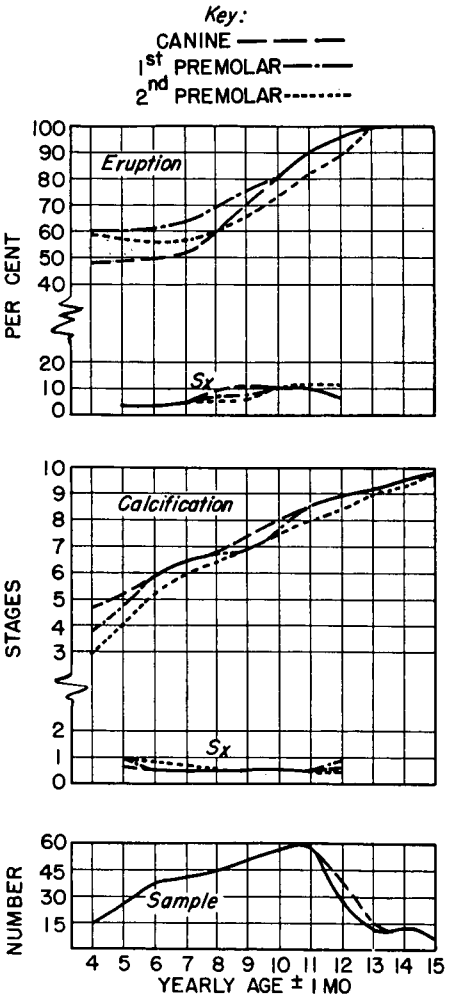

Fig. 4 Mean per cent of eruption, mean calcification stage, and their standard deviations (Sx), and sample size at each yearly age plus or minus one month.

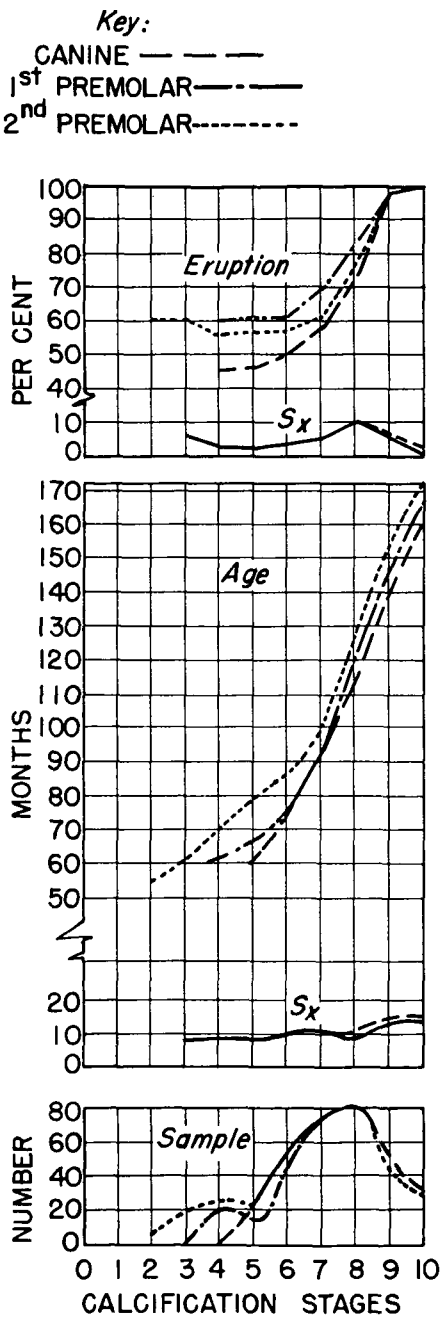

Fig. 5 Mean per cent of eruption, mean age in months, and their standard deviations (Sx), and sample size at each calcification stage.

tooth erupted as soon as it was visible in the oral cavity. The decrease in eruption per cent shown by the second premolar around five years of age is probably the result of alveolar growth which would cause measurement "a" to increase. The canine and first premolar did not show this decrease in eruption per cent, possibly because they had already begun to erupt; and the inferior border of the mandible may have had some appositional growth[12,13] which would have tended to increase eruption per cent by increasing measurement "b". Ninety-five per cent of the sample fell within the limits of about plus or minus two and one-half years of the mean time of attaining 100 per cent eruption of each of the three teeth. The individual variation in per cent of eruption appears to be less when measured at calcification stages than when measured at years of age plus or minus one month, and variation seems to increase around stage eight, the period of most rapid eruption.

Crowding

The distribution of the casts and of the malposed teeth in relation to dental arch space adequacy is shown in Figure 6. The range of right side dental arch space adequacy was from plus 6.8 mm to minus 3.9 mm. There were no canines or premolars which did not erupt to the plane of occlusion.

The relationships between dental arch space adequacy, and eruption and calcification were investigated by analyzing seven pairs of variables cross-sectionally at periodic intervals for each of the three teeth to determine whether there were significant correlations. The pairs of variables examined were as follows:

1. Age (months) of attaining each calcification stage with right side dental arch space adequacy (mm) in the permanent dentition.

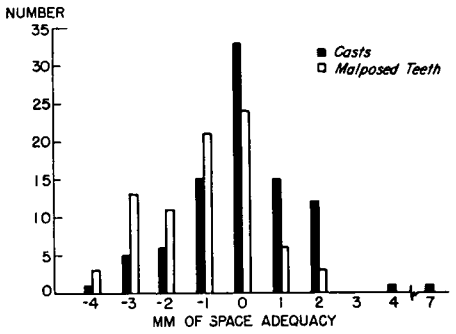

Fig. 6 Distribution according to right side dental arch space adequacy of 89 casts and 81 malposed teeth which were found on 53 of the casts.

2. Age of attaining each calcification stage with rate of eruption (per cent per year plus or minus one month).
3. Space adequacy with rate of eruption at successive intervals.
   a. Per calcification stage at each stage.
   b. Per year plus or minus one month at each stage.
   c. Per year at each yearly age plus or minus six months.
   d. Per year plus or minus one month at each yearly age plus or minus six months.
4. Space adequacy with eruption (per cent) at successive intervals.
   a. Each calcification stage.
   b. Each yearly age plus or minus one month.
   c. Each ten months plus or minus five months.
5. Space adequacy with measurement "a" (mm) (Figure 2) at each stage.
6. Space adequacy with measurement "b" at each stage.
7. Space adequacy with measurement "a" plus measurement "b" at each stage.

Scatter diagrams for each pair of variables for each tooth at each interval were made whenever the sample size exceeded twenty. When any correlation between variables was suggested by the scatter diagram, the correlation coefficient (r) and the probability (P) that it might have occurred by chance were calculated[11]. All of the calculations, which were performed with a machine, and all entries of data on the calculation sheets were repeated for accuracy. Out of the 181 scatter diagrams there were 37 correlations (see Figure 7) with coefficients exceeding .10, but none greater than .43, indicating considerable individual variation. Nine of the correlations could have occurred by chance less than 5 per cent of the time (P equals .05), and none of these had a coefficient below .30 or a sample size smaller than 47. All of the nine occurred between calcification stages four and eight, and they constituted 8 per cent of the 117

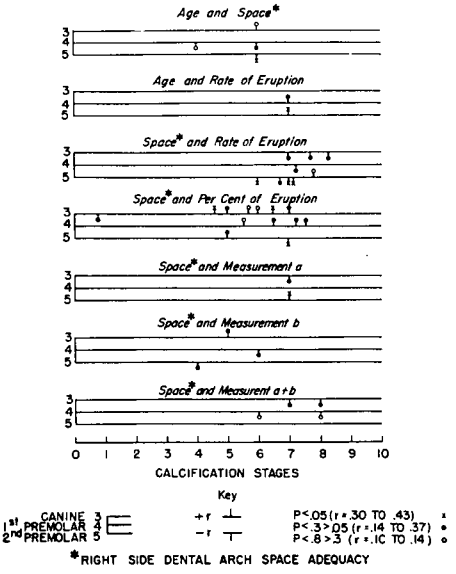

Fig. 7 Positive or negative correlations and the probability (P) of their occurring by chance in the 37 instances in which the paired variables had a correlation coefficient (r) exceeding .10. This is recorded at the calcification stages at which the correlations occurred. Data recorded in months were converted to the mean calcification stage for that age.

scatter diagrams between these stages; and of the nine, seven could have occurred by chance less than 2 per cent of the time, and four less than one per cent of the time. Although there were more correlations with coefficients exceeding .10 for space adequacy with rate of eruption, and space adequacy with per cent of eruption than for some of the other pairs of variables, these two had three or four times as many scatter diagrams.

Greater importance was attached to the correlations which had a lesser probability of having occurred by chance, but it was also noted that most of those correlations with a greater probability of having occurred by chance conformed in sign to the overall pattern. With reduction in space adequacy (1) the mandibular canine had a retarded eruption per cent around calcification stages five through seven (space with per cent of eruption). With reduction in space adequacy (2) the mandibular second premolar reached stage six at a later age (age with space), but (3) at stages six and seven its rate of eruption was greater (space with rate of eruption), and (4) by stage seven its eruption per cent was greater (space with per cent of eruption), and (5) it was closer to the occlusal plane (space with measurement "a"). Also (6) when the second premolar reached stage seven late, its rate of eruption was greater (age with rate of eruption).

It is not possible from the findings definitely to conclude casual relationships, but several may be hypothesized. (1) Retarded eruption of the canine or retarded calcification of the second premolar might permit excessive mesial drift of the permanent first molar and primary molars, reducing arch circumference; or inversely, crowding may be causing retardation of eruption, but it does not seem likely that crowding could retard calcification. (2) The accelerated eruption of the second premolar following retardation of its calcification might be because the roots of the primary second molar have had longer to resorb. (3) The correlations diminish by stage eight, and it could be either that the eruptive process has exerted its main influence on space adequacy by that stage, or that the eruptive process is no longer affected by space inadequacy after stage eight.

Individual variation, as indicated by the low correlations, appears to be too great for it to be practical to attempt to use calcification stages, eruption per cent, or eruption rate to predict crowding in the mandibular permanent dentition, or to be concerned about the eruption timing of the mandibular canine and premolars being affected by moderate crowding.

Summary

Using a sample of eighty-nine boys from the University of Michigan Elementary School Growth Study, an average of seven annual lateral jaw radiographs for each individual along with dental casts were measured and analyzed cross-sectionally to determine the relationship between dental eruption, dental calcification, and dental arch crowding for the mandibular canine and premolars.

Tables relating eruption and calcification were compiled indicating mean values and individual variation. The means showed the following: (1) The canine and premolars began erupting when their crowns were complete, and reached the occlusal plane just prior to completion of their roots. (2) The canine and first premolar began and completed eruption at approximately the same times, followed by the second premolar. (3) At the same time eruption began, the order of proximity to the occlusal plane was first premolar,

second premolar, and canine. The data used in this study may be analyzed longitudinally to permit a more accurate prediction of eruption times from calcification stages.

Increased crowding in the mandibular permanent dentition had a low but significant correlation with (1) retardation of the early phases of eruption of the canine, and (2) retarded calcification of the second premolar, followed by an acceleration of the early phases of its eruption.

Individual variation was so great that it appears to be impractical to predict crowding from calcification or eruption timing, or to be concerned about moderate crowding affecting eruption timing.

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