

Time and duration of eruption of first and second permanent molars: a longitudinal investigation

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Abstract – Objective: The aim of this study was to investigate the variation in (i) the time (age) of eruption and (ii) the duration of the eruption of first (M1) and second (M2) permanent molar teeth. Finally, the study also provides data about the association between time of eruption of the first of the M1s and the first of the M2s. **Methods:** The study was carried out in Nexø Public Dental Health Service, Denmark. All children who, in a period of 12 months, had the first of their M1s or M2s recorded as erupted and the occlusal surface still partly covered by gingiva formed the study groups ($N = 69$ and 112 children, respectively). The continued eruption of all four molar teeth was recorded at recall intervals not exceeding 4 months until functional occlusion was obtained. **Results:** First permanent molars: eruption time – girls: from the age of 5 years and 3 months to 7 years and 8 months (mean 6.1 years); boys: from 5 years and 2 months to 7 years and 10 months (mean 6.3 years). The duration of eruption – girls: from 5 to 32 months (mean 15.4 months); boys: from 7 to 28 months (mean 15.0). Second permanent molars: eruption time – girls: from the age of 8 years and 11 months to 14 years and 4 months (mean 11.3 years); boys: from 9 years and 11 months to 13 years and 11 months (mean 12.0 years). The duration of eruption – girls: from 12 to 44 months (mean 27.1 months); boys: from 9 to 45 months (mean 27.9 months). No correlation was found between the time of eruption and the duration of eruption of M1 or M2. There was a strong positive association between the time of eruption of the M1s and the M2s ($r_s = 0.81$). **Conclusions:** A tremendous variation was found in time of eruption and in duration of eruption of permanent molars. This variation highlights the importance of individualizing caries preventive strategies for children.

Key words: caries; eruption period; molar teeth; risk factor

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In the early 1970s, Helm and Seidler (1) stated that 'the timing of eruption of the permanent dentition is of considerable importance in child dental health planning of diagnostic, preventive and therapeutic measures'. Therefore, using a cross-sectional design, Helm and Seidler investigated the mean times (ages) of eruption of permanent teeth and the mean times of onset of specific dental stages in school children in Denmark. It was found that, for individual tooth types, the eruption time varied by several months, an observation

recently confirmed in a longitudinal population study also on Danish children (2). Similar findings have been published from other countries in the world (3–7).

To the best of the author's knowledge, data about the duration of the eruption in a Danish/European child population has not been provided. Such information is of particular interest for permanent molar teeth because Carvalho et al. (8, 9) and Ekstrand et al. (10) have shown that the period when these teeth are partially erupted favors occlusal

plaque accumulation and caries initiation with a fast progression rate. When the molar teeth finally come into occlusion, the progression rate of the caries slows and the disease may even be arrested (8–10). Thus, based on these observations, it is reasonable to consider the eruption period of permanent molar teeth as a risk factor concerning caries development on these caries-prone occlusal surfaces (11, 12). Modern programs for controlling occlusal caries development, therefore, ought to be initiated from the moment of eruption of molar teeth, with a close follow-up during the eruption period until functional occlusion is established.

The aim of this study, therefore, was to investigate (on Danish children) the time of eruption of permanent first molars (M1) and permanent second molars (M2), and to determine the duration of the eruption of M1 and M2. In addition, data will be provided to show the relationship between the time of eruption of the first of the M1s and that of the first of M2s in the same subjects.

The investigation was carried out at Nexö Public Dental Health Service in Denmark. In this service, a non-operative caries treatment program has been in operation since 1987 (9). For each child, the program starts at the age of about 8–10 months, and during the eruption period of permanent molar teeth, recall intervals vary between 1 and 4 months. This study was planned as an integral part of the normal treatment provided for children and adolescents in this service, and a longitudinal design with short recall intervals (from 1 to 4 months) was therefore possible.

Materials and methods

Recording of eruption stage

The following criteria were used to record the stage of eruption of each of the permanent first and second molar teeth (modified from 6, 8).

- 0: Unerupted;
- 1: Appearance of some part of the occlusal surface;
- 2: The occlusal surface free of gingiva; and
- 3: Functional occlusion (firm contact). In cases of doubt, a thin sheet of paper had to be held in place by the occlusion.

In these criteria, stage 1 defines the time of tooth eruption (or eruption time), and the time period between stage 1 and 3 will define the duration of the eruption, but only when functional occlusion is established on both pairs of M1/M2.

Samples, inclusion and exclusion criteria

Two groups of children were selected during a 12-month period: children who had their first M1 (sample 1) or first M2 (sample 2) recorded as erupted by their regular dentist. Children were only included in the study if the first erupting M1 or M2 did not exceed stage 1 described above.

Permanent first molars

During the period 1st March 1995–1st March 1996, the dentists in the dental service found that 81 children had one or more M1s recorded as erupting. Of these children, 69 fulfilled the inclusion criteria. Thus, 35 boys and 34 girls made up the study group for investigating the time of eruption of M1s. During the following period, one child left the municipality and two children were excluded from the study, one because of ectopy of the upper M1s and the other as a result of lack of co-operation, giving a total number of 66 children. Thirty-four boys and 32 girls then made up the study group for investigating the duration of the eruption of M1.

The children in this group were further observed until August 2002, and during this period, the first of the M2s had begun erupting in all children. A total of 32 boys and 32 girls were available for this part of examination. This procedure was followed in order to investigate the relationship between the eruption time of the first of the M1s and that of the first of the M2s in the same children.

Permanent second molars

A total of 118 children had their first M2 recorded as erupting by their regular dentist during the period 1st September 1995–1st September 1996. Of these children, 112 (49 boys and 63 girls) fulfilled the inclusion criteria. During the following period, nine children left the municipality and one child was excluded from the study because of orthodontic treatment, giving a total number of 102 (46 boys and 56 girls) children at the end of the study (functional occlusion on both pairs of M2).

Calibration

Two dentists took part in this investigation. The criteria for recording the eruption stages were developed by these dentists, and, as such, the different eruption stages were found to be easily distinguishable clinically. Therefore, no calibration was performed.

Variables recorded

In practice, when the gingiva in the regions of the M1s and the M2s began to swell, the period until the

next appointment was reduced to at most 4 months. If the child at the next visit to the clinic met the inclusion criteria, the date of birth was noted. At the subsequent visits to the clinic, the actual eruption stages of M1s/M2s were recorded, and the date was noted. This procedure was followed until functional occlusion (eruption stage 3) was obtained for all four molars. During the eruption period until the teeth in question reached functional occlusion, the recall intervals varied only between 1 and 4 months in accordance with the non-operative caries treatment program the children followed (9).

Statistical analyses

Mean time and standard deviations were calculated for the eruption time of the first of the M1s or M2s for both male and female subjects. Percentage distributions were used to express (i) the variation in eruption time and (ii) to describe the duration of the eruption of M1 and M2. *t*-tests were used to test the null hypotheses that (i) the time of eruption and (ii) the duration of eruption were equal between girls and boys. The relationship between the eruption time of the first of the four M1s or M2s and the actual duration of the eruption was determined using the Spearman's rank correlation coefficient (r_s ; $\alpha = 5\%$). The relationship between the time of eruption of the first of the M1s and that of the first of the M2s, for each individual, was expressed by a regression line and the 95% confidence interval. Initially, *t*-tests were performed to test the null

hypotheses that the slopes and the constants of the equations for the regression lines for boys and girls were the same (P -values > 0.1).

Results

Permanent first molars

Figure 1(a) shows the mean time and standard deviation for the time of tooth eruption for the first of the M1s in girls (mean = 73.6 months/6.1 years; SD = 6.8 months/0.57 years). The bars illustrate the variation in the time of eruption and disclose the percentage distribution of teeth, which erupted at a particular age. The eruption time for the girls starts at 63 months (5 years and 3 months) and ends at 92 months (7 years and 8 months) (Fig. 1a).

Similar figures are shown in Fig. 1(b) for the boys. The mean time of eruption was 75.2 months (6.3 years), and the standard deviation was 8.6 months (0.72 years). The variation in the eruption time for the boys was from 62 months (5 years and 2 months) to 94 months (7 years and 10 months) (Fig. 1b). A *t*-test confirmed that there was no significant difference between girls and boys with regard to time of eruption of M1 ($P \geq 0.05$).

The duration of the eruption of first permanent molars (Fig. 2) for the girls varied from 5 to 32 months (mean = 15.4 months; SD = 7.5 months), and in the boys, it varied from 7 to 28 months (mean = 15.0 months; SD = 5.3 months; $P > 0.7$, *t*-test).

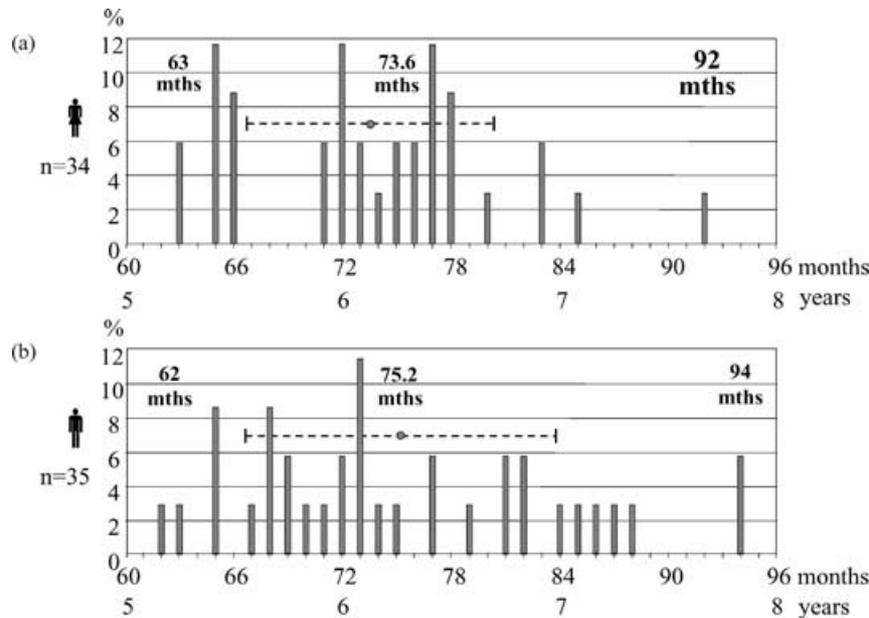


Fig. 1. Mean times, standard deviations (1 SD), and variation in the time of eruption of the first of permanent first molars for girls (a) and for boys (b).

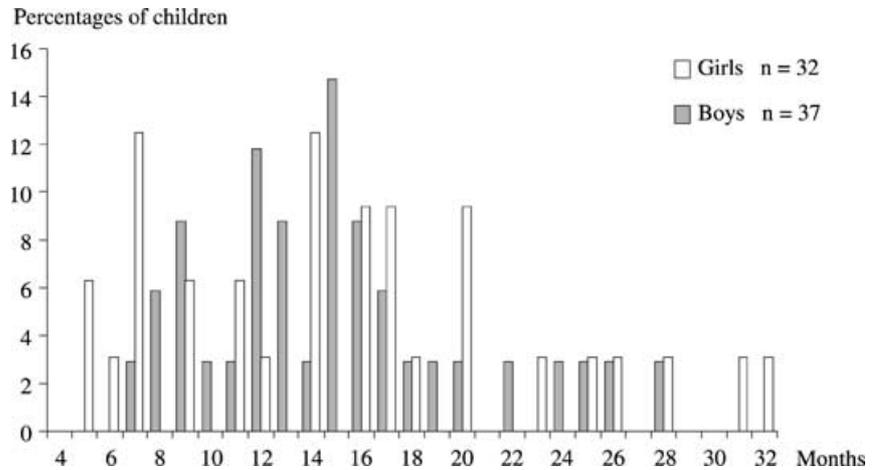


Fig. 2. The variation in time that it takes from the time of eruption to functional occlusion is established on both pairs of permanent first molars.

Further analyses disclosed that there was no significant correlation between the time of eruption of the first of the M1s and the duration of the eruption, respectively, for girls and boys (r_s : girls = 0.30 ($P > 0.05$); boys = -0.17 ($P > 0.05$)).

Permanent second molars

Figure 3(a,b) show, for girls and boys, respectively, the mean time and standard deviations for the eruption time of the first of the M2s, the variation in the time of eruption and the percentage distribution of the eruption time for M2s. The mean eruption time for the first of the M2s of girls was 136.2 months (11.3 years), and the standard deviation was 14 months (1.17 years). The eruption time of M2s of the girls varied from 107 months (8 years

and 11 months) to 172 months (14 years and 4 months).

For boys, the mean eruption time was 143.9 months (12.0 years), and the standard deviation was 13.6 months (1.13 years). The time of eruption varied from 119 months (9 years and 11 months) to 167 months (13 years and 11 months). A *t*-test showed that girls had a significantly earlier eruption of M2s than boys ($P < 0.006$).

The duration of the eruption for M2s (Fig. 4) in girls varied from 12 to 44 months (mean = 27.14 months; SD = 8.25 months); in boys, it varied from 9 to 45 months (mean = 27.85 months; SD = 10.32 months; $P > 0.7$, *t*-test).

Analyses further disclosed that there was no correlation between the time of eruption and the

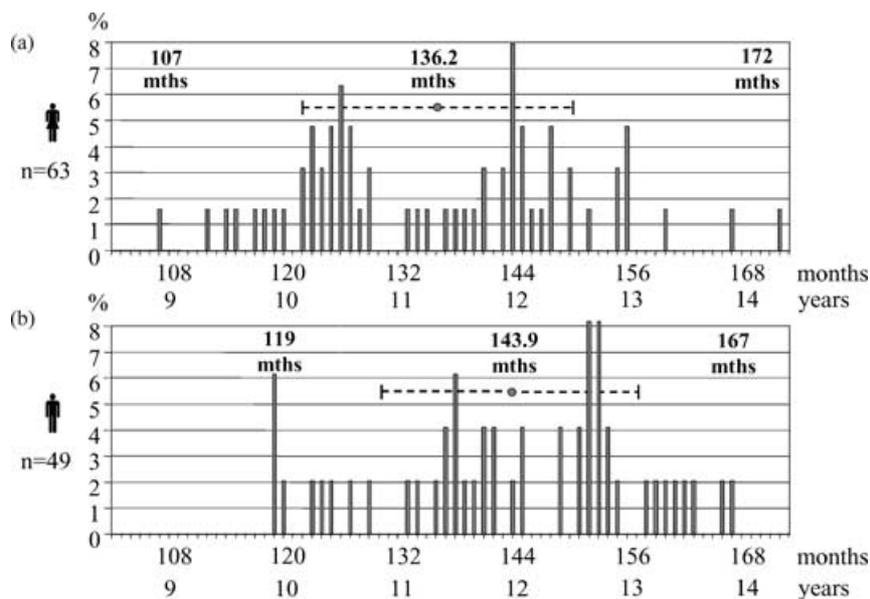


Fig. 3. Mean times, standard deviations (1 SD), and variation in the time of eruption of the first of permanent second molars for girls (a) and for boys (b).

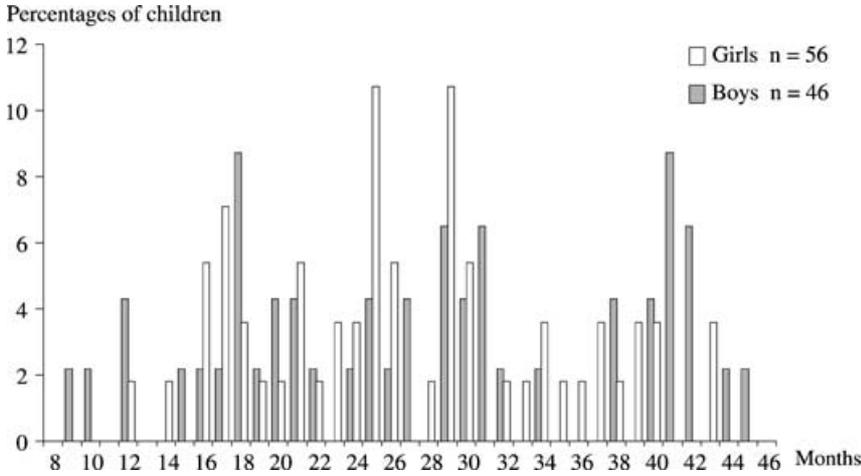


Fig. 4. The variation in time that it takes from the time of eruption to functional occlusion is established on both pairs of permanent second molars.

duration for girls or boys (r_s : girls = -0.07 ($P > 0.05$); boys = -0.003 ($P > 0.05$)).

Relationship between the time of eruption of M1s and M2s

Using follow-up data on sample 1, Fig. 5 shows a scatter diagram with respect to the time of eruption of the first of the M1s (independent variable) and the time of eruption of the first of the M2s for both boys and girls (dependent variable). The line of regression, its equation, the 95% confidence interval, and the coefficient of determination (R^2) are presented using merged data. The R^2 -value (0.68) is substantial, indicating that the line fits well to the data. Further, it appears that early eruption of M1s is associated with early eruption of M2s, and late eruption of M1s is associated with late eruption of M2s. The confidence interval covers, however, a

period of ± 16.5 months. So, if it is observed that a boy or a girl had eruption of the first of the M1s at the age of 65 months (5 years and 5 months), then it can be predicted in 95 out of 100 cases that the first of the M2s will erupt between the age of 112 and 145 months (9 years and 4 months and 12 years and 1 month).

Discussion

The present study focuses on the variation in the eruption time of permanent molar teeth and the variation in the duration of eruption of these teeth. Some definitions in this respect are therefore considered relevant.

According to Carr (13) and Sato (5), tooth eruption can be divided into embryological tooth eruption

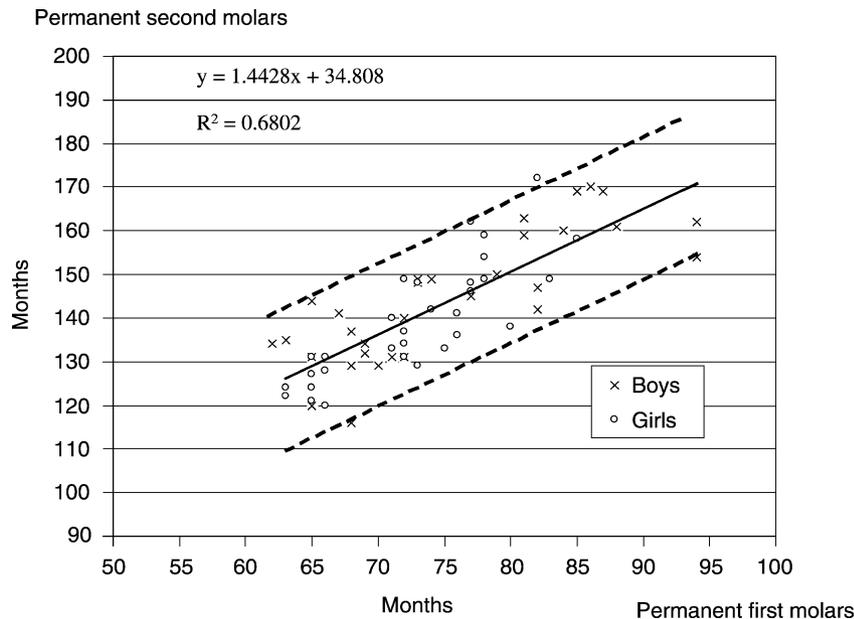


Fig. 5. The relationship between the time of eruption of the first of the permanent first molars and that of the first of the permanent second molars (girls and boys together). The 95% confidence interval is presented by the dashed lines.

and clinical eruption. Clinical tooth eruption is considered in this investigation, and refers to the appearance of some part of the tooth in question above the gingival surface. This definition was adopted in this investigation, but only for the first of the four M1s or for the first of the four M2s, which became visible in the oral cavity (eruption stage 1). Also, according to Sato (5), the eruption of molar teeth is completed when the edges of the occlusal surfaces are free of the gingiva. This means that the completion of the eruption of molar teeth does not necessarily include the establishment of functional occlusion. However, the present study was undertaken with a caries perspective in mind, and it is known that erupting molar teeth accumulate significantly more plaque than molar teeth in full occlusion (8). This influences the caries progression rate, and it was therefore found necessary to include stage 3 (functional occlusion) in the classification of the time when molar teeth complete their eruption period.

The present study was carried out as an integral part of the normal dental treatment provided for the children in a Public Dental Health Service. When the gingiva in the region of the permanent first or second molar teeth began to swell, the period until the next appointment was reduced to at most 4 months in accordance with the non-operative caries treatment program (NOCTP) followed in the dental service (9). During the eruption period until the teeth in question reached functional occlusion, the intervals were no longer than 4 months, also in accordance with the NOCTP. Thus, there is an uncertainty of a maximum of 4 months only in the assessment of the eruption time. The same applies to the assessment of the duration of the eruption.

Very recently, Parner et al. (2) studied the time trends in the eruption of permanent teeth in Danish children during a 14-year period. They used the system for reporting dental conditions among Danish children in the Child Dental Health Service System. It was a large-scale study involving more than 30,000 children in the cohorts. Of interests for the present study was that they found the distribution of the eruption time for the individual tooth types to be close to normal. This allows for the parametric statistical *t*-test analysis to be performed, and the *t*-test was carried out in the present study. Furthermore, Parner et al. (2) found an increase in mean eruption time corresponding to only 1.5–2.6 days per year during a 14-year period. Thus, their findings concerning eruption time of perma-

nent teeth did not differ from that of Helm and Seidler performed in 1974 (1). Concerning the time of eruption of M1 or M2 and, in particular, the variation in the time of eruption among individuals, our results are in agreement with those obtained by Helm and Seidler (1) and by Parner et al. (2). Detailed analyses disclosed, in fact, that the means for the time of tooth eruption of the first of the M1s and M2s in our study differed with a maximum 1.5 months from the means presented by Parner et al. (2). The fact that girls have a tendency for an earlier eruption time than boys was a common feature in all three studies. That our small-scale data concerning the time of tooth eruption mirror data from big-scale examinations are very important for the validity of the other findings in this study. Thus, it seems logical that if our data are representative concerning the time of tooth eruption, they should also be representative concerning, for example, the duration of the eruption period.

The most important finding in this study was that there was a great variation in the duration of the period from the time of eruption until functional occlusion was established. For M1 and M2, this period could vary from 5 to 32 months and from 9 to 45 months, respectively. Furthermore, from the time of eruption of the first of M1 or the first of M2, it was not possible to predict whether the duration of the eruption would be short or long.

We also found that the period from the eruption of the first of the four molars to the time that functional occlusion was established on both pairs of molars was much longer for M2 than for M1. This conflicts with data published by Sato (5), but the most obvious explanation for this difference is the difference in defining when a molar is considered fully erupted.

As a result of the longitudinal design in this study, it was possible for us to examine the relationship between the eruption time of the first of the M1s and that of the first of the M2s. The statistical analyses disclosed that we could merge the data from girls and boys. Our data confirmed the clinical experience that early/late eruption of M1 is followed by early/late eruption of M2s. In spite of this association, precise prediction of the time of eruption of M2s based on the knowledge about eruption time of M1s could not be obtained. On a population basis, the variation was ± 16.5 months approximately.

A lesson to be learned from this study is that a tremendous variation exists in the time of eruption and in the duration of the eruption of permanent molar teeth. Further, it is not possible to make a

clinically relevant prediction of the eruption time of second permanent molars based on the knowledge about the time of eruption of permanent first molars. These conditions underline why measures to control occlusal caries development on permanent molars – which are the most caries-prone surfaces in the dentition of children and adolescents – should be organized on an individual basis.

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