Dental Development Dental Age and Tooth Counts

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A longitudinal study of the timing of tooth emergence in Swedish children from birth to 18 years

KEY WORDS: • DENTAL AGE • EMERGENCE • ERUPTION • TOOTH, DECIDUOUS • TOOTH, PERMANENT

Frequent examination is essential to determining the time of emergence of individual teeth. Variations in the sequence of tooth emergence in both dentitions adds to the difficulties of establishing a dental age based on such data.

A count of the total number of teeth present in the mouth is one useful means for evaluating dental development (FILIPSSON 1975, MOORREES AND KENT 1978), but reference values of age at the emergence of various numbers of deciduous and permanent teeth in a well-defined representative sample are not available.

The objectives of this study are:

- to determine the age at emergence of the deciduous and the first 29 permanent teeth
- to establish and test the validity of a dental age based on counts of the deciduous and permanent teeth
- to determine mean scores and standard deviations of dental development on the basis of *tooth emergence curves*.

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— Methods and Material —

The reference values for tooth emergence were based on data collected as part of an interdisciplinary prospective study of growth and development (KARLBERG, ET AL. 1976). The subjects were 212 randomly selected urban Swedish children (90 girls and 122 boys) born between 1955 and 1958.

The subjects were examined at 1, 3, 6, 9, 12 and 18 months of age, and then annually from 2 years to 18 years. At 18 years of age, 76% of the original children were examined (HÄGG 1980).

Tooth emergence was determined by direct inspection. A tooth was considered to have emerged if any part of the crown was visible. Supplementary data from the Swedish National Dental Service was used to systematically adjust for marked deviations from the symmetric pattern of tooth emergence in the permanent dentition before the statistical analysis (HÄGG 1980).

Statistical methods

Mean age at emergence of any specific tooth was calculated by probit analysis (FINNEY 1971). In these analyses maximum information was extracted from the sample according to principles described earlier (TARANGER 1976) to give an unbiased estimate of the mean value (SWAN 1969).

Subjects with aplasia of one or more teeth (0.5% of the deciduous, 8.4% of the 28 permanent teeth) were given an "emergence interval" for the missing tooth/teeth, based on the general pattern of emergence in that particular subject.

The prevalence of third molar aplasia was not evaluated.

Dental Age Assessed by Tooth Counts

Dental age values were calculated for each number of emerged deciduous and permanent teeth (Table 1). These values were based on the assumption that an individual subject with a certain number of emerged teeth is, from a maturation point of view, midway between the ages at emergence of the previous tooth and the succeeding tooth.

The horizontal lines in Figs. 1-6 represent such levels of dental maturity. Means and standard deviations for the emergence of the various numbers of teeth were combined graphically as *tooth emergence curves*. The intersection of the curves with the horizontal lines in the figures indicates the dental development in terms of mean age and ±1 S.D. and ±2 S.D. for each number of emerged teeth.

Validity of Dental Age Assessed by Tooth Counts

The validity of the values for dental age established in this study (Table 1) was evaluated by counting the number of emerged permanent teeth as estimated from orthopantomographs of another sample of 200 Swedish children between 6.5YR and 12.5YR(HÄGG AND MATSSON 1985). These subjects were born between 1964 and 1973.

The 192 subjects (98 girls and 94 boys) who had 1 to 27 emerged permanent teeth were included in the statistical analysis. Dental age of individual subjects was determined on the basis of the mean age corresponding to the number of emerged permanent teeth as shown in Table 1. The difference between that dental age and actual chronological age was then calculated for each subject.

— Results —

On average, the first deciduous tooth emerged at about 7 months, and the last at 29 months of age (Table 2). Sexual dimorphism was not noted in the mean eruption times of the deciduous teeth.

After an average interval of 3.3YR in girls and 3.6YR in boys, the first permanent teeth emerged at 5.7YR and 6.0YR, respectively (Table 3).

After an average additional interval of 6.8YR in girls and 7.0YR in boys, the 28th permanent tooth emerged at 12.5YR in the girls and at 13.0YR in the boys.

There was then an average interval of about 6 years before the emergence of the 29th permanent tooth in either sex.

Deciduous Dentition

Average sex differences for emergence of specific teeth were less than one month, which was not statistically significant (Table 2 and Fig. 1).

Table 1

Dental age vs. Number of Emerged Teeth

Number of Emerged Teeth	**Deciduous** Dental Age in MONTHS		**Permanent** Dental Age in YEARS	
	Girls	Boys	Girls	Boys
1	7.72	7.55	5.76	6.04
2	8.73	8.63	5.92	6.22
3	9.76	9.60	6.10	6.32
4	10.41	10.19	6.27	6.52
5	11.15	10.76	6.42	6.66
6	12.16	11.75	6.54	6.93
7	13.13	13.01	6.73	7.18
8	14.44	14.34	6.90	7.46
9	15.72	15.26	7.12	7.58
10	16.11	15.28	7.50	7.81
11	16.35	16.20	7.89	8.29
12	17.75	17.26	8.59	9.24
13	19.25	18.47	9.33	10.27
14	19.78	19.19	9.65	10.50
15	20.45	19.74	9.93	10.73
16	23.17	23.05	10.13	10.91
17	25.77	26.48	10.35	11.05
18	26.87	27.37	10.50	11.20
19	28.19	28.28	10.61	11.36
20			10.73	11.48
21			10.86	11.60
22			11.05	11.72
23			11.27	11.89
24			11.54	12.13
25			11.79	12.37
26			12.08	12.60
27			12.40	12.86

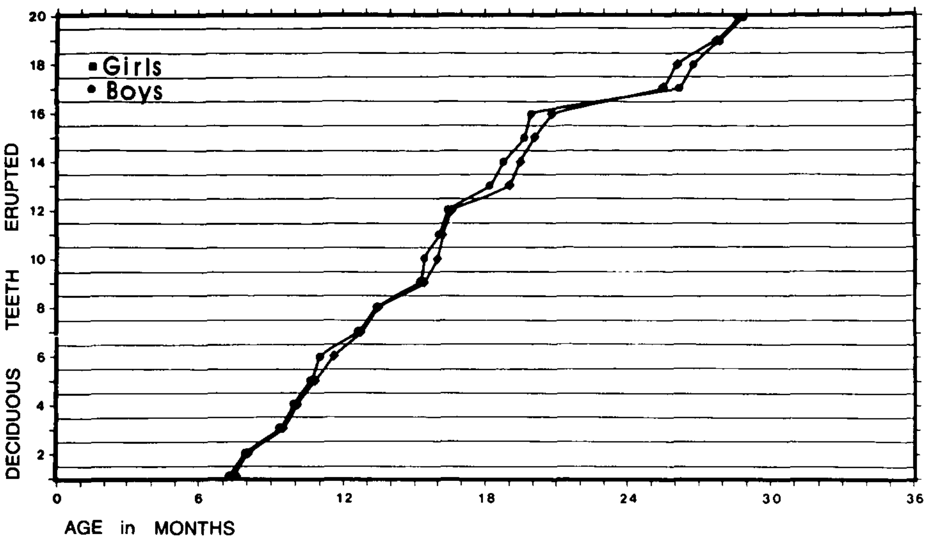

Fig. 1 **Mean emergence curves for the deciduous dentition**

Table 2

Age at Emergence of Successive Deciduous Teeth
(months)

Teeth Emerged	Girls Mean	Girls S.D.	Girls x^2	Boys Mean	Boys S.D.	Boys x^2
1	7.46	2.02	2.24	7.27	2.01	4.70
2	7.98	2.00	0.81	7.82	2.26	4.95
3	9.47	1.67	0.24	9.42	2.19	▿183.99
4	10.04	1.99	▿370.63	9.78	2.34	▿154.13
5	10.78	2.13	▿33.73	10.60	2.72	▿22.99
6	11.52	2.67	5.30	10.91	2.66	▿19.81
7	12.79	2.54	0.43	12.58	2.62	4.57
8	13.46	2.34	1.92	13.44	2.76	1.99
9	15.42	1.88	0.03	15.23	2.32	▿103.35
10	16.01	2.14	▿126.18	15.28	2.29	▿119.88
11	16.21	2.21	▿52.82	16.07	2.64	▿58.35
12	16.48	2.12	▿60.67	16.33	2.66	▿39.25
13	19.02	2.97	1.44	18.19	3.11	4.55
14	19.47	3.24	1.68	18.74	3.05	0.79
15	20.09	3.19	0.75	19.63	3.04	1.14
16	20.81	3.24	0.39	19.85	3.13	1.14
17	25.52	3.61	0.32	26.19	4.30	1.25
18	26.02	3.35	0.27	26.76	4.12	0.91
19	27.72	3.57	0.35	27.85	4.15	0.01
20	28.65	4.01	0.43	28.70	4.44	0.02

Table 3

Age at Emergence of Successive Permanent Teeth
(years)

Teeth Emerged	Girls Mean	Girls S.D.	Girls x^2	Boys Mean	Boys S.D.	Boys x^2
1	5.70	0.52	0.83	5.97	0.51	0.42
2	5.82	0.61	0.30	6.11	0.57	0.07
3	6.02	0.57	2.67	6.32	0.63	▿16.88
4	6.16	0.61	2.37	6.42	0.59	▿7.45
5	6.37	0.57	1.57	6.61	0.67	5.98
6	6.47	0.53	0.61	6.72	0.71	1.42
7	6.70	0.58	0.17	7.13	0.70	6.32
8	6.76	0.56	0.15	7.21	0.66	▿7.80
9	7.04	0.63	0.23	7.51	0.70	3.60
10	7.20	0.74	0.47	7.65	0.77	7.25
11	7.79	0.70	0.93	8.16	0.83	5.70
12	7.98	0.70	0.51	8.42	0.87	0.80
13	9.20	0.97	5.92	10.05	0.93	0.97
14	9.45	1.04	4.74	10.37	0.96	▿10.46
15	9.84	1.11	4.46	10.63	0.96	6.18
16	10.02	1.05	3.81	10.82	0.97	5.17
17	10.24	1.07	2.94	10.99	1.00	2.75
18	10.45	1.12	4.31	11.11	1.04	3.06
19	10.55	1.13	2.62	11.29	1.04	3.53
20	10.67	1.15	6.33	11.41	1.03	4.70
21	10.78	1.13	4.64	11.55	0.97	5.28
22	10.93	1.14	3.17	11.66	0.97	6.03
23	11.17	1.18	2.32	11.80	0.99	3.88
24	11.37	1.21	8.70	11.97	0.98	1.48
25	11.71	1.13	6.09	12.29	1.01	7.87
26	11.87	1.14	4.60	12.45	1.01	4.35
27	12.29	1.21	5.23	12.74	0.96	3.02
28	12.50	1.31	5.98	12.98	1.06	3.34
29	18.88	1.44	1.31	19.13	1.69	1.51

▿ The value of x is statistically sigificant at $p<0.05$

All sex differences except for the 29th tooth are statistically significant at $p<0.05$

Nevertheless, there *was* a consistent sex-specific difference in the *pattern* of emergence of the deciduous dentition. The 1st to 16th deciduous teeth tended to emerge earlier in boys, and the 17th to 20th deciduous teeth tended to emerge earlier in girls (Table 2 and Fig. 1).

These differences are blurred by the wider distribution of the emergence of the 17th to 20th teeth in boys, in that the early boys were ahead of the early girls (Table 2 and Figs. 2 and 3).

The 95% confidence limits ($\cong \pm 2$ S.D.) for the emergence of the deciduous teeth varied from about ±4MO to ±9MO.

The mean interval between emergence of succeeding deciduous teeth was less than 2.5MO, except between the 16th and 17th, where the mean interval was 4.7MO in girls and 6.3MO in boys (Table 2).

Permanent Dentition

All permanent teeth emerged 3MO to 11MO earlier in girls than in boys on average (Table 3 and Fig. 4). The sex difference was statistically significant for all teeth except the 29th to appear.

Individual variation was more apparent in the eruption of the second and third molars. Even though average eruption of the 28th tooth was earlier in girls, late-maturing girls were as late as late-maturing boys in the emergence of the 28th tooth (Table 3 and Figs. 5 and 6). According to the mean age at emergence of the 29th permanent tooth, girls were still ahead of boys, but the age distribution in boys was so much wider that the early boys were ahead of the early girls.

The 95% confidence limits for emergence of specific teeth in the 28-tooth permanent dentition varied from about ±12MO to ±25MO in boys, and from ±12MO to ±32MO in girls.

Confidence limits for the 29th tooth were ±2.9YR in girls and ±3.4YR in boys.

The mean interval between emergence of succeeding permanent teeth varied between 1MO and 7MO, except for the interval between the 12th and 13th permanent teeth, which was 15MO in girls and 20MO in boys.

Validity of Dental Age Assessed by Tooth Counts

The mean difference between chronological age and dental age based on counts of the first 28 permanent teeth was −1.1MO in girls and +0.7MO in boys. In both sexes the mean difference between dental and chronological age was positive in the younger group (7YR–9.5YR) and negative in the older group. The 95%

Table 4

Mean differences ($\bar{d}$) and standard deviations of difference (s_d) between dental age and chronological age in 98 girls and 94 boys from 7 to 12 years

(Months)

	7–12 years		7–9.5 years			9.5–12 years		
	n	$\bar{d}$	n	$\bar{d}$	s_d	n	$\bar{d}$	s_d
Girls	98	−1.1	50	1.2	10.8	48	−3.4	11.0
Boys	94	0.7	50	4.8	9.6	44	−3.9	14.2

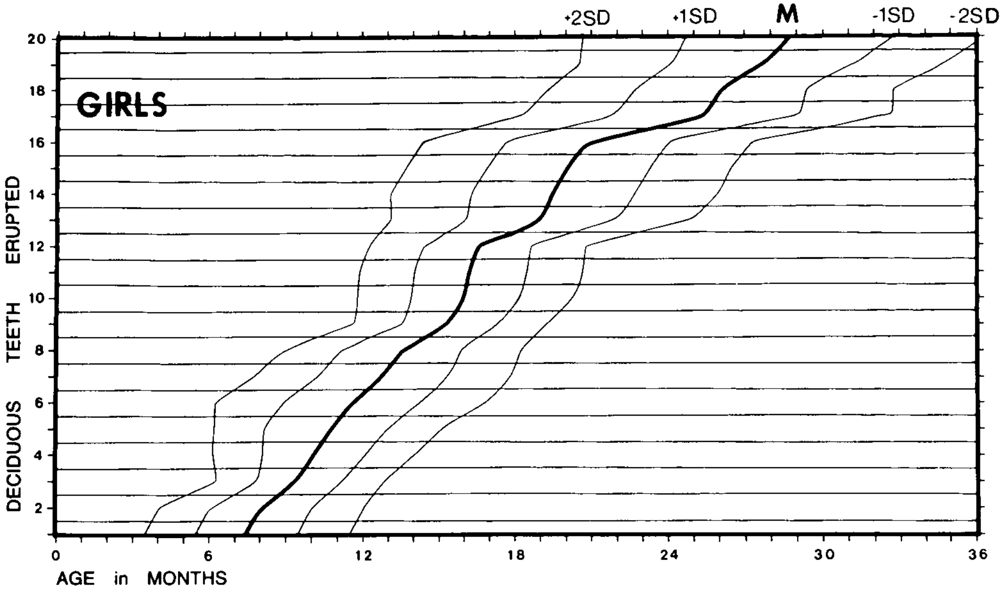

Fig. 2 Emergence of deciduous dentition in girls, showing mean ages and ±1 and ±2 standard deviations

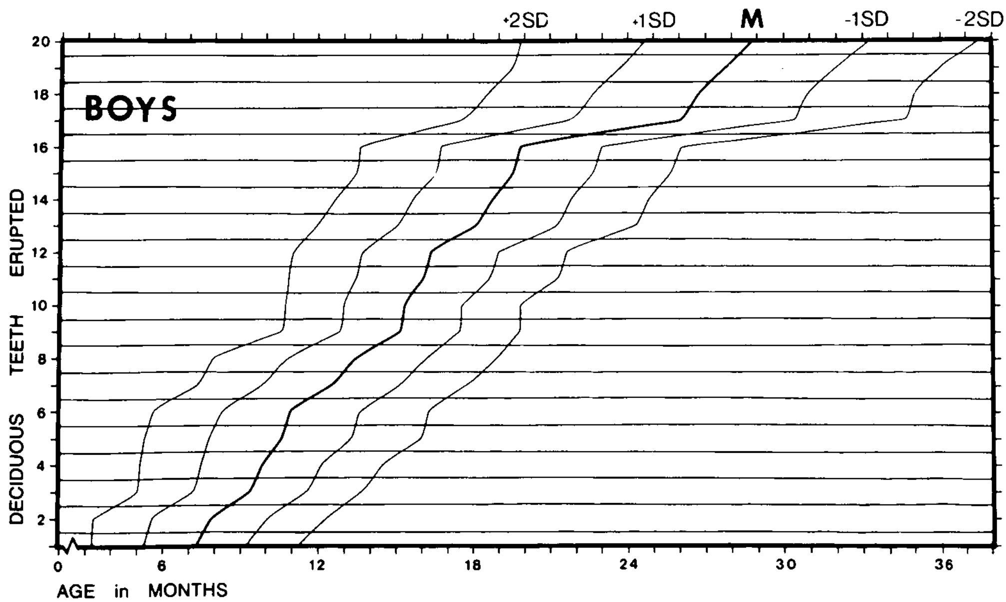

Fig. 3 Emergence of deciduous dentition in boys, showing mean ages and ±1 and ±2 standard deviations

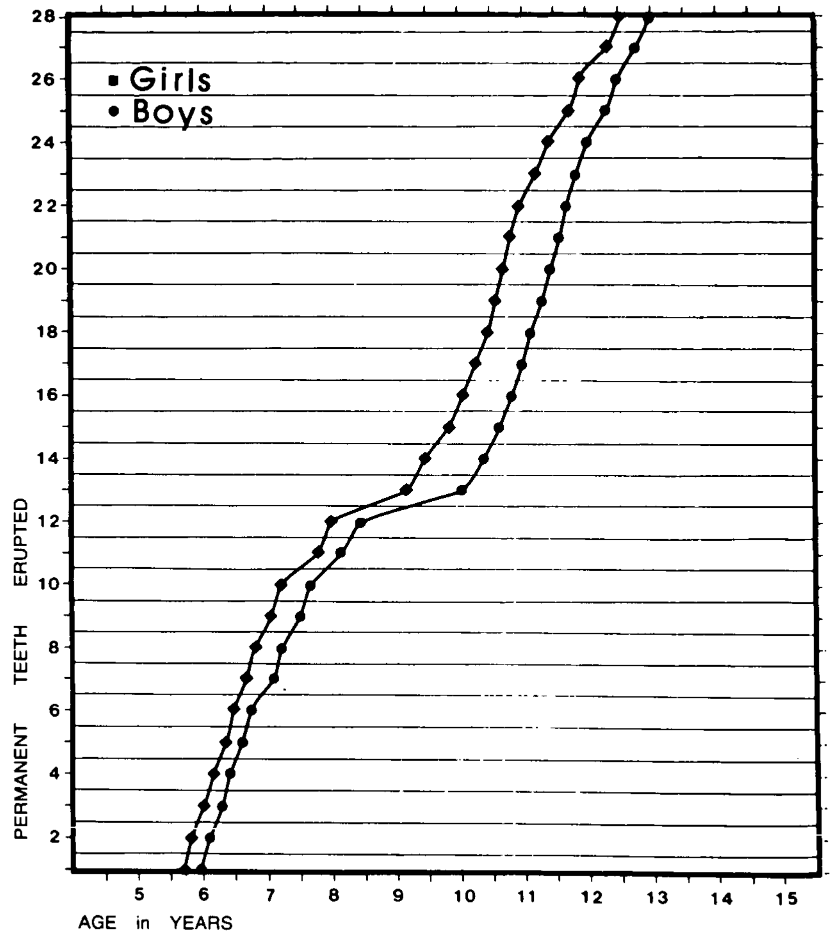

Fig. 4 Mean emergence curves for the permanent dentition

confidence limits were were ±22MO in girls and ±20MO–28MO in boys (Table 4).

The wide distribution of dental development in relation to chronological age in this sample is evident in Fig. 7. At about 8.5YR chronlogical age in the girls, the dental age ranged from 7.1YR to 10.7YR (Table 1).

Dental development can be expressed as the difference between dental age and chronological age. This indicates dental development in the girls ranging from 1.4YR retardation to 2.2YR acceleration. This same information could also be presented in terms of standard deviation scores, which varied from −2.1 to +1.7 (Fig. 7).

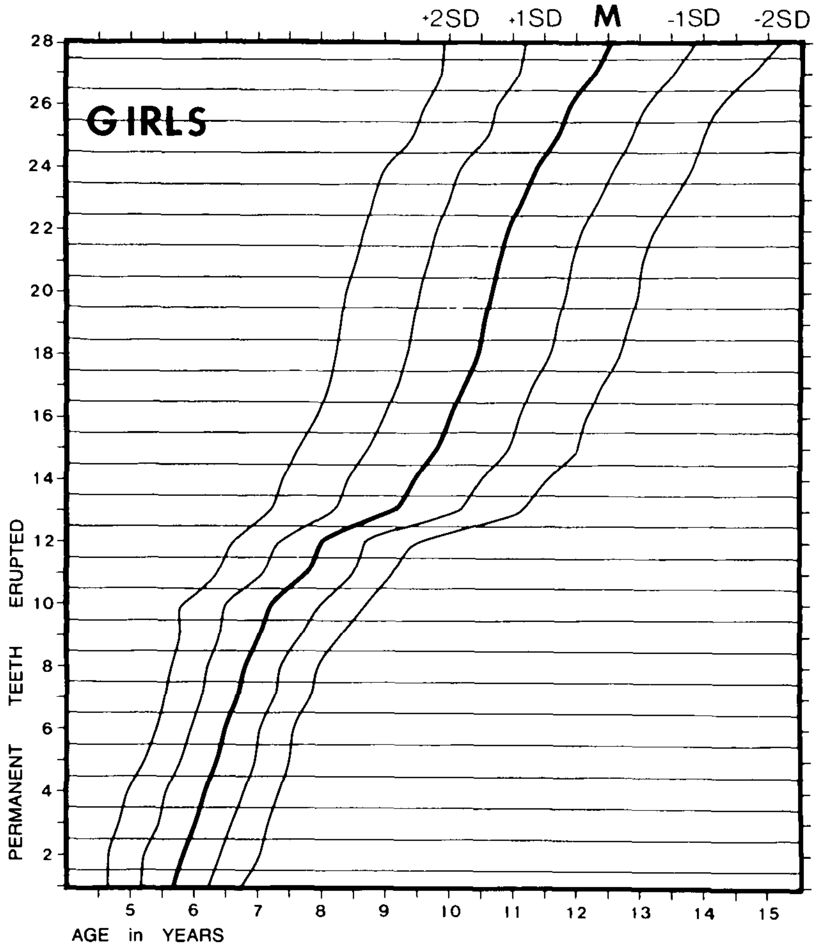

Fig. 5 **Permanent dentition emergence in girls, showing mean ages and ±1 and ±2 standard deviations**

— Discussion —

The emergence data on the deciduous and permanent teeth published in this study are based on a longitudinal prospective follow-up of a relatively large representative sample of urban Swedish children. Regular examinations covered the entire period from before emergence of any deciduous tooth to the emergence of all teeth with the possible exception of third molars. The low number of drop-outs and missing examinations was allowed for in the statistical analysis (Hägg 1980 and Karlberg, et al.1976).

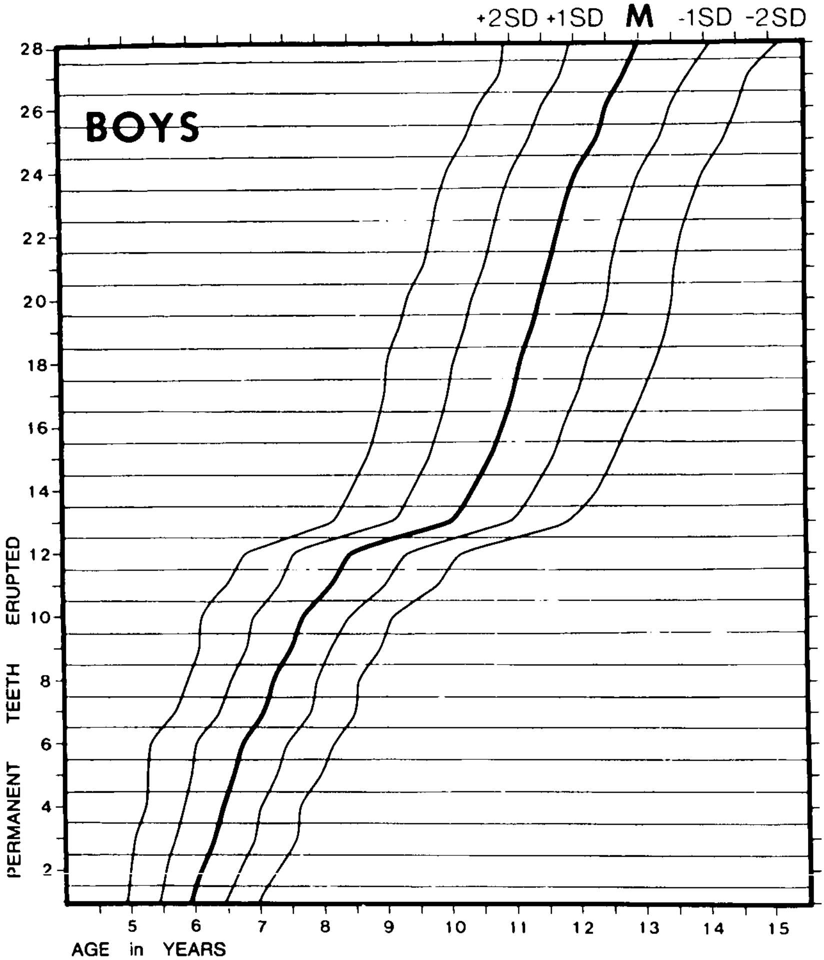

Fig. 6 Permanent dentition emergence in boys, showing mean ages and ±1 and ±2 standard deviations

Deciduous Dentition

Other available emergence data for the deciduous teeth in Swedish children are those of Lysell, Magnusson and Thilander (1962), which include only the 1st and 20th deciduous teeth. With allowance for the observation interval, no significant difference was found between the results.

Permanent Dentition

The average emergence age for any specific permanent tooth of the first 28 was in agreement with the American study of Moorrees and Kent (1978), but at variance with the previous Swedish study by Filipsson (1975). The first 12 teeth were found by Filipsson to emerge consis-

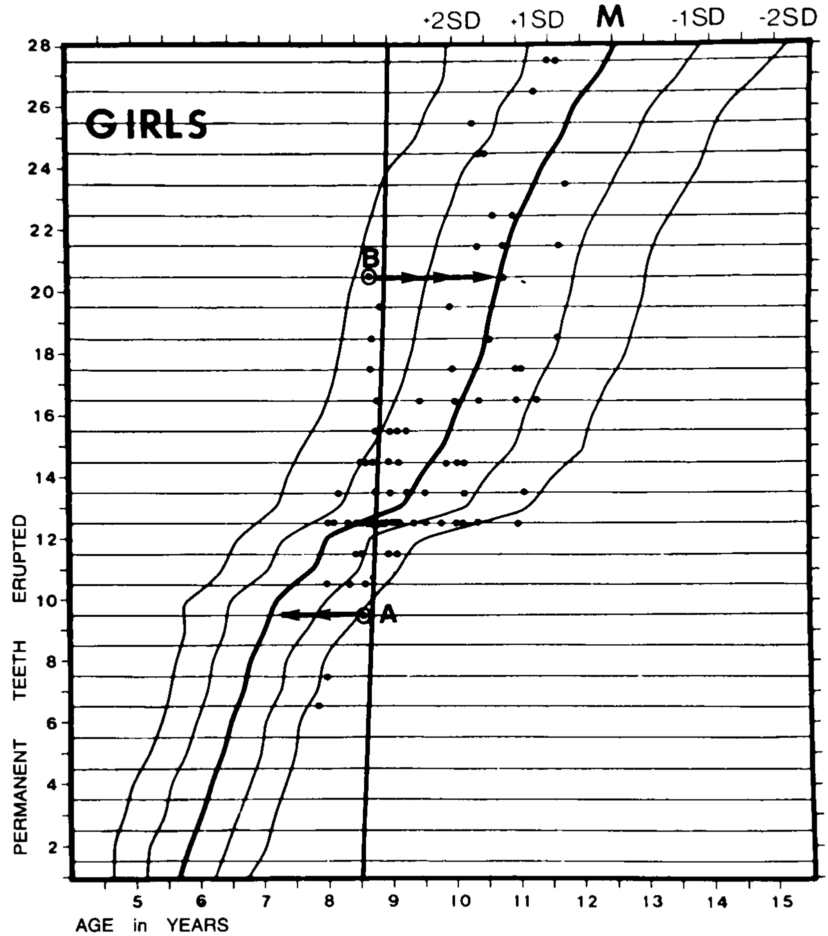

Fig. 7 Tooth counts in 98 girls aged 7 to 12 years. The number of emerged teeth in girls about 8.5 years old (vertical line) ranged from 9 to 20.

One girl (A), age 8.4 years, had 9 emerged teeth, corresponding to a dental age of 7.1 years (Table 3) or a lag of 1.4 years (−2.2 S.D.) in dental development.

Another girl (B), age 8.3 years, had 20 emerged teeth, corresponding to a dental age of 10.7 years or dental development accelerated 2.3 years (+1.7 S.D.).

tently later, and the late-emerging teeth (13-28) consistently earlier than in this study.

Filipsson based the norms for permanent tooth emergence on two different samples (DAHLBERG AND MAUNSBACH 1948, AND LYSELL, MAGNUSSON AND THILANDER 1969), and two different methodological approaches. The norms for the early-emerging teeth were based on tooth counts without reference to the order of emergence of the individual teeth, and the norms for the late-emerging teeth were based on the order of the median ages of emergence of individual teeth.

With allowance for the observation interval in the study by Lysell et al., the data on the early-emerging teeth published by Filipsson does agree well with the results of this study and that of Moorrees and Kent.

Filipsson reported very close agreement between the mean ages for each of the early-emerging teeth obtained by the two different methods of analysis of the data from Lysell et al. However, the reference data on the late-emerging teeth was obtained from Dahlberg and Maunsbach, and it is evident from their figures that there are larger differences between the means obtained by the two different methods, especially for the first and last teeth to emerge.

Premature loss of deciduous molars is generally expected to cause accelerated emergence of the permanent successors and other teeth in the posterior segment (RÖNNERMAN, 1977). A similar effect is caused by early extraction of first permanent molars. Accordingly, the earlier appearance of the late-emerging teeth in the study published by Filipsson could be due to a general acceleration of posterior tooth emergence caused by the comparatively high incidence of caries in the Dahlberg and Maunsbach sample born in the thirties.

Validity of Dental Age and Dental Development Assessments

The pilot test of dental age assessed by tooth counts in 8.5YR-old girls showed a satisfactory validity for the overall population. However, the 95% confidence limits must be considered in assessing specific individuals. The 95% confidence limits can be wider than the distribution of the attainment of emergence of a specific number of teeth because the duration of such a maturity indicator must also be taken into account.

The time period during which a given number of teeth are present can be quite brief. Indicators with brief duration and narrow distribution are more informative than those with long duration and wide distribution. Estimations of age based on the deciduous dentition are therefore more precise than later estimations based on the permanent dentition.

The reliability of the present method was not investigated statistically, but it appears to be higher than methods based on tooth formation (HÄGG AND MATSSON 1985).

The wide distribution of dental developmental status in 8.5YR-old girls in the pilot study is evident in Fig. 7.

Individual dental development can be expressed in absolute values or in standard deviation scores. Standard deviation scores have the advantage of relating dental development to a frequency distribution characterizing the normative sample (MOORREES, FANNING AND HUNT 1963). A lag of 1.4YR from the mean age for the presence of 9 emerged permanent teeth in 8.5YR-old girls (Fig. 7) represents a −2.1 S.D. level. This indicates a retardation in dental development more marked than the acceleration of 2.2YR from the mean age for 20 emerged permanent teeth, which represents only +1.7 S.D.

Sex Differences in Dental Development

In the deciduous dentition the teeth consistently emerged slightly earlier in boys than in girls until the 17th tooth (Table 2 and Fig. 1), but the difference was not statistically significant.

Findings on sex difference in previous studies of deciduous tooth emergence are not consistent. Some investigators have found a pattern of earlier emergence of the deciduous dentition in boys, and others have reported no sex difference (DEMIRJIAN 1978).

From the 17th deciduous tooth to the 29th permanent tooth, girls were consistently ahead of boys on average (Tables 2 and 3 and Figures 1 and 4). In the permanent dentition there was an almost steady increase in the sex difference from the 1st to the 14th teeth, followed by a decrease in the difference from the 15th to the 29th.

The sex differences for the 1st and 29th tooth were about the same.

Sex differences in emergence of the 28 permanent teeth were in agreement with those reported by MOORREES AND KENT (1978). Girls in this study were still ahead of boys at the emergence of the first emerging third molar (29th tooth).

However, the emergence and late stages of formation of the mandibular third molar have been found to occur earlier in boys than in girls (LEVESQUE, ET AL 1981). Boys appear to be ahead of girls at the beginning and the end of tooth emergence.

Hormones

The effect of hormones on tooth development is largely unknown (DEMIRJIAN 1978), but it is tempting to hypothesize that such factors may influence the sex differences in dental development.

Exogenous administration of testosterone to male primates markedly accelerated the emergence of the permanent canines (WAGENEN AND HURME 1950). In human studies of exogenous administration of testosterone skeletal maturation has been markedly accelerated, while the effect of estrogen is less marked (ZACHMANN, ET AL. 1975).

Testosterone levels in the human male vary through different periods of prenatal and postnatal development (SIZONENKO AND AUBERT 1978, WINTHER 1978). In some periods the level of testosterone is higher in males, while in intervening periods it is almost as low as in females.

High testosterone levels have been reported in males during the 10th–20th weeks of gestation, the first months of postnatal life, and in adolescence (SIZONENKO AND AUBERT 1978, AND WINTHER 1978). These periods immediately precede or coincide with the periods in which dental development in males is more advanced than in females (BURDI, GARN AND MILLER 1970, DEMIRJIAN AND LEVESQUE 1980, KUHNS AND POZNANKI 1980, LEVESQUE, DEMIRJIAN AND TANGUAY 1981, MOORREES, FANNING AND HUNT 1963).

The largest sex difference observed in this study was in the emergence of the 13th and 14th permanent teeth (Table 3). The emergence of these teeth is preceded by a long period with low levels of testosterone in boys. This is followed by a consistent increase in testosterone levels and concurrent decrease in the sex difference in permanent tooth emergence (Table 3).

The most marked increase in testosterone level occurs after the emergence of the 28-tooth permanent dentition, when it could affect the development of the third molars. LEVESQUE, DEMIRJIAN AND TANGUAY (1981) found that the emergence and late stages of formation of the mandibular third molar occurred earlier in boys than in girls, and in this study the early boys were ahead of the early girls in the emergence of The 29th permanent tooth.

A similar pattern of sex difference can be observed in skeletal development. In the early prenatal period male fetuses are skeletally advanced (GARN, ET AL. 1974). In the perinatal period there is no sex difference in skeletal development (TARANGER, ET AL. 1976). In late adolescence the sex difference in skeletal development has been found to decrease (HÄGG AND TARANGER 1983).

— Summary —

Emergence data on the 20 deciduous teeth and the first 29 permanent teeth were collected from 212 randomly selected urban Swedish children who were followed from birth to 18 years of age.

The sex difference in the emergence of the deciduous teeth is less than one month, which is not statistically significant.

Boys are consistently ahead of girls until the 17th deciduous tooth. From the 17th deciduous tooth on through most of the permanent dentition, girls are consistently ahead of boys. In the permanent dentition the sex difference ranges from 3MO to 11MO; these differences are statistically significant except for the 29th tooth.

Reference data on dental age based on counts of 1-19 deciduous and 1-27 permanent teeth are tabulated and tooth emergence curves constructed. The tooth emergence curves can be used to express individual dental development in terms of standard deviation scores.

Validity of dental age assessed by counts of permanent teeth is evaluated by a cross-sectional comparison with another sample of Swedish boys and girls. The mean difference between estimated age and chronological age is about one month in either sex.

Precision of an individual estimate of dental development in terms of 95% confidence level ($\cong \pm 2$ S.D.) varies from about ± 4 months in the deciduous dentition to ± 3 years in the permanent dentition.

Assessment of dental development and dental age by means of tooth counts is a convenient and simple method, although it can only be applied at ages when emergence can be expected. It is especially useful in cross-sectional evaluations, as no serial data are required. In populations with a low incidence of caries the impact of such disturbing factors on emergence is correspondingly low, further increasing the validity of assessments of dental development based on tooth emergence.

This study was supported by grants from the faculty of Odontology, University of Lund (Project No. 207998), and the Faculty of Medicine, University of Göteborg (Project No. 305894), Sweden.

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