Emergence of permanent teeth and dental age in a series of Finns

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The emergence of permanent teeth was studied in 187 Finnish children who had longitudinal records of the emergence of all permanent teeth except third molars. Exact emergence dates were known for about one third of the teeth. Emergence ages of the remaining teeth were based on their presence and absence at clinical examinations. We calculated ages at clinical eruption of permanent teeth and tooth counts at half-year intervals. Ages corresponding to counts of permanent teeth from 1 to 27 are also given. The schedules presented, which show means, standard deviations, and percentage distributions, are expected to serve as useful references in clinical dentistry, pediatrics, forensics, and research. The mandibular central incisor emerged before the first molar of the same jaw in 68% of the children. A change in the emergence order of these teeth in Finns seems to have occurred in the 1960s. A visual comparison of dental maturity curves based on tooth counts with curves based on tooth mineralization in a previous Finnish radiographic study showed that the mean curves had roughly the same form, whereas the forms of standard deviation curves differed distinctly. It appears that the two methods to assess dental maturity are not interchangeable in practice. Tooth counts can be used in maturity estimations up to about 13 years of age, whereas the radiographic method works best to about 11 years. □ *Dental maturity; tooth count; tooth development; tooth eruption*

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Knowledge of the timing of emergence of specific teeth and normal variations is needed in clinical pedodontics and orthodontics, to make it possible to check whether the emergence of teeth in an individual child is within normal limits. There may also be a need to estimate the stage of development of the child's dentition as a whole in relation to that of normal children of the same age. Two types of methods are useful to estimate dental maturity: radiographic methods based on tooth mineralization (1) and clinical counting of emerged teeth (2, 3). Mineralization of a tooth is a long continuous process, whereas emergence is an event with a very short duration. Tooth counts serve well as a measure of maturity only when teeth are actively emerging, in the permanent dentition during the first and second transitional phases. Whereas methods based on mineralization stages can be used over a wider age range, the method of counting the number of clinically erupted teeth is more precise (4, 5) and requires no special equipment. These two methods have rarely been compared with each other (4–6).

Tooth counts in a normal population are used as references for estimations of a child's dental age. The difference between the child's chronologic age and the population average corresponding to the child's tooth count shows how much his/her dental age, usually calculated in years, is advanced or delayed. Standard deviations and percentage distributions of population averages make it possible to check the child's dental age in relation to normal variation. If a child's chronologic age is not known, average ages corresponding to tooth counts in a population can serve as a tool in estimations of age, and standard deviations and percentage distributions in the normal population show the confidence limits of these age estimations. Whether it is a question of emergence ages of teeth, dental maturity, or estimations of chronologic age, normal reference values should derive from healthy children preferably representing the same population as the individual observed (7).

Several cross-sectional studies dealing with the emergence of specific permanent teeth in Finnish child groups were published in the 20th century (8–14). Most studies give mean or median values, and one of them also shows standard deviations (13). The only study of tooth counts (15) represents a period of poor dental health (16). Poor dental health of deciduous teeth may indirectly affect emergence ages of some permanent teeth (17, 18), and there is a need for data on average values and variations in emergence ages and counts of permanent teeth in children with healthy dentitions.

The aim of the present longitudinal study was to provide reference values showing normal variation in the timing of emergence of specific permanent tooth pairs and in tooth counts in children with good dental health. The goal was to present the results in such forms that they will be of practical help in clinical dentistry and pediatrics, forensics, and research. An additional aim was to compare graphs obtained by the two types of methods to estimate dental maturity—that is, that based on counts of emerged

Table 1. Emergence ages* of analogous permanent teeth in a longitudinal series of 86 Finnish boys and 101 girls. Right and left sides combined

Tooth	5%	16%	Median	84%	95%	No. of teeth	Min.	Mean	Max.	Standard deviation
Boys										
Maxilla										
I1	5.8	6.3	6.86	7.8	8.2	166	4.9	7.00	10.3	0.78
I2	6.8	7.3	8.21	9.3	9.9	159	6.3	8.28	12.3	1.04
C	9.5	10.1	11.41	12.7	13.5	156	8.4	11.44	15.0	1.27
P1	9.2	9.7	10.89	12.2	13.3	152	8.0	10.94	14.3	1.26
P2	9.9	10.5	12.11	13.4	14.7	157	8.9	12.02	16.1	1.48
M1	5.3	5.7	6.31	7.0	7.6	153	5.0	6.36	8.8	0.72
M2	10.6	11.2	12.21	13.8	14.8	159	9.9	12.35	15.4	1.27
Mandible										
I1	5.1	5.4	6.07	6.7	7.1	164	4.2	6.08	8.4	0.70
I2	6.0	6.3	7.00	8.0	8.8	161	5.2	7.14	9.9	0.86
C	9.0	9.4	10.50	11.7	12.9	150	8.6	10.62	13.5	1.09
P1	9.0	9.6	10.56	12.1	13.4	143	8.4	10.80	14.5	1.28
P2	9.4	10.3	11.55	13.4	14.7	150	8.9	11.82	15.3	1.56
M1	5.3	5.6	6.27	6.9	7.5	157	5.0	6.28	8.3	0.68
M2	10.1	10.6	12.04	13.3	14.4	152	8.9	12.02	15.1	1.30
Girls										
Maxilla										
I1	5.6	6.2	6.75	7.3	7.8	191	4.9	6.73	8.4	0.64
I2	6.7	7.1	7.77	8.4	9.2	183	5.7	7.78	12.0	0.84
C	9.0	9.7	10.77	11.9	13.5	187	8.0	10.84	14.0	1.23
P1	8.4	9.3	10.53	11.6	12.5	180	6.9	10.44	13.3	1.17
P2	9.5	10.2	11.37	12.6	14.0	179	7.1	11.45	15.5	1.35
M1	5.2	5.5	6.19	6.8	7.4	186	4.7	6.19	7.9	0.66
M2	10.1	10.5	11.68	13.3	13.8	185	9.1	11.85	15.8	1.21
Mandible										
I1	4.8	5.3	5.95	6.5	6.8	190	4.5	5.92	8.0	0.61
I2	5.6	6.3	6.90	7.7	8.0	186	5.2	6.97	9.1	0.71
C	8.1	8.7	9.76	10.7	11.4	180	7.0	9.76	13.3	1.02
P1	8.6	9.2	10.30	11.4	12.2	184	7.9	10.30	13.3	1.06
P2	9.4	10.1	11.36	12.8	13.5	185	8.3	11.40	14.5	1.28
M1	5.1	5.4	6.00	6.8	7.2	184	4.4	6.06	8.4	0.66
M2	9.8	10.3	11.49	12.7	13.3	181	9.2	11.51	14.8	1.11

* Calculations were based on a combination of exact emergence ages and ages based on clinical examinations performed at half-year or 1-year intervals.

teeth in the present sample and that based on radiographic estimation of tooth mineralization (1) from a previous Finnish study (19).

Materials and methods

This study is part of a longitudinal Finnish study of dental and craniofacial growth (20). During 1967–69 pregnant mothers were informed about the investigation at the Mother and Child Welfare Centers in Helsinki. The mother volunteers brought 435 healthy children to the first examination at the age of 6 months. The number of children was 267 at 5 years and 187 at 16 years. Of these children 136 were first-born and 51 their siblings. They were born in 1967–73. Oral health in the children was excellent (21). The present study included all the 187 children, 86 boys and 101 girls, who at the age of 16 years still participated the longitudinal study.

The presence or absence of permanent teeth was checked by dentists in clinical examinations performed in a dental chair at the Institute of Dentistry, University of Helsinki. A tooth was considered emerged if any part of it had pierced the gum. The clinical examinations were semiannual from the age of 1.5 years onwards until January 1980. At that time 122 of the children (65%) were at least 10 years of age, and the 9 youngest children (5%) were 6 years. Thereafter, clinical examinations were conducted annually. For many teeth the exact dates of emergence were also recorded by parent volunteers together with the children themselves. The parents had been personally instructed by dentists to record emergence dates in a booklet designed for this purpose. Some exact dates were recorded at clinical examinations by dentists, and all exact dates recorded by parents in the booklets were also checked by dentists at these examinations. For the present study clinical records were additionally checked with the help of dental casts and panoramic tomograms taken during the growth study. Exact dates of emergence were known for 1,624 permanent teeth. Of

Table 2. Ages* (in years) corresponding to counts of permanent teeth (age-in-stage) in 86 Finnish boys

Tooth count	5%	16%	Median	84%	95%	Min.	Mean	Max.	Standard deviation	Stage − emerg.**
1	5.0	5.3	5.79	6.6	7.2	4.2	5.90	7.7	0.66	0.06
2	5.1	5.5	6.01	6.7	7.4	4.6	6.08	7.9	0.66	0.12
3	5.3	5.6	6.25	6.8	7.6	4.7	6.26	8.1	0.67	0.06
4	5.3	5.7	6.34	6.9	7.7	4.7	6.38	8.2	0.67	0.07
5	5.4	5.8	6.48	7.0	7.8	4.8	6.50	8.3	0.68	0.04
6	5.6	6.0	6.64	7.3	8.1	5.2	6.69	8.7	0.69	0.15
7	5.9	6.2	6.84	7.6	8.3	5.2	6.94	9.4	0.72	0.09
8	6.1	6.3	7.08	7.8	8.5	5.2	7.14	9.9	0.77	0.12
9	6.2	6.5	7.26	8.1	8.6	5.2	7.33	10.1	0.83	0.07
10	6.5	7.0	7.77	8.7	9.4	5.8	7.78	10.7	0.88	0.37
11	6.9	7.2	8.19	9.3	9.9	6.3	8.25	11.2	1.00	0.09
12	7.8	8.3	9.27	10.3	10.9	7.4	9.30	12.6	0.99	0.96
13	8.8	9.3	10.31	11.5	12.4	8.4	10.39	13.0	1.08	0.13
14	9.0	9.6	10.46	11.7	12.6	8.4	10.62	13.1	1.05	0.11
15	9.2	9.7	10.58	11.9	13.0	8.7	10.77	13.3	1.07	0.04
16	9.3	9.9	10.71	12.0	13.0	8.9	10.90	13.8	1.09	0.09
17	9.3	10.0	11.03	12.2	13.1	8.9	11.05	14.3	1.14	0.06
18	9.4	10.0	11.15	12.4	13.1	8.9	11.21	14.3	1.18	0.10
19	9.5	10.0	11.33	12.4	13.4	8.9	11.35	14.5	1.23	0.04
20	9.7	10.3	11.39	12.7	13.8	8.9	11.51	14.6	1.24	0.12
21	9.9	10.3	11.72	12.7	14.0	8.9	11.68	15.1	1.24	0.06
22	10.0	10.5	11.75	13.0	14.2	8.9	11.82	15.1	1.24	0.09
23	10.1	10.8	12.01	13.2	14.4	8.9	11.99	15.1	1.25	0.09
24	10.3	10.9	12.15	13.4	14.4	8.9	12.15	15.1	1.24	0.07
25	10.5	11.1	12.30	13.4	14.5	8.9	12.31	15.2	1.23	0.11
26	10.8	11.2	12.47	13.9	14.7	9.5	12.54	15.3	1.22	0.14
27	10.8	11.4	12.66	14.2	15.0	10.0	12.80	15.6	1.30	0.13

* Explanation of method in Table 1.
** Difference (in years) between means of age-at-stage and age at attaining the same stage.

these teeth 971 (60%) were incisors or first molars. For 3,612 teeth only the presence or absence of the tooth on clinical examinations was known. In 28 children 43 teeth never emerged. Of these, 39 were congenitally missing, and 6 were extracted surgically. Of the congenitally missing teeth, 24 (62%) were second premolars.

Age at emergence of a specific tooth was calculated by the exact date of emergence or, when the exact date was not available, by the midpoint between the age at the first examination when the tooth was present and the age at the last examination when a tooth was not present. The greatest accepted interval between consecutive examinations was 14 months (1.17 years). In tooth counts, missing emergence ages and those ages outside the accepted limits were estimated. When an emergence age was missing unilaterally (25 teeth), it was given the emergence age of the contralateral tooth. Bilaterally missing teeth (10 tooth pairs) and insufficiently exact emergence ages (483 teeth, 9%) were replaced by estimates calculated by the method of maximum likelihood (22).

The maturity curves based on tooth mineralization derive from 2,483 dental panoramic tomograms of 1,651 healthy Finns ranging in age from 2 to 25 years (19), including also the subjects of the present study. Dental maturity was assessed using a method based on developmental stages of seven left mandibular teeth (1). In that method the teeth are rated on an 8-stage scale, and each stage of each tooth is given a biologically weighted score. The sum of the scores is the dental maturity score of the subject, which can be converted to dental age.

Statistics

Percentile calculations were based on internal sorting in the memory of the computer so that observations attached to the age or the count concerned were sorted in ascending order, and percentiles were calculated by interpolation. Ages corresponding to tooth counts (age-at-stage) were counted as a midpoint of the age at the emergence of a tooth and the successive tooth. Tooth counts corresponding to ages were based on simulated daily inspections. The program checked the number of permanent teeth in the mouth of an individual by means of the given dates of emergence. These simulated check-ups started before the emergence of the first tooth in the sample and ended at 17 years of age. Two-way analysis of variance (ANOVA) was used in comparisons. The level of significance was chosen as $\alpha = 0.05$. To avoid bias, ages in tables and figures are expressed using the centered system: in half-year steps age group 7.0 includes all children from 6.75 to 7.24 years of age (Figs. 1–4, Table 4).

The method of maximum likelihood (22) was used to make estimates to replace inexact emergence ages. The first step was to calculate sex-specific tables of mean differences between emergence ages of all possible tooth

Table 3. Ages* (in years) corresponding to counts of permanent teeth (age-at-stage) in 101 Finnish girls

Tooth count	5%	16%	Median	84%	95%	Min.	Mean	Max.	Standard deviation	Stage – emerg.**
1	4.9	5.2	5.76	6.3	6.7	4.5	5.76	7.2	0.56	0.04
2	5.0	5.3	5.90	6.5	6.8	4.5	5.91	7.2	0.55	0.11
3	5.2	5.5	6.07	6.7	7.0	4.6	6.07	7.7	0.58	0.04
4	5.3	5.5	6.21	6.8	7.2	4.7	6.18	7.8	0.59	0.07
5	5.4	5.7	6.29	6.8	7.4	4.7	6.30	8.0	0.60	0.04
6	5.6	5.9	6.49	7.1	7.5	4.8	6.51	8.2	0.60	0.17
7	5.6	6.2	6.73	7.4	7.7	5.0	6.73	8.4	0.63	0.04
8	5.8	6.3	6.86	7.5	7.8	5.3	6.89	8.7	0.61	0.12
9	5.9	6.5	7.07	7.7	7.9	5.5	7.07	9.1	0.63	0.06
10	6.3	6.9	7.51	8.1	8.4	5.7	7.42	9.1	0.65	0.28
11	6.7	7.2	7.78	8.4	9.1	5.9	7.77	10.7	0.74	0.07
12	7.4	7.8	8.73	9.5	9.9	6.5	8.70	10.9	0.80	0.85
13	8.1	8.6	9.65	10.7	11.2	6.9	9.65	12.3	0.99	0.10
14	8.4	8.8	9.88	10.8	11.5	7.1	9.92	12.3	0.98	0.16
15	8.6	9.2	10.20	11.2	11.9	7.3	10.17	12.8	1.01	0.10
16	8.8	9.4	10.37	11.3	11.9	7.4	10.34	13.3	1.02	0.08
17	8.8	9.5	10.45	11.5	11.9	7.5	10.47	13.3	1.00	0.05
18	9.0	9.7	10.60	11.6	12.1	7.7	10.61	13.3	0.99	0.08
19	9.2	9.8	10.77	11.8	12.4	7.9	10.77	13.3	1.01	0.07
20	9.3	10.0	10.81	12.1	12.6	7.9	10.96	13.5	1.03	0.11
21	9.5	10.1	11.09	12.3	12.8	8.1	11.15	14.0	1.03	0.08
22	9.8	10.2	11.29	12.4	12.9	8.3	11.31	14.3	1.03	0.08
23	9.8	10.4	11.35	12.6	13.0	8.4	11.45	14.3	1.03	0.06
24	10.0	10.6	11.49	12.8	13.3	8.8	11.60	14.5	1.04	0.10
25	10.1	10.7	11.65	13.0	13.5	9.2	11.78	15.0	1.09	0.08
26	10.2	11.0	11.85	13.3	13.8	9.3	12.04	15.3	1.14	0.20
27	10.3	11.2	12.29	13.7	14.4	9.4	12.35	15.5	1.22	0.15

* Explanation of method in Table 1.
** Difference (in years) between means of age-at-stage and age at attaining the same stage.

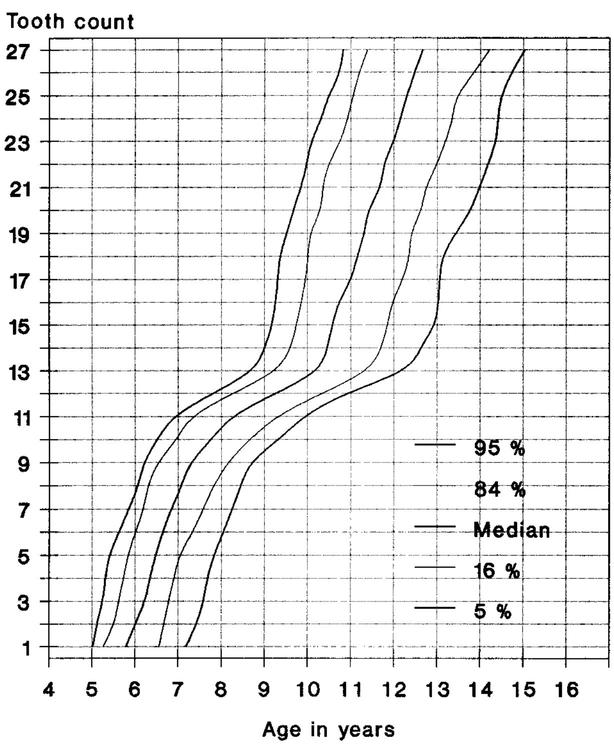

Fig. 1. Distribution of ages corresponding to counts of permanent teeth in Finns. Longitudinal data of 86 boys.

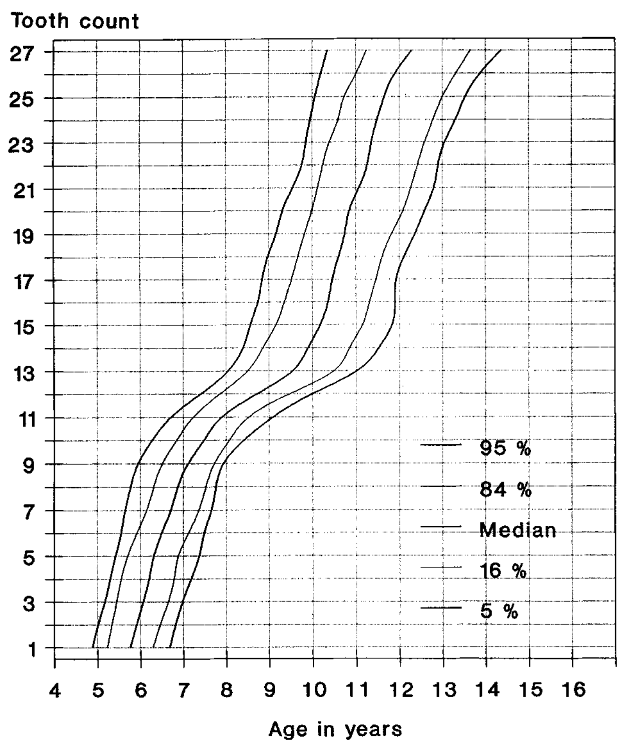

Fig. 2. Distribution of ages corresponding to counts of permanent teeth in Finns. Longitudinal data of 101 girls.

Table 4. Counts of permanent teeth at half-a-year intervals. Longitudinal data of 187 Finns

Age in years*	5%	16%	Median	84%	95%	Min.	Mean	Max.	Standard deviation
Boys ($n = 86$)									
4.5	0	0	0	0	0	0	0.07	4	0.48
5.0	0	0	0	0	2	0	0.45	10	1.45
5.5	0	0	1	4	6	0	1.66	10	2.31
6.0	0	0	3	7	10	0	3.47	10	3.07
6.5	0	3	6	10	10	0	6.17	12	3.28
7.0	1	6	9	11	12	0	8.22	12	3.10
7.5	5	8	10	12	12	2	9.66	12	2.45
8.0	7	9	12	12	12	4	10.65	13	1.88
8.5	9	10	12	12	13	6	11.43	15	1.40
9.0	10	11	12	13	16	7	12.22	26	2.28
9.5	10	12	12	15	20	7	13.26	26	3.00
10.0	12	12	13	20	23	9	15.06	28	4.24
10.5	12	12	16	23	26	10	16.91	28	4.99
11.0	12	12	18	26	28	11	19.13	28	5.76
11.5	12	14	21	28	28	11	21.17	28	5.68
12.0	12	17	25	28	28	11	23.15	28	5.12
12.5	14	21	27	28	28	12	24.86	28	4.42
13.0	18	23	28	28	28	14	26.03	28	3.45
13.5	20	26	28	28	28	16	26.87	28	2.58
14.0	22	27	28	28	28	16	27.22	28	2.21
14.5	26	28	28	28	28	20	27.72	28	1.07
15.0	27	28	28	28	28	25	27.91	28	0.39
15.5	28	28	28	28	28	27	27.98	28	0.15
16.0	28	28	28	28	28	28	28.00	28	0.00
Girls ($n = 101$)									
4.5	0	0	0	0	0	0	0.10	6	0.66
5.0	0	0	0	1	4	0	0.57	8	1.46
5.5	0	0	1	6	8	0	2.24	11	2.88
6.0	0	0	4	8	10	0	4.36	12	3.13
6.5	2	4	8	10	12	0	6.98	12	3.07
7.0	4	6	10	12	12	2	8.99	15	2.50
7.5	8	9	10	12	12	3	10.58	18	1.89
8.0	10	10	12	12	14	6	11.68	21	1.54
8.5	10	12	12	14	16	8	12.53	24	1.95
9.0	11	12	12	16	19	10	13.45	26	2.75
9.5	12	12	13	19	22	10	14.86	28	3.65
10.0	12	12	15	22	26	10	16.74	28	4.77
10.5	12	14	19	26	28	11	19.20	28	5.06
11.0	13	15	21	27	28	12	21.47	28	5.03
11.5	14	19	26	28	28	12	23.68	28	4.66
12.0	18	21	27	28	28	12	25.21	28	3.83
12.5	20	24	28	28	28	15	26.32	28	2.78
13.0	23	26	28	28	28	15	27.06	28	2.03
13.5	26	27	28	28	28	21	27.60	28	1.04
14.0	26	28	28	28	28	21	27.83	28	0.80
14.5	28	28	28	28	28	24	27.93	28	0.45
15.0	28	28	28	28	28	25	27.96	28	0.31
15.5	28	28	28	28	28	27	27.99	28	0.10
16.0	28	28	28	28	28	28	28.00	28	0.00

* Centered age used: age group 9.0 years includes all children from 8.75 to 9.24 years of age.

combinations, using teeth with adequate information (emergence ages known with $\leq$7-month accuracy). For each individual child the age of emergence of a tooth that had inadequate information was estimated by using the emergence ages of all the child's teeth with adequate information and the mean differences, listed in tables, between the tooth with unknown emergence age and all the teeth with known emergence ages. These known emergence ages of the child and the corresponding differences were summed up. The mean of these sums was the emergence age estimate of the tooth concerned.

Results

Emergence of teeth

Differences between left and right sides were counted for the 602 analogous teeth with exact emergence ages

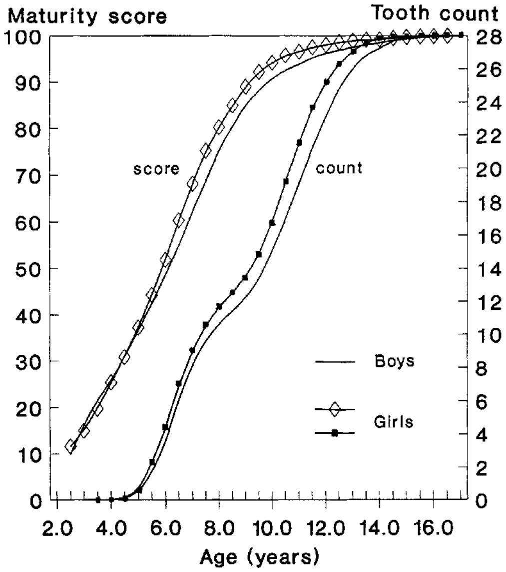

Fig. 3. Means of counts of permanent teeth by age in 86 Finnish boys and 101 girls. Mean curves of Finnish dental maturity scores (19), obtained by a radiographic 7-tooth method (1), are given as a comparison.

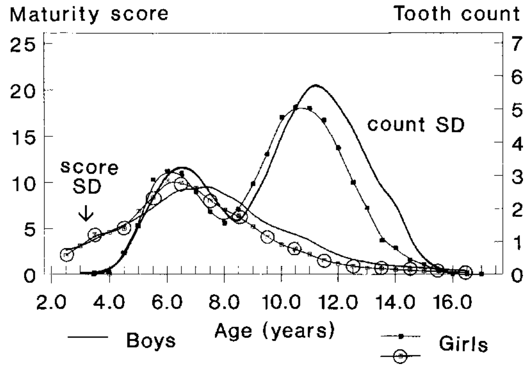

Fig. 4. Standard deviations (SD) of counts of permanent teeth by age in 86 Finnish boys and 101 girls. Standard deviation curves of Finnish dental maturity scores (19), obtained by a radiographic 7-tooth method (1), are given as a comparison.

known for both sides. In boys the mean difference in all the 270 pairs was −0.01 years (standard deviation (s) = 0.33) and in girls 0.01 years (s = 0.24). In further calculations the sides were pooled. Ages at emergence of specific permanent tooth pairs are given in Table 1, separately for boys and girls. The mean and median ages of all teeth were younger in girls. Of the exact emergence ages of mandibular central incisors and first molars in both jaws, 31 (5.7%) were less than 5 years, the lowest being 4.19 years. The 5% to 95% range in emergence ages varied from 2 years for mandibular central incisors to more than 4 years for canines and premolars, and also for second molars in boys. The mandibular central incisor (I1) emerged before the mandibular first molar (M1) in the same quadrant in 83 of the 122 children with exact emergence dates of these teeth (68%).

The first permanent tooth emerged in boys at the mean age of 5.84 years (s = 0.66) and in girls at the age of 5.72 years (s = 0.57). The mean emergence age of the last tooth excluding third molars was 12.92 (s = 1.38) in boys and 12.47 (s = 1.25) in girls.

Tooth counts

The ages of children with 1 to 27 permanent teeth in the mouth (age-at-stage, dental age) are given in Table 2 for boys and Table 3 for girls. Percentage distributions are also presented (Tables 2 and 3 and Figs. 1 and 2). The mean duration of stages with tooth counts from 1 to 27 varied from 0.07 years (s = 0.12) years to 0.33 years (s = 0.33), with the exception of tooth counts 10 and 12, which were longer. The duration of the stage with 10 emerged permanent teeth was 0.74 years (s = 0.57) in boys and 0.57 years (s = 0.57) in girls. The duration of the stages with 12 teeth was 1.8 years (s = 0.96) and 1.7 years (s = 0.91), respectively. Counts of permanent teeth in half-year age groups are given in Table 4.

Dental maturity by two methods

Fig. 3 illustrates dental maturity by sex-specific counts of teeth, and Fig. 4 standard deviations of these counts. As a comparison the figures also include dental maturity curves based on radiographic estimation of tooth mineralization from a previous Finnish study (19). The standard deviation curve of the count has two peaks, one at approximately 6 years and the other, higher, at about 11, whereas the mineralization score standard deviation reaches its maximum at about 6.5 years in girls and 1 year later in boys, and then decreases.

Discussion

This longitudinal Finnish study resulted in average values for and variations in clinical eruption of permanent teeth and tooth counts. The participants had excellent dental health (21), which makes the child group suitable for a study of normal dental development. The present tables and graphs make it easy to follow the dental development of a child in relation to a normal population also longitudinally. The accuracy of the results is greater for the early emerging teeth—that is, incisors and first molars—because most of their emergence ages were based on exact emergence ages and examinations at half-year intervals. Since this study began before any permanent tooth had emerged in any child and continued until all permanent teeth except third molars had emerged in all individuals, the results describe the entire variation in this group. The number of observations was large, but, as shown in other longitudinal studies, a relatively small

Table 5. Emergence ages of permanent teeth in the present study, in a previous Finnish study (8) and in Swedish (27), Danish (28) and Icelandic (29) populations

	Boys					Girls				
Tooth	Finnish, present	Finnish, 1926*	Swedish	Danish	Icelandic	Finnish, present	Finnish, 1926*	Swedish	Danish	Icelandic
Maxilla										
I1	7.0	7.2	7.2	7.2	7.1	6.7	6.9	6.8	6.9	6.8
I2	8.3	8.4	8.3	8.2	8.1	7.8	8.0	7.9	7.8	7.8
C	11.4	11.8	11.6	11.5	11.3	10.8	11.0	10.8	10.8	10.9
P1	10.9	10.6	10.8	10.6	10.5	10.4	10.2	10.3	10.1	9.9
P2	12.0	11.7	11.5	11.4	11.4	11.5	11.2	11.0	11.0	10.8
M1	6.4	6.3	6.5	6.3		6.2	6.1	6.3	6.1	
M2	12.4	12.5	12.4	12.4	12.5	11.9	12.1	12.0	11.9	11.8
Mandible										
I1	6.1	6.3	6.3	6.2		5.9	6.1	6.0	6.0	
I2	7.1	7.3	7.5	7.4	7.4	7.0	7.0	7.0	7.1	7.0
C	10.6	10.7	10.7	10.5	10.5	9.8	9.6	9.5	9.6	9.6
P1	10.8	10.9	11.1	10.7	10.6	10.3	10.0	10.3	10.0	10.0
P2	11.8	11.5	11.8	11.5	11.5	11.4	10.9	11.2	11.0	10.9
M1	6.3	6.0	6.4	6.2		6.1	5.8	6.1	6.0	
M2	12.0	12.0	12.0	11.9	12.0	11.5	11.5	11.6	11.4	11.3

* Indicates medians. Other studies show means.

number of individuals may lead to slight underestimation of overall variability (23).

The average ages of emergence of specific permanent teeth in this longitudinal series of urban children from the south of Finland resembled closely average ages in cross-sectional studies of rural children in western, eastern, and central Finland, born in the 1970s and 1980s (13, 14). Premolars emerged earlier in children born in the 1920s (Table 5). Similarly, in a study conducted in Helsinki from 1965 to 1968 (11) premolars emerged earlier, and the exfoliation ages of deciduous molars were also earlier at that time (24) than in a group consisting almost exclusively of the children in the present study (25). Helsinki children generally had poor dental health in the 1960s (26). Compared with some Scandinavian studies (27–29), differences between average emergence ages of all teeth but premolars were small, seldom over 0.2 years (Table 5).

It is difficult to draw conclusions about secular trends and differences between populations because study methods and dental health vary. Extensive caries in the deciduous dentition indirectly influences the emergence of permanent teeth. Caries may diminish the mesiodistal crown widths of deciduous molars or cause extractions of these teeth. Very early extractions often lead to mesial drifting or tilting of first permanent molars, space loss, and retarded eruption of premolars (17, 18). If, on the other hand, deciduous molars have been lost prematurely but not before approximately 7.5 years of age, the succeeding premolars emerge earlier than normal (17, 18). Permanent second molars have also been reported to erupt earlier after premature loss of deciduous second molars (18). Similarly, very early loss of deciduous second molars facilitates the emergence of permanent first molars. Delayed emergence of permanent canines, premolars, and second molars has been reported in a Finnish community with high endemic fluoride contents (13).

The average order of emergence of the first two permanent teeth in Finns has changed in the 1960s. Mandibular M1 emerged first in 68% of children born about 1950 (10). In children born around the year 1960 the median emergence ages of M1 and I1 were about the same (11), whereas I1 was earlier than M1 in 68% of children of the present study, who were born around the year 1970. The average emergence age of I1 was earlier also in children born more recently (13, 14). The shift in emergence order seems to be associated with timing of the emergence of both M1 and I1 (Table 5). Of all Finnish studies, the emergence age of I1 was earliest in the most recent study (14) and in this study. A Japanese group (30) reported shifts in the eruption order of mandibular I1 and M1 even with the season of year of the child's birth, the changes occurring only in the timing of the emergence of I1. They suggested that the reasons are environmental.

The emergence of permanent teeth is clustered so that the first 12 teeth emerge from 6 to 8 years of age, and the remaining teeth except third molars usually from 10 to 12 years of age. The accuracy of age assessments is limited during the intervening quiescent period. The use of tooth counts in the permanent dentition is also complicated by irregularities caused by congenital and local factors. Owing to irregularities in the clinical eruption of permanent teeth, median ages and percentage distributions of emergence ages of specific teeth or of tooth pairs in a population may be the best method to estimate dental age on the basis of tooth emergence (31). Exact emergence ages of a child's specific teeth are, however, seldom known, whereas it is always possible to count the number of emerged teeth.

The mean counts of permanent teeth at different ages were in the present study generally higher than in a cross-sectional study of Finnish children born about 20 years earlier (15). Only in the 9- to 11-year age groups were the counts of the previous study slightly greater, a phenomenon probably associated with premature eruption of premolars. Only small differences existed in ages at emergence of successive permanent teeth between this study and a Swedish and a North American longitudinal study (2, 3).

The sex-specific mean curves of dental maturity based on counts of permanent teeth and those based on eight mineralization stages of seven mandibular teeth have roughly the same form, but the quiescent period in the emergence of teeth between the first and second transitional period is seen as a deflection to the right in the tooth-count curve (Fig. 3). Tooth counts can be used in maturity estimations up to about 13 years of age, whereas the radiographic method works best up to about 11 years (Fig. 3). The standard deviation curves differ distinctly in form (Fig. 4). The visual comparison of these dental maturity curves of Finns, obtained by the two types of methods, confirms previous findings that mineralization and clinical eruption are two distinct processes, and the methods are not interchangeable in practice (4, 6, 32).

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