Original Article

Secular trends affect timing of emergence of permanent teeth

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ABSTRACT

Objective: To examine the expression of possible secular trend in timing of the emergence of permanent teeth in Finnish children over the past few decades, considering the differences between genders.

Materials and Methods: Two age groups of Finnish children, one born in 1976–1985 (group 1980) and the other born in 1999–2002 (group 2000), were examined. Group 2000 comprised 483 children (235 girls and 248 boys) aged 6.4 to 8.5 years at the time of the examination, and the same children were examined at the age of 9.0 to 11.8 years. Altogether 405 children could be recalled, 196 girls and 209 boys. For comparison, matching age groups were selected from the group 1980 data (n = 1579), resulting in a sample of 312 children (155 girls and 157 boys) aged 6.4 to 8.5 years and 393 children aged 9.0 to 11.8 years. The emergence stage of each permanent tooth was determined clinically (Grades 0–3), based on which the subjects were furthermore divided according to the emergence stage of the dentition.

Results: Linear regression models showed that the permanent teeth of the first phase of the mixed dentition erupted earlier in group 2000 than in group1980, but the teeth of the second phase of the mixed dentition erupted later in group 2000. Girls showed more advanced tooth eruption than boys.

Conclusion: The longer duration of mixed dentition in group 2000 than in group 1980 makes the duration of combined follow-up and active treatment longer, and should be considered in timing of efficient orthodontic treatment. (*Angle Orthod.* 2016;86:53–58.)

KEY WORDS: Tooth eruption; Tooth emergence; Permanent teeth; Secular trend

INTRODUCTION

The elaborate knowledge of permanent tooth eruption is of major importance for dentists working especially in the fields of pedodontics and orthodontics. The knowledge of normal tooth eruption and its variation is critical for diagnosing eruption disorders and in making a treatment plan. By comparing the tooth emergence of a child to the timetable of normal tooth eruption in a population, it is possible to determine whether the eruption of the permanent teeth of the child is within normal limits of population-based standards or if there is a reason to expect early or delayed development of the dentition or even to suspect a developmental disorder. The clinical maturation stage of a permanent dentition is determined by how many permanent teeth have erupted in a child's mouth by a specific age. In the majority of studies, a tooth has been considered erupted when one of its cusps or its incisal edge has penetrated the oral mucosa.[1–4]

A variety of factors has been reported to influence permanent tooth emergence.[5] Genetic factors play a major role in tooth emergence, which results in variation in tooth emergence between different ethnic

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Table 1. Median Ending Age of the First and Second Phase of Mixed Dentition in Different Populations[a]

Nationality/Ethnicity	End of the First Phase of Mixed Dentition, Girls, Median Age, y	End of the First Phase of Mixed Dentition, Boys, Median Age, y	End of the Second Phase of Mixed Dentition, Girls, Median Age, y	End of the Second Phase of Mixed Dentition, Boys, Median Age, y
Australia (Diamanti and Townsend, 2003)[2]	8.24	8.61	12.30	12.6
Belgium (Leroy et al., 2003)[24]	7.84	8.25	11.95	12.27
Croatia (Rajik et al., 2000)[25]	8.3	8.54	12.42	12.62
Denmark (Helm and Seidler, 1974)[26]	7.8 (mean)	8.2 (mean)	11.9 (mean)	12.4 (mean)
Finland (Eskeli et al., 1999)[9]	7.64	8.08	11.9	12.39
Finland (Nyström et al., 2001)[15]	7.8 (mean)	8.3 (mean)	11.9 (mean)	12.4 (mean)
Germany (Friedrich et al., 2006)[22]	7.5	8.0	11.9	12.5
India (Lakshmappa et al., 2011)[3]	8.54 (mean)	8.67 (mean)	12.3 (mean)	12.6 (mean)
Iran (Moslemi, 2004)[7]	8.83	9.42	12.42	13.00
Japan (Höffding et al., 1984)[11]	8.0	8.2	12.3	12.7
Jordan (Shaweesh, 2012)[4]	8.07	8.54	12.32	12.61
Lithuania (Almonaitiene et al., 2012)[5]	7.55	7.96	12.08	12.31
New Zealand, Caucasian (Kanagaratnam and Schluter, 2012)[14]	7.8	8.2	12.2	12.6
Spain (Hernández et al., 2008)[27]	7.37	8.21	12.24	12.48
Sweden (Hägg and Taranger, 1986)[28]	7.9 (mean)	8.3 (mean)	12.0 (mean)	12.4 (mean)
Uganda (Kutesa et al., 2013)[6]	7.2 (mean)	8.5 (mean)	10.7 (mean)	11.6 (mean)
United Kingdom (Elmes et al., 2010)[23]	8.24	8.81	12.4	12.8

[a] The phase is regarded as ended when the last tooth of the phase has clinically erupted. Figures are mostly given as median numbers; mean figures are followed by (mean).

groups. Table 1 summarizes ages at the end of the first and second phases of the mixed dentition in different populations. The largest difference in the ending of both the first and second phase of mixed dentition was between Ugandan[6] and Iranian[7] girls, 1.6 and 1.7 years, respectively. Permanent teeth have been noticed to erupt earlier in African children than in those of white origin.[6,8] In addition, Diamanti and Townsend[2] reported that permanent teeth erupted later in Australian children than in their Finnish[9] or Asian counterparts.[10,11]

In the majority of studies, permanent teeth have been noticed to erupt earlier in girls than in boys.[1,2,12] There has also been a difference in the eruption sequence of permanent teeth between genders. Almonaitiene et al.[13] noted that in girls, maxillary canines erupt earlier than maxillary premolars, whereas the sequence was opposite in boys. In most studies,[3,12] mandibular permanent teeth have been shown to erupt earlier than their maxillary counterparts. In contrast, no significant difference in the timing of tooth emergence between right and left teeth has been found.[4,8]

Most studies carried out over the past few decades in various populations have shown that the timing of permanent tooth emergence has accelerated over the years in the same population.[9,11,14] It has been reported that the emergence of permanent teeth in the first phase of mixed dentition in Finnish children has accelerated compared to previous studies conducted in Scandinavian populations.[9,15]

The aim of this study was to examine the expression of possible secular trend in timing of the emergence of permanent teeth in Finnish children over the past few decades, considering the differences between genders.

MATERIALS AND METHODS

The study was based on two samples of Finnish children, one born in 1976–1985 (group 1980) and the other born in 1999–2002 (group 2000). The earlier cross-sectional sample was composed of children aged 4.2 to 17.0 years in rural communities of Vimpeli in Western Finland and Juuka in Eastern Finland. All preschool and schoolchildren in both communities were studied, except those who did not attend school during the examination days and a few children with severe developmental problems attending special schools. The sample, described in detail elsewhere[9] consisted of 1579 subjects, 787 girls and 792 boys. The size of the age cohorts varied from 37 to 115, and the developmental stage of the dentition varied from complete primary to complete permanent dentition.

The latter sample (group 2000) was part of the Physical Activity and Nutrition in Children study (PANIC study)[16,17] and was composed of 483 children, 235 girls and 248 boys, including all children in 20 of 40 elementary and middle schools in the City of Kuopio. Age range of the group was from 6.4 to 8.5 years at the time of examination. To study the effects of secular trend on timing of tooth eruption, a matching age group

Table 2. Description of the Study Groups According to Age and Gender

Study Groups	N	Gender Girls, %	Age, y Median	Age, y Mean (SD)
Age 6.4–8.5 y				
Group 1980	312	49.7	7.5	7.6 (0.6)
Group 2000	483	48.7	7.6	7.6 (0.6)
Age 9.0–11.8 y				
Group 1980	393	52.4	10.3	10.3 (0.9)
Group 2000	405	48.4	10.1	10.1 (0.4)

(aged 6.4–8.5 years) was selected from the group 1980 data, resulting in a sample of 312 children, 155 girls and 157 boys.

In group 2000, the same children were examined at the age of 9 to 11 years, age ranging from 9.0 to 11.8 years at the time of examination. Altogether 405 children could be recalled, 196 girls and 209 boys. For comparisons, all children within the same age range were extracted from the group 1980 data, resulting in a sample of 393 children. Description of age and gender distribution of all study groups is given in Table 2 and in Figure 1.

The emergence stage of each permanent tooth, except third molars, was determined in the earlier sample, as well as in the current sample, clinically as follows:

- Grade 0: the tooth is not visible in the oral cavity;
- Grade 1: at least one cusp/part of the incisal edge is visible in the oral cavity;
- Grade 2: the entire occlusal surface/mesiodistal width of the incisal edge of the tooth is visible; and
- Grade 3: the tooth is in occlusion or at the occlusal level, if the antagonistic tooth is not fully erupted.

For interexaminer and intraexaminer consistencies for registering emergence stages of the permanent teeth, Cohen kappa coefficients were calculated based on double measurements of 20 and 39 cases, respectively. Kappa values for interexaminer consistencies varied from satisfactory to excellent, from 0.84 to 1.00, except for the mandibular lateral incisor with the kappa value of 0.46. Those for intraexaminer consistencies were excellent, the kappa values for individual teeth varying from 0.91 to 1.00.

Emergence scores of the permanent dentition were calculated as the sum of the emergence categories of individual teeth (Grades 0–3) and used to determine the emergence stages of the permanent dentition (0–84) as follows:

- emergence stage 0 (ES0): complete primary dentition only (ES = 0);
- emergence stage 1 (ES1): incomplete first phase of the mixed dentition ($1 \leq ES \leq 35$) (permanent incisors and first molars erupting);
- emergence stage 2 (ES2): complete first phase of the mixed dentition (ES = 36) (permanent incisors and first molars fully erupted);
- emergence stage 3 (ES3): incomplete second phase of the mixed dentition ($37 \leq ES \leq 83$) (permanent canines, premolars and second molars erupting); and
- emergence stage 4 (ES4): complete permanent dentition (ES = 84).

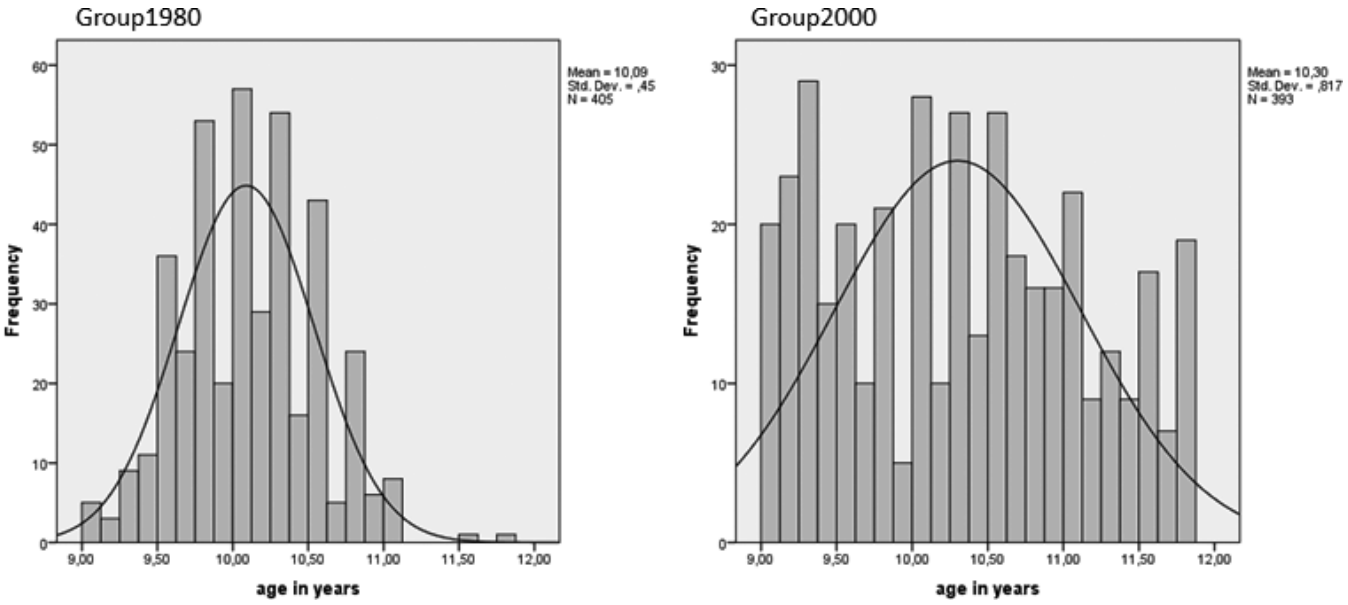

Figure 1. Age distributions of children aged 9.0 to 11.8 years of age among group 1980 and group 2000.

Table 3. Differences in Eruption Stages of the Permanent Teeth Between Girls and Boys at the Age of 6 to 8 Years (See Materials and Methods)[a]

	Girls (n = 390), %	Boys (n = 405), %	P[b]
Maxillary lateral incisor			<.001
Not erupted (grade 0)	38.5	59.5	
Erupting (grade 1+2)	19.7	15.1	
Fully erupted (grade 3)	41.8	7.7	
Mandibular lateral incisor			.002
Not erupted (grade 0)	12.6	21.0	
Erupting (grade 1+2)	13.1	15.0	
Fully erupted (grade 3)	74.4	64.0	

[a] Only statistically significant differences are given.
[b] Pearson chi-square test.

Pearson chi-square test was used to analyze the differences in eruption stages of the permanent teeth between girls and boys and between the right and left sides of the dental arches. Because the differences between the right and left sides were nonsignificant, results from the right maxillary and mandibular arch are given. Linear regression models were used to analyze the differences in emergence stages of dentition ES (0–84) between group 1980 and group 2000 (group 1980 = 1, group 2000 = 2) in the two cohorts, considering the effect of gender (girls = 0, boys = 1).

RESULTS

Table 3 shows the differences in eruption stage (Grades 0–3) of permanent teeth between genders during the first phase of mixed dentition in children from 6.4 to 8.5 years of age. In the maxillary dentition, the only statistically significant difference was related to the lateral incisor, the girls showing more advanced eruption stages ($P < .001$). In only 38.5% of girls, lateral incisor was not clinically erupted (Grade 0), whereas in boys the percentage was 59.5%. Similarly, in the mandible, there was a statistically significant difference between girls and boys only in the case of mandibular lateral incisor, girls showing more advanced eruption stages.

Differences in eruption stages of the permanent teeth between girls and boys at the age of 9 to 11 years are given in Table 4. There was a statistically significant difference between genders in the case of mandibular canine, first premolar, second premolar, and second molar, but in the maxilla statistically significant difference was seen only for the canine, with girls showing more advanced tooth eruption stages.

Linear regression model (Table 5) showed a statistically significant difference in emergence stage of the permanent dentition between the two groups. At the age of 6.4 to 8.5 years, the children born between 1999 and 2002 showed more advanced tooth eruption compared to the children born between 1976 and 1985 ($P < .001$) at the first phase of mixed dentition. At the second phase of mixed dentition (9.0–11.5 years), the group 2000 children, however, showed more delayed tooth eruption compared to the group 1980 children, but the difference was not statistically significant ($P = .093$). The effects of age and gender proved to be statistically significant.

Table 4. Differences in Eruption Stages of the Permanent Teeth Between Girls and Boys at the Age of 9 to 11 Years (See Materials and Methods)[a]

	Girls (n = 401), %	Boys (n = 396), %	P[b]
Maxillary canine			
Not erupted (grade 0)	68.8	75.8	
Erupting (grade 1+2)	12.7	14.4	.002
Fully erupted (grade 3)	18.5	9.8	
Mandibular canine			
Not erupted (grade 0)	31.9	53.8	
Erupting (grade 1+2)	20.9	18.4	<.001
Fully erupted (grade 3)	47.1	27.8	
Mandibular first premolar			
Not erupted (grade 0)	50.6	60.7	
Erupting (grade 1+2)	10.7	9.6	.014
Fully erupted (grade 3)	38.7	29.7	
Mandibular second premolar			
Not erupted (grade 0)	73.6	83.6	
Erupting (grade 1+2)	4.7	2.8	.003
Fully erupted (grade 3)	21.7	13.6	
Mandibular second molar			
Not erupted (grade 0)	84.3	89.1	
Erupting (grade 1+2)	7.7	7.1	.037
Fully erupted (grade 3)	8	3.8	

[a] Only statistically significant differences are given.
[b] Pearson chi-square test.

DISCUSSION

This study examined the expression of possible secular trend in the timing of the emergence of permanent teeth in Finnish children over the past few

Table 5. Differences in Emergence Stages of Dentition (ES 0–84) Between Group 1980 and Group 2000 in Two Cohorts Using Linear Regression Models, Adjusted for Gender. The Effect of Age Was Also Taken Into Consideration at the Age of 9.0 to 11.5 Years

	Beta	P
At the age of 6.4–8.5 y		
Group (group 1980 = 1, group 2000 = 2)	0.175	<.001
Gender (0 = girl, 1 = boy)	−0.174	<.001
At the age of 9.0–11.5 y		
Group (group 1980 = 1, group 2000 = 2)	−0.052	.093
Gender (0 = girl, 1 = boy)	−0.148	<.001
Age, y	0.504	<.001

decades, considering the differences between genders. The municipalities, of which populations comprised the earlier sample, were rural communities and the latter sample was composed of children living in the City of Kuopio. Nationwide in Finland, children are followed regularly from newborn to 18 years of age for their general and dental health, free of charge. Body mass index (BMI = weight/(height/100)^2) is 12 to 27 for Finnish children aged 7 to 15 years,[18] the cut-off point for overweight being 25 to 30, and for obesity >30. In the present group 2000, the median (interquartile range) of body fat percentage was 20.6 (17.4–27.1) in girls and 15.0 (11.4–21.6) in boys, indicating slight overweight but not obesity.[16] Regarding dental health, the present data are in accordance with national statistics: low mean values for decayed, missing, and filled teeth (DMFT) index, namely 1.0–1.3 for 5- to 12-year-old and 3.8 for 17-year-old children; and high proportion of caries-free children, 70% of 5-year-old, 42% of 12-year-old, and 20% of 17-year-old children, with no clear differences between urban, semi-urban, and rural areas.[19] Considering good to excellent general and dental health among children and ethnically homogenous population, the results on permanent tooth eruption can be applied to the whole population.

The emergence stage of each permanent tooth was determined clinically in the present study. While in an earlier study conducted by Nyström et al.,[15] radiological methods were used to examine the maturation stage of the dentition, it was not possible for these large samples of healthy children for ethical reasons. In the present study, interexaminer and intraexaminer consistencies were good.

Girls showed more advanced eruption stages than boys, which has been confirmed in previous studies in different populations.[1,2,7] This difference has been attributed to the earlier physical development and maturation of girls.[5] The difference of eruption time between girls and boys has been found to vary between 4 and 6 months depending on the tooth.[5]

The age ranges of the study groups were identical. However, the age distributions within the two older age groups were different, shown as wider standard deviation in group 1980 than in group 2000. Therefore, age was included in the linear regression model.

In the present study, there was an indication of a secular trend showing the permanent teeth of the first phase of mixed dentition to erupt earlier at present than 20 years ago. This is also in accordance with the secular trend reported in other studies in different populations.[11,14] In contrast, the permanent teeth of the second phase of mixed dentition seemed to erupt later, though the difference was not statistically significant. Rousset et al.[20] also noted this in their study which examined the secular trend of permanent tooth eruption in French children since the 1950s. In their study, maxillary premolars tended to erupt later and second molar earlier than in the previous French study.[21] Rousset et al.[20] attributed these changes to an evolutionary reduction in the size of the maxilla, a progressive decrease in genetic control of canines and premolars and/or progress in dental preventive measures to conserve primary molars, as earlier high incidence of caries in deciduous molars resulted in earlier loss of them, which accelerated the eruption of permanent premolars.

On the other hand, a study conducted by Friedrich et al.[22] did not show any significant acceleration in permanent tooth emergence anymore. In fact, Elmes et al.,[23] Kutesa et al.,[6] and Diamanti and Townsend[2] noted that, in contrast to the worldwide secular trend, the permanent teeth of British, Ugandan, and Australian children erupted later than in the previous similar studies. As a possible explanation, Elmes et al.[23] attributed the later emergence of permanent teeth to the poorer nutritional status of contemporary British children in the Colchester area compared to previous generations.

According to our study, the duration of mixed dentition, ie, the time spanning from the beginning of permanent tooth eruption to full permanent dentition is at present longer than in children born 20 years earlier. In patient care, waiting for the permanent teeth to erupt to determine optimal timing of efficient orthodontic treatment, longer duration of mixed dentition makes duration of combined follow-up and active treatment longer, especially in cases where early orthodontic treatment precedes treatment in the fully developed permanent dentition.

CONCLUSIONS

- In this study, the findings that permanent teeth erupt earlier in the mandible than in the maxilla and girls show more advanced tooth eruption than boys both during the first and second phase of mixed dentition, are in accordance with earlier studies conducted in different populations.
- The present results show that secular trend still affects permanent tooth eruption in Finnish population but not systematically. The permanent teeth of the first phase of mixed dentition erupt earlier and the teeth of the second phase of mixed dentition seem to erupt later in children born around 2000 compared to children born around 1980. Thus, the longer duration of mixed dentition results in longer duration of combined follow-up and active treatment and should be considered in optimal timing of effective orthodontic treatment.

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