Has hypodontia increased in Caucasians during the 20th century? A meta-analysis

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SUMMARY It has been claimed that agenesis of permanent teeth has increased over the years. The present study tested this hypothesis in Caucasians.

Published data on the prevalence of children with one or more congenitally missing permanent teeth were selected on the basis of strictly imposed criteria. Using a meta-analysis, the data were evaluated and presented chronologically. Furthermore, the selected publications were checked for differences in the prevalence of agenesis between the male and female populations. Finally, information on the occurrence of upper and lower premolars as well as upper incisor agenesis was collected and calculated as a percentage of the total number of congenitally missing teeth.

From 42 studies on this subject, 19 were selected based upon six stringently applied criteria. Chronological classification of the percentage of children with congenital absence of one or more permanent teeth revealed relatively higher percentages since 1957. Fourteen out of the selected studies presented data on sex distribution. In all but one publication girls tended to have a slightly higher occurrence of missing teeth compared with boys of the same age. The second lower premolars were most often agenetic, whereas missing upper laterals occurred almost equally as agenesis of the upper second premolars.

The considered period of time is too short and the available data too limited to describe a possible trend in the human dentition. However, this meta-analysis seems to confirm that hypodontia has been diagnosed more often in recent studies.

Introduction

For many years, dental anthropologists have been undertaking research on the evolution of the human dentition. All agree that the development of food processing from pre-historic to modern times is reflected in morphological changes in the human masticatory apparatus. The decreasing rate of physiological attrition of the teeth is a well-documented evolution, but has ended since nutritional habits have stabilized (Sengupta *et al.*, 1999). Begg (1954) and Berry and Poole (1976) believed in the beneficial consequences of dental wear: less crowding, less impaction of third molars and more stable occlusions.

In addition to dental wear, other evolutionary aspects of the masticatory system have been studied on human skulls. Compared with the past there has been a reduction in the width of the alveolar process (Lavelle and Moore, 1973), as well as changes in crown morphology (Dahlberg, 1945). Moreover, the stability of the curve of Spee (Begg, 1954; Sengupta *et al.*, 1999) seems to have increased, whereas there has been a reduction in the number of teeth (Sengupta *et al.*, 1999). Also, a reduction of the facial part of the skull (also called debrachycephalization) has been reported (Hauspie *et al.*, 1997). According to the literature, the mesio-distal width of human teeth has decreased over time (Dahlberg, 1945) and it is generally accepted that hypodontia is often associated with a reduction in tooth size (Garn and Lewis, 1970; Baccetti, 1998). These changes, however, are complex, and because evidence cannot be collected over several centuries, many statements are purely hypothetical.

Tooth agenesis (currently the most common anomaly in the development of the human dentition) is one of the most intriguing phenomena, because it is frequently associated with other oral anomalies: structural variations and malformations of other teeth, late eruption, transposition, crowding (Dermaut *et al.*, 1986; Vastardis, 2000; Arte *et al.*, 2001). Many authors have also suggested a connection with sex, based on the possibly higher prevalence of agenesis in the female population (Brook, 1975). Clinicians often claim that tooth agenesis has increased during recent decades. There is, however, no evidence as to whether this is a true trend in the dentition of homo sapiens or a purely hypothetical observation due to more advanced screening and diagnosis of dental anomalies.

Recent genetic research opens fascinating new horizons on this matter, for it will clarify the mystery of dental agenesis, and dental embryological and evolutionary development. Familial tooth agenesis is described by Arte *et al.* (2001) and Vastardis (2000) as an autosomal dominant mutation in the *MSX1* gene on chromosome 4p. Other genetic defects and environmental

factors may also play an important role in the variability of the phenotypic expression.

The hypothesis put forward in this study was, that hypodontia has been observed more frequently over the past decades.

Materials and methods

In order to test the hypothesis that hypodontia is observed more frequently now than in past generations, information gathered from the literature was evaluated by means of a meta-analysis. Epidemiologists (Blettner et al., 1999) generally suggest, the meta-analysis was initiated by a profound search for the available published data on this issue. Several methods were used to select appropriate studies. An electronic search by means of the PubMed database was supplemented by a manual search of reference lists in various published papers and books (Schuurs, 1988). Since the beginning of the 20th century, some authors have defined, investigated and described the phenomenon of genetically missing teeth. However, the oldest article on the prevalence of this anomaly was published by Stegemann (1935). From 42 publications, a rigorous selection procedure was carried out based on the following six criteria:

- 1. All participants were Caucasians.
- 2. Only agenesis in the permanent dentition (except for third molars) was taken into consideration.
- 3. Congenital absence must have been diagnosed both clinically and radiographically.
- 4. Only studies with randomly selected participants were included (samples of orthodontic patients only were excluded from this analysis).
- 5. Only publications in which the age of the participating children was at least 3 years were used for this study.
- 6. A sample size of at least 1000 examined children per study was required as an inclusion criterion.

No investigations other than those matching these conditions were used for the present analysis, resulting in the selection of 19 studies.

The findings of this meta-analysis were presented in different ways. First, the percentages of agenesis reported in the present study were calculated as the number of children with one or more missing teeth, divided by the total number of children used in the sample. These data were presented graphically in chronological order.

Second, from these 19 studies, other interesting data concerning the pattern of possible regression of the human dentition were derived. Fourteen authors ordered their data by sex. It was another aim of this study to compare the occurrence of agenesis in boys and girls. Detailed information on the occurrence of tooth agenesis of upper and lower premolars and upper incisors was only available in 14 publications. For uniformity, data on the location of the missing tooth germs are reported: the percentages of agenesis per tooth was calculated as the number of missing teeth divided by the total number of agenetic teeth.

Results

To test the hypothesis that hypodontia has been observed more frequently over the past generations, the 19 articles selected based on the reported inclusion criteria are listed chronologically in Table 1. The earliest study available was published by Dolder (1936). From 10 000 children, 3.4 per cent had tooth agenesis. Recently, Aasheim and Øgaard (1993) examined 1953 children and found a prevalence of missing permanent teeth of 6.5 per cent. Between both extremes (1936 and 1993), most of the relevant studies were published around the 1970s. The percentage of missing teeth varies from 0.027 (Byrd, 1943) to 10.1 (Hunstadtbraten, 1973).

Chronological classification of the percentages reveals a remarkable increase in the number of children with congenital absence of one or more permanent teeth before 1956 (Figure 1).

Figure 2 represents graphically the evolution of the dentition of males and females between 1943 and 1993 (14 studies). For all of the 14 publications, differences between males and females were significant but limited. Compared with young boys, girls were found to have slightly more agenetic teeth in all but one study (Hunstadtbraten, 1973), where the percentage of boys was far higher than the other reported figures.

Figure 3 illustrates the occurrence of agenesis for the most frequently missing teeth in the selected articles (see Table 2). Besides agenesis of the third molars, generally accepted as the most often reported missing teeth, agenesis of second premolars and upper lateral incisors occurred most often. According to the consulted articles, the percentage of missing upper first premolars was the lowest, whereas the second lower premolars were more often missing than the upper second premolars. Although agenesis of the lower second premolars was most frequently reported, only three studies showed the highest percentage for missing upper lateral incisors.

Discussion and conclusions

From 42 relevant studies over the past six decades, 19 could be used in this meta-analysis. The sample size of the reported studies varied between 1000 (Werther and Rothenberg, 1939) and 21 384 (Eidelman *et al.*, 1973). As all of the investigations reported percentages, and were therefore comparable, the weight of each study was considered equal on the basis of statistical analysis.

Author	Year of publication	Sample size	Prevalence (%)*	Male (%)*	Female (%)*	Age
Dolder	1936	10.000	3.4	nr	nr	6–15
Werther and Rothenberg	1939	1000	2.3	nr	nr	3-15
Byrd	1943	2835	<0.1	<0.1	<0.1	4-14
Grahnén	1956	1006	6.1	nr	nr	11–14
Volk	1963	15 294	6.4	5.6	7.3	6-15
Davies	1968	2170	5.9	5.3	6.7	14
Helm	1968	1700	6.1	4.8	7.3	6–18
Muller et al.	1970	14 940	3.5	2.9	4.1	11-15
Egermark-Eriksson and Lind	1971	3327	6.3	4.9	7.7	10-16
McKibben and Brearly	1971	1500	5.5	5.2	5.7	3-12.5
Thilander and Myrberg	1973	5466	6.1	nr	nr	10-13
Hunstadbraten	1973	1295	10.1	11.8	8.4	7-14
Eidelman et al.	1973	21 384	4.6	4.4	4.8	12-18
Thompson and Popovich	1974	1191	7.4	6.0	8.9	6-12
Bergström	1977	2589	7.4	5.6	9.3	8–9
Magnussen	1977	1116	7.9	6.7	8.9	8-16
Rølling	1980	3325	7.8	7.7	7.8	9-10
Cua-Benward et al.	1992	1619	5.3	nr	nr	6.5-32
Aasheim and Øgaard	1993	1953	6.5	5.8	7.2	9

 Table 1
 Publications selected on the reported inclusion criteria.

nr, not reported.

*Number of children with missing teeth divided by the total number of children in the sample.



Figure 1 The prevalence of children with one or more agenetic teeth from 1935 to 1993. *The number of children with one or more missing permanent teeth divided by the total number of children in the sample.



Figure 2 The prevalence of agenesis in the male and female populations. *The number of boys/girls with one or more missing teeth divided by the total number of children in the sample.

Agenesis per tooth



Figure 3 The prevalence of agenesis of the upper and lower second premolars, upper lateral incisors and upper first premolars in the selected articles. *The number of missing teeth divided by the total number of agenetic teeth.

 Table 2
 The prevalence of agenesis of the upper and lower second premolars, upper lateral incisors and upper first premolars in the selected articles.

Author	Year of publication	<u>2 2</u> *	515*	<u>5 5</u> *	<u>4 4</u> *
Dolder	1036	12	47	25	6
Werther and Rothenberg	1930	30	47	15	3
Byrd	1943	17	57	15	3
Volk	1963	22	43	24	3
Muller <i>et al.</i>	1970	47	36	20	nr
McKibben and Brearly	1971	20	59	13	nr
Thilander and Myrberg	1973	20	40	32	nr
Hunstadbraten	1973	12	46	28	nr
Thompson and Popovich	1974	23	35	16	nr
Bergstrom	1977	23	41	18	1
Magnussen	1977	14	53	19	5
Rølling	1980	19	42	25	3
Cua-Benward et al.	1992	41	29	10	nr
Aasheim and Øgaard	1993	16	50	20	1

nr, not reported.

*Number of missing teeth divided by the total number of missing teeth.

Van der Linden (1994) and DuBrul (1980) found evidence that crypt formation of the permanent second lower premolars starts when a child is only 9 months of age. Calcification of the crown starts at the age of 3 years and is generally complete at 6 years. Because most studies where younger children were considered were published in the first half of the 20th century, an overestimation of the amount of hypodontia in the earlier studies is to be expected. Therefore, investigations incorporating 3-year-old children were not excluded in this analysis. Moreover, Wisth et al. (1974) proved that the prevalence of agenetic teeth is higher when examined at the age of 7 years compared with 9 years of age. At 7 years, 7.1 per cent of the children had missing teeth, while 2 years later hypodontia was diagnosed in only 6.6 per cent of the same sample.

Looking at the data, the majority of the studies on this issue were published in the 1970s, while only a few studies date from the first half of the 20th century. Moreover, a period of six decades is very short to investigate an evolutionary trend in the human dentition. If dental practitioners claim they have seen more and more patients with hypodontia in the latest decades, this can be ascribed to a sudden jump in the prevalence of missing teeth since 1956, rather than a gradual change. Possible explanations for this finding could be an improvement in imaging over the years and increasing dental awareness. As a result, the true prevalence could have remained unchanged while reported prevalences will have increased. Another possible explanation for this sudden increment could be a yet unidentified environmental factor influencing the phenotype (Brook, 1984).

The percentage of prevalence varies in similar samples from 0.027 to 10.1, and is in all but one of the studies slightly higher for girls than for boys. Although agenetic lateral incisors and missing upper second premolars are often diagnosed, in most of the studies used in this meta-analysis it was concluded that except for the third molars, the lower second premolar is the tooth most frequently missing.

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