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Prevalence of Hypodontia and Associated Dental Anomalies

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ABSTRACT

The individuals with hypodontia were 859 (8.28%). The most frequently missing teeth were lower second premolars (29.40%), upper second premolars (25.16%), lower central incisors (19.11%) and upper lateral incisors (16.47%). Dental anomalies including ectopic maxillary canine, microdontia, rotation of premolar, taurodontism, short root anomaly, invagination in incisiors, and malformed teeth in individuals affected with hypodontia were found at higher frequency than those without hypodontia. The association between ectopic maxillary canine and maxillary lateral incisor or mandibular second premolar agenesis was found, with 20.9% and 18.7%, respectively. These results indicate that dental anomalies in human are associated with hypodontia.

Keywords: Hypodontia, Prevalence, Dental Anomaly, Tooth Agenesis.

Article Information

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INTRODUCTION

Hypodontia is the congenital absence of one or more (up to six) permanent and/or deciduous teeth, being one of the most common alterations of the human dentition. Hypodontia does not represent a serious public health problem, but it may cause masticatory and speech dysfunctions, and esthetic problems. Hypodontia, the term congenitally missing teeth, is often used synonymously with tooth agenesis. It has a multifactorial aetiology involving both genetic and environmental factors [(1)].

Hypodontia is a subject that has been widely reported in different parts of the world **(Table 1)** [(2-10)]. The prevalence of tooth agenesis varied from 2.8% in the Turkish [(5)] to 11.3% in the Irish population [(3)]. In most reports [(5-7,10)], the prevalence of dental agenesis in females was always higher than in males; however Laganà et al. [(4)], Gupta et al. [(8)] and Hagiwara et al. [(9)] reported that there was no significant a difference based on sex. The types of teeth reported missing varied in different ethnic groups. In Europeans, the mandibular second premolar was most frequently absent, followed by the maxillary lateral incisor and second premolar [(3,4)]. In the Turkish [(5)], Jordan [(7)] and Indian populations[(8)], the most frequently missing tooth was the maxillary lateral incisor; and, in Chinese, it was the mandibular central and lateral incisors[(6)].

Many dental anomalies have been reported to associate with hypodontia: small tooth size, malposition of canine, short root anomaly, invaginations in incisors, taurodontism, and rotation of premolars and maxillary lateral incisors [(1,7,11,12)]. These dental anomalies commonly appear together in the same patient. Malposition of the human canine and agenesis of at least 1 tooth (hypodontia) were abnormalities known to occur together frequently. Garib et al. [(12,13)] found that the patients with agenesis of maxillary lateral

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incisors and mandibular second premolars had an increased prevalence of ectopic maxillary canines. Although previous studies reported associations between tooth agenesis and other dental anomalies, the studies that have evaluated the association between most missing teeth and ectopic maxillary canines occurring significantly in large sample of subjects with congenitally missing teeth are rare.

Therefore, this study aimed to determine the prevalence of hypodontia, to evaluate the frequencies of other dental anomalies in patients with tooth agenesis, comparing these frequencies with those in general population, and to analyze the association between tooth agenesis and ectopic maxillary canines. The hypothesis was that subjects with tooth agenesis have significantly increased prevalence of other dental anomalies.

MATERIAL AND METHODS

The study was based on dental history, clinical examination and evaluation of dental casts and panoramic radiographs of 10377 young adults (5520 males, 4857 females), who visited the dental clinic at Pyongyang University of Medical Sciences, DPR Korea, between October 2023 and December 2024, after obtaining their informed consent. They were aged between 14 and 25 years. The subjects or their guardians accepted their participation after receiving information on the study protocol. Other conditions that had to be ruled out before a definitive diagnosis could be made were premature loss of teeth due to extractions or trauma in question. Third molars were excluded because reliable data on them were only partly available. This study was analyzed and approved by the Ethics Committee of the Institute of Dentistry, Pyongyang University of Medical Sciences, and followed the guidelines of the Helsinki Declaration.

A comprehensive clinical examination was carried out to identify the presence of selected anomalies. The following developmental dental anomalies were assessed: ectopic maxillary canines, rotation of premolars, taurodontism, microdontia, short root anomaly, malformed teeth, invagination in incisors, and impaction. The condition wherein a maxillary canine did not follow its normal eruption path, with asymmetry between the right and left maxillary canines, was considered to represent an ectopic maxillary canine [4]. Rotation of premolar was considered as any evident(at least 20°) mesiolingual or distolingual intra-alveolar displacement of premolar around its longitudinal axis [8]. If the distance from the lowest point of the roof of the pulp chamber (A) to the highest point of the floor (B) divided by the distance from A to the root apex was equal to or greater than 0.2, and when the distance from B to the cementoenameljunction (CEJ) was greater than 2.5mm, the tooth is considered a taurodontism [8].

When gross deviation in size easily discernible by clinical judgment was accepted or the mesiodistal width of the crown was less than that of the opposing mandibular lateral incisor, the tooth was evaluated as microdontia [7,8]. Short root anomalies were determined by radiological evaluation comparing with normal root length. The lingual pit(foramen cecum) and teeth, which showed radiographically distinct enamel notching, were recorded as invagination [11]. The tooth was categorized as impacted when the eruption of the tooth was interfered with by an adjacent tooth, bone, or soft tissue [8]. The significance of the differences in observed frequencies was assessed by the odds ratio and chi-square test with 95% confidence interval. Analysis was carried out in Excel 2010(Microsoft Office, Microsoft Corporation, USA). Data collected were entered into a spreadsheet (Excel 2010; Microsoft Office, Microsoft Corporation, USA) and statistical analysis was performed with the Statistical Package for Social Sciences (Window version 9.0; SPSS Inc., Chicago, IL, USA).

RESULTS

Among the 10377 young adults, the patients with hypodontia was 859 (8.28%), male 451 (8.17%), female 408 (8.40%) **(Figure 1)**. There was no significant difference between genders as determined by chi-square test (P=0.671). Number of total missing teeth of patients with hypodontia was 1439 **(Table 1)**.

When the distribution of hypodontia in both dental arches was evaluated, we found that the most frequently missing teeth were MnP2 (29.40%), following MxP2 (25.16%), MnI1 (19.11%) and MxI2 (16.47%). On the other hand, the least frequent congenitally missing teeth were upper central incisors (0.28%), lower first molars (0.42%), and upper first molars (0.49%) **(Table 2)**.

In the present study, Ectopic maxillary canine was the most prevalent dental anomaly, followed by rotation of premolar, microdontia, taurodontism, malformed tooth, invagination in incisor, short root anomaly and impaction **(Table 3)**.

Ectopic maxillary canine was seen in individuals (11.4%) with hypodontia, which was 2.6 times the prevalence (4.4%) of the individuals without hypodontia and was statistically significant (P<0.001). Rotations of premolar was more frequently in individuals (8.0%) with hypodontia than in individuals (3.6%) without hypodontia (P<0.001). The frequency (4.8%) of microdontia in individuals with hypodontia exceeded 1.8 times the frequency (2.7%) in individuals without hypodontia, and there was a significant difference (P<0.001). Taurodontism was assessed in 34 (4.0%) individuals with hypodontia, which was 1.6 times individuals without hypodontia and was statistically significant (P=0.009). Likewise the frequency of short root anomaly, malformed teeth and invagination in incisors in individuals with hypodontia were significantly higher than in individuals without hypodontia (P=0.043, 0.0398 and 0.044, respectively). However, impaction in individuals with hypodontia was more frequent than in individuals without hypodontia, though the difference was statistically insignificant. Therefore odds ratio to occur ectopic maxillary canine, microdontia, rotation of premolar, taurodontism, short root anomaly, invagination in incisors and malformed teeth in individuals with hypodontia were 2.14, 1.83, 1.65, 1.62, 1.59, 1.57 and 1.55, respectively.

Out of 859 subjects with hypodontia, 253 (29.5%) exhibited at least one dental anomaly. Approximately, 19.7% showed only one anomaly, 8.4% two anomalies, while only 1.4% had more than two anomalies **(Figure 2)**.

Ectopic maxillary canine was the most frequent dental anomaly in the present study. The association between teeth of high prevalence of hypodontia and ectopic maxillary canines in individuals with hypodontia was seen in **(Table 4)** . The individuals with agenesis of maxillary lateral incisor and mandibular second premolar had ectopic maxillary canines frequencies of 20.9% and 18.7%, respectively, which were statistically significant (p=0.023, 0.043).

Table 1. Comparison of findings on prevalence of hypodontia in various populations.

Nationality of subjects	Author	No. of subjects	Prevalence total (female:male)	Most/second most frequently missing teeth
Kenya[c]	Ng'ang'a and Ng'ang'a (2001)	615*	6.3% (0.7:1)	35,45/12,22
Irish	O'Dowling and McNamara (1990)	3056*	11.3% (1.2:1)	35,45/12,22
Italian[a]	Laganà et al. (2017)	4706†	7.1% (1:1)	35, 45/12, 22
Turkish	Altug-Atac and Erdem (2007)	3043*	2.8% (1.29:1)	12,22
Chinese[c]	Davis (1987)	1093*	6.9% (1.27:1)	31,41/32,42

Nationality of subjects	Author	No. of subjects	Prevalence total (female:male)	Most/second most frequently missing teeth
Jordan	Al-Abdallah et al. (2015)	3315*	6.5% (1.55:1)	12,22/35,45
Indian	Gupta et al. (2011)	1123*	4.19% (0.99:1)	12,22/31,41
Japanese[c]	Hagiwara et al. (2015)	9584†	3.88%(1.04:1)	35, 45/15, 25
Mexican	Herrera-Atoche et al. (2014)	670*	5.82%(1.78:1)	35,45/32,42

*[a] Caucasian, [b] Asian, [c] Negro, * Referral/clinical studies, † Population studies*
Excluding criteria; third molars, agenesis of primary teeth.

Table 2. Prevalence of hypodontia by tooth type (n=1439).

Jaw	Central incisor(%)	Lateral incisor(%)	Canine(%)	Frist premolar(%)	Second premolar(%)	First molar(%)	Second molar(%)
Maxilla	4 (0.28)	237 (16.47)	31 (2.15)	14 (0.97)	362 (25.16)	7 (0.49)	11 (0.76)
Mandible	275 (19.11)	24 (1.67)	12 (0.83)	16 (1.11)	423 (29.40)	6 (0.42)	17 (1.18)

Table 3. Comparative analysis on prevalence of dental anomalies between in individuals with hypodontia and without hypodontia using p values from Chi-square test.

Dental anomalies types	Individuals with hypodontia N(%)	Individuals without hypodontia N(%)	OR	95% CI	P-value
Ectopic maxillary canine	98(11.4)	421(4.4)	2.78	2.21-3.51	<0.001
Rotation of premolar	69(8.0)	347(3.6)	2.31	1.77-3.02	<0.001
Taurodontism	34(4.0)	236(2.5)	1.62	1.12-2.34	0.009
Microdontia	41(4.8)	254(2.7)	1.83	1.30-2.56	<0.001
Short root anomaly	22(2.6)	155(1.6)	1.59	1.01-2.50	0.043
Malformed tooth	27(3.1)	193(2.0)	1.55	1.02-2.35	0.038
Invagination in incisor	23(2.7)	164(1.7)	1.57	1.01-2.44	0.044
Impaction	18(2.1)	127(1.3)	1.58	0.96-2.61	0.069

OR, odds ratio; CI, Confidence interval.

Table 4. Association between the most frequently missing teeth and maxillary ectopic canines calculated by Chi-squared test.

Most frequently missing teeth	Individuals with hypodontia	Mx ectopic canines	Prevalence rate	P-value
Mx lateral incisor	148	31	20.9%	0.023
Mx second premolar	197	21	10.7%	0.057(NS)
Mn central incisor	183	20	10.9%	0.089(NS)
Mn second premolar	251	47	18.7%	0.043

Mx=Maxillary; Mn=Mandibular; NS, Not significant.

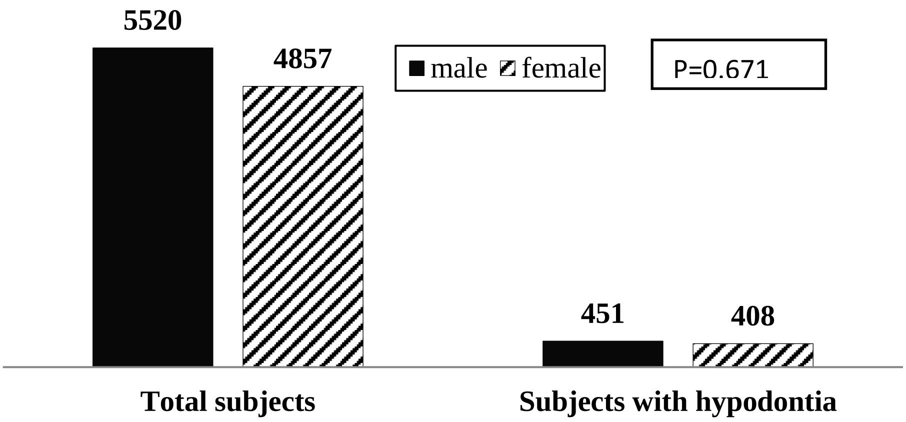

Figure 1. Prevalence of hypodontia in total subjects.

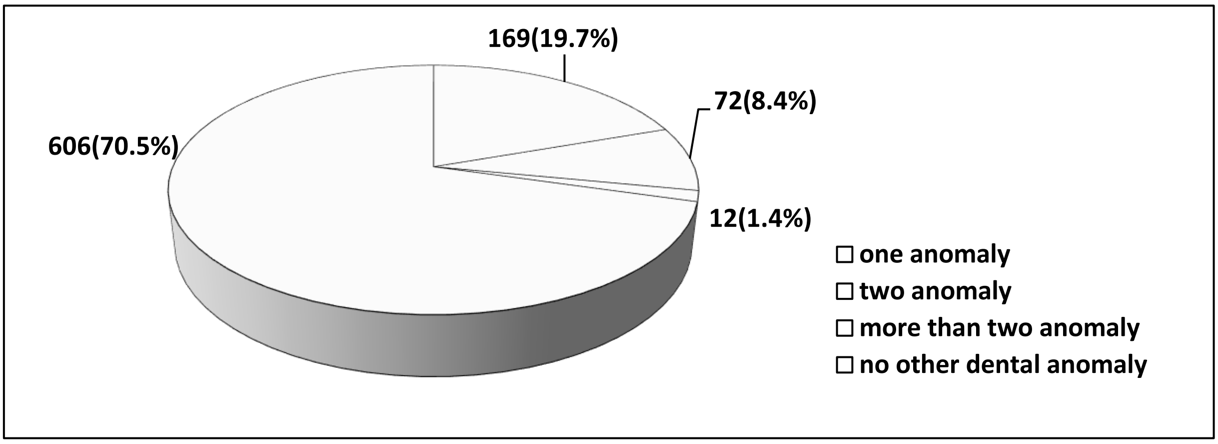

Figure 2. Frequency by number of other dental anomalies in the same subjects with hypodontia.

DISCUSSION

Hypodontia, or tooth agenesis, is one of the most common abnormalities of the human dentition and has a critical and often lifelong impact on the oral health of affected individuals. The prevalence of tooth agenesis, the proportion of a population who are diagnosed as having at least one congenitally missing tooth at one point in time, varies highly between studies [2-10]. This could be attributed to different study designs and racial background. Khalaf et al. [14] found that the highest prevalence of hypodontia is in Africa, followed by Europe, then Asia and Australia, and lastly North America (Caucasians) by meta-analysis on the prevalence of non-syndromic tooth agenesis, which included different studies. This suggests that genetic background may influence the expression of the trait.

(Table 1) summarized the results from studies previously published on the prevalence of congenital absence of permanent teeth [2-10]. In present study, the prevalence of hypodontia was 8.28% **(Figure 1)**, which was higher than the prevalence rates (3.88%, 6.9%, respectively) reported by Hagiwara et al. [10] and Davis [7]. While there was no significance between genders, which agreed with some studies [4,8,9]. The prevalence identified in the present study was higher than all of these, which could be explained by evolution of jaws and teeth. The more distal teeth in each field were less genetically stable, and could become obsolete during the evolution process [15]. Therefore, human dentition appears to reduce by decreasing of the size of the jaws and the number of teeth, as humans evolve. To confirm prevalence of hypodontia by tooth type is important for explaining the specific tendency in development of hypodontia. The teeth most frequently missing in Korean young adults were the lower second premolars, followed by the upper second premolars and then mandibular central incisors **(Table 2)**. Some studies in **(Table 1)** reported that the most frequently missing teeth were mandibular second premolars and followed by maxillary lateral incisors (2-4). However, Hagiwara et al. (9) reported that the teeth most frequently missing in Japanese school students were the lower second premolars, followed by maxillary second premolars and then upper lateral incisors, and a study (6) of Chinese subjects showed the highest prevalence among mandibular central incisors, followed by mandibular lateral incisors. In most studies, it is apparent that the most common congenitally missing teeth are mandibular second premolars, followed by maxillary lateral incisors or maxillary second premolars. Both the lateral incisor and second premolar are the most distal teeth to develop in their specific family of teeth, which suggests that the last teeth to develop in a specific morphogenetic field may fall below a developmental threshold, putting them at a greater risk for agenesis. Moreover, mandibular central incisors seemed to be the common missing teeth in Asian populations (6,8). These conflicting results can be explained primarily by racial differences, study designs, local environmental influences and nutrition. Hypodontia didn't occur separatively, and it tended to occur in association with various dental abnormalities. In this study, a strong association between hypodontia and dental anomalies such as ectopic maxillary canines, rotated premolar and microdontia was found **(Table 3)**.

The prevalence rate (11.4%) of ectopic maxillary canine in subjects with hypodontia was nearly 2.6 times higher compared to that in subjects without hypodontia. It has been reported that it was more common in individuals with hypodontia, with prevalence rate of 6% in a sample of 78 patients (11). Microdontia that presents in the severest form of ectodermal dysplasia (15) is a widely reported feature of hypodontia in case reports and case series. Brook (16) proposed that microdontia and hypodontia are linked genetically as a continuum of tooth size, where a tooth will fail to develop if the tooth germ does not reach a particular tooth size and tooth number "thresholds". In the present study, the prevalence of microdontia in subjects with hypodontia was 4.8%, a 1.8-fold increased prevalence (OR, 1.83) compared with the non-hypodontia subjects. These results corroborate previous studies (16) and suggest that tooth agenesis and microdontia are different expressions of the same genetic defect, since these phenotypes are frequently associated.

Our results showed that 8% of the patients with hypodontia have rotation of premolars, a 2.2-fold increased prevalence (OR, 2.31) compared with the non-hypodontia subjects. Arte et al. (11) reported that the frequency of rotated premolars in the individuals with hypodontia exceeded 2~3 times that of the population. We could guess that rotation of premolars represented a different phenotype of the same genetic defect causing the tooth agenesis.

The prevalence of taurodontism was found to be 4% in hypodontia group. An association between taurodontism and hypodontia was found in a Dutch study, where taurodontism was present in 29% of patients with congenitally missing teeth but only 10% of controls (17). This is significantly higher than ours (4%) and it could be due to racial difference and differences in diagnostic methods.

In this study, malformed teeth, short root anomaly and invagination in incisors were rare finding and showed a weak association with hypodontia group. In addition, we could not confirm the association of impaction with hypodontia. These findings may suggest that the anomalies have independent genetic pathways and different etiologic factors than those for tooth agenesis.

Although there is a significant difference between the frequency of dental anomalies observed in individuals with hypodontia in the present study and those reported in previous epidemiological studies [4,7,8,10,11], it is consistent that dental anomalies such as ectopic maxillary canines, rotation of premolar, taurodontism and microdontia are significantly more common in hypodontia group compared with non-hypodontia group. The dissimilarity could be attributed to differences in racial background, diagnostic criteria, study design and assessed teeth. Our results support the findings of previous studies showing other physical dental traits associated with the occurrence of tooth agenesis. It contributes to mounting evidence that tooth agenesis and its associated abnormalities are under genetic control. The possible explanation is that a single genetic defect may give rise different anomalies, so that two or more dental anomalies in the same patient may present a common genetic origin [12,13].

The prevalence of the subjects with at least a single other dental anomaly in hypodontia group was 29.5% **(Figure 2)**, which was higher than that reported (20.9%) in randomly selected subjects-studies by Laganà et al. [4] and showed significant associations between hypodontia and other dental anomalies.Our study indicated significantly elevated prevalence rates for congenital missing teeth in association with ectopic maxillary canines which was the most common anomaly. Ectopic maxillary canines appeared to be associated with conspicuously increased MxI2 agenesis($p=0.023$), representing the anterior orofacial field, and MnP2 agenesis seemed to represent an intermediate field, found in significantly elevated frequency of ectopic maxillary canines ($p=0.043$) **(Table 4)**.

These findings of anterior and intermediate orofacial field specificity are strengthened data for statistically significant associations of MxI2 and MnP2 agenesis with ectopic canines. Garib et al. [12] reported an increased prevalence of ectopic maxillary canines in a sample of subjects with maxillary lateral incisor agenesis, compared with a control group. Similarly, Garib et al. [13] showed significant correlations between agenesis of mandibular second premolars and ectopic canines with chi-square values of 28.02, compared with the control group. Currently, 2 theories explained the occurrence of ectopic maxillary canine. Becker [18] proposed that local factors such as maxillary lateral incisor agenesis are the major etiologic factors of maxillary canine ectopic eruption because the roots of maxillary lateral incisors work as guides for maxillary canine eruption. Another explanation for the occurrence of ectopic maxillary canine is the genetic theory [19]. Peck et al. [19] compiled that maxillary lateral incisor agenesis and ectopic maxillary canine might share a common genetic background. These findings support the results of our study and indicate that absence of maxillary lateral incisors and mandibular second premolars might be an early risk indicator for ectopic maxillary canine development. Thus, early detection of associated ectopic maxillary canines, based on MxI2 and MnP2 agenesis, could permit early intervention, since patients with agenesis of maxillary lateral incisor and mandibular second premolar have a considerable chance of developing ectopic eruption of maxillary canines during the late mixed dentition period [20]. However, it is controversial whether the primordial cells develop in the ectopic position or whether the tooth germs develop correctly and subsequently move to transposed positions. A deficiency in the cell signalling process of teeth could cause the tooth germs to migrate in the wrong direction. The genes responsible for ectopic canines are associated with osteoclast/osteoblast function. These genes seem to be linked with the genes causing hypodontia.

Studies of odontogenesis at the molecular level indicate that the development of teeth is under strict genetic control, which determines the positions, numbers, and shapes of different teeth [21]. Mutations of several gens that are necessary for tooth development, have been shown to cause tooth agenesis [1,22]. MSX1 as candidate gene for specification of the posterior developmental field is the powerful regulator of M3 and MnP2 agenesis [23]. PAX9 associated with tooth bud positioning at the mesenchymal level could be significant in the elucidation of genetic mechanisms for tooth displacement anomalies, such as ectopic canines [24].

Transcription factors such as MSX1 and PAX9 might be components in the genetic control of canine malposition.In summary, the clinical implications of patterns of associated dental anomalies are important, since early detection of a single dental anomaly (such as the emergence of agenesis of maxillary lateral incisor and mandibular second premolar) may call the attention of professionals to the possible development of other associated anomalies in the same patient or in the family, allowing timely orthodontic intervention. Although several researchers have determined the prevalence of hypodontia, none have statistically analyzed the prevalence and distribution of hypodontia and dental anomalies in Korean population.

CONCLUSION

Early detection of the number of missing teeth and evaluation of developmental dental anomalies is of usefulness in the planning and managing treatment with a multidisciplinary team approach to achieve an aesthetic and functional dentition and reduce the complication of hypodontia like malocclusion.Investigating patterns of congenitally absent teeth could both increase understanding of the condition and contribute to identifying the etiology of hypodontia and the selection of patients for future genetic studies. When clinical and genetic results are combined, classification of the different forms of hypodontia will become more exact.

Points to remember

1. The prevalence of hypodontia in young adults, DPR Korea has been shown to be 8.28%.
2. Hypodontia seen mostly in lower second premolars, followed by upper second premolars, lower central incisors and upper lateral incisors and few percentage for upper central incisors, lower first molars and upper first molars.
3. Dental anomalies, such as ectopic maxillary canine, rotated premolar, microdontia and taurodontism were found more frequently in the hypodontia group than the control group. The difference was statistically significant.
4. There was a significant association between ectopic maxillary canines and agenesis of maxillary lateral incisors or mandibular second premolars.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

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