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ORIGINAL ARTICLE

Dental anomaly patterns associated with tooth agenesis

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ABSTRACT

Objective: The objective of this study is to evaluate the relationship between tooth agenesis and the occurrence of other dental anomalies in children and adolescents.

Material and methods: Panoramic radiographs of 195 subjects with tooth agenesis, except for the third molar, were retrospectively examined and compared with a non-agenesis control group of 600 subjects. Their ages ranged from 7 to 15 years. Panoramic and periapical radiographs were used to analyze the presence of other associated dental anomalies. The occurrences of these anomalies were compared with those in the non-agenesis group.

Results: Subjects with tooth agenesis showed a significantly higher prevalence of a small maxillary lateral incisor (17.7%), distoangulation of the mandibular second premolar (6.5%), delayed development of a permanent tooth (10.8%), and hypo-occlusion of a primary molar (11.8%). In contrast, the prevalence of a supernumerary tooth was higher in the control group, and no difference was observed in the prevalence of ectopic eruption of a first molar. According to the agenesis area, microdontia of the maxillary lateral incisors occurred more often in patients with anterior or premolar agenesis than in the molar agenesis groups. Distoangulation of the mandibular second premolars, delayed tooth development, and hypo-occlusion of the primary molars were associated with premolar tooth agenesis.

Conclusions: A small maxillary lateral incisor, distoangulation of the mandibular second premolar, delayed development of a permanent tooth, and hypo-occlusion of a primary molar were frequently associated with tooth agenesis, providing additional evidence of a genetic interrelationship in the causes of these dental anomalies.

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Introduction

Congenital tooth agenesis, which is a developmental dental anomaly, causes aesthetic problems, dislocation of non-affected teeth, lack of alveolar bone, as well as malocclusion [1]. Therefore, early intervention and appropriate treatment plans are required [2,3]. Moreover, tooth agenesis is frequently associated with other dental anomalies, and genetic factors play a fundamental role in its aetiology [4]. Previous studies demonstrated that dental anomalies such as tooth agenesis, microform teeth, delayed tooth development, palatally displaced canines (PDCs), hypo-occlusion of the deciduous molars, and distoangulation of the mandibular second premolars have been found to occur together much more frequently than would be expected by chance alone [5–13]. Combinations of these occurrences were named dental anomaly patterns (DAPs) by Peck [14].

Several genes have been identified by mutational analysis as the major causes of non-syndromic hypodontia. For instances, a mutation in the MSX1 gene was identified in a family with hypodontia of permanent second premolars and third molars [15]. Another study confirmed that a mutation of the EDA gene may be associated with a specific form of hypodontia that affects mainly incisors [16]. Because a genetic relationship between different dental anomalies has been proposed [5], investigating patterns that occur in patients with tooth agenesis and other accompanying dental anomalies may facilitate early diagnosis and comprehensive treatment planning. Nonetheless, few epidemiological studies have been carried out in an Asian population to establish DAPs. Therefore, this study aimed to investigate the characteristics of tooth agenesis by assessing the prevalence of tooth agenesis in Koreans, relationships with other dental anomalies, and different DAPs observed according to the location of tooth agenesis.

Material and methods

In all, 2197 patients with mixed to permanent dentition who presented to Wonkwang University Daejeon Dental Hospital, Daejeon, Korea, from July 2010 to June 2015 for regular oral and orthodontic checkups were selected based on the presence of panoramic radiographs and medical records. Subjects with systemic disease with oral repercussions, trauma, history of extraction of the permanent dentition, or prior orthodontic treatment were excluded. Finally, 195 Koreans with tooth agenesis, except for the third molar, were included in the study. The study group consisted of 98 female and 97 male patients. As controls, 600 age- and sex-matched patients

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Table 1. Demographics of children with tooth agenesis and the control groups.

	Sex	*N*	Age (year) Mean ± SD
Children with tooth agenesis	Girls	98	10.1 ± 2.36
	Boys	97	9.9 ± 2.29
Control groups	Girls	300	10.2 ± 2.43
	Boys	300	9.7 ± 2.31

N: number; SD: standard deviation.

(300 female and 300 male) with no tooth agenesis were chosen randomly. The subjects ranged in age from 7 to 15 years at the time of construction of the diagnostic records used in this study. Table 1 summarizes the age and sex distribution of the subjects.

Panoramic radiographs were used to investigate the presence of the following anomalies. Periapical radiographs were additionally examined when panoramic radiographs were insufficient.

Agenesis of permanent teeth except for the third molars

The critical age of 10 years was considered to be confirmation of the absence of a second premolar [17,18]. This criterion was used to restrict the sample to only those with diagnostic records at greater or equal to 10 years of age. The prevalence and distribution of tooth agenesis were evaluated.

Microdontia of the maxillary lateral incisors

Microdontia was considered present when the maximum mesiodistal crown diameter was smaller than the same dimension of the opposing mandibular lateral incisor in the same patient [5]. Conical or peg-shaped maxillary lateral incisors were also included.

Ectopic eruption of unerupted first molars

Ectopic eruption can be distinguished into two types: (1) the reversible type, in which the molar frees itself and erupts as normal occlusion and (2) irreversible ectopic eruption, in which the first molars are unable to resorb the deciduous second molar root, which is retained and causes premature exfoliation of the primary molar or necessitates some type of treatment [6,19]. This study only included the irreversible type.

Distoangulation of the mandibular second premolars

Measurement of distoangulation of the mandibular second premolars followed the method suggested by Shalish et al. [20] by using the inferior border of the mandible as the baseline. Distal angulation of the mandibular second premolar of less than 60° was considered distoangulation [21].

Localized delayed development of permanent teeth

The developmental stages of teeth were evaluated using the method suggested by Demirjian [18], and compared with antimere or neighbouring teeth, while considering dental age. Only cases with localized delayed development of permanent teeth were included. Generalized late development of dentition was not included in this study.

Hypo-occlusion of the primary molars

The extent of hypo-occlusion on panoramic radiography was determined by measuring the distance between the occlusal tables and the occlusal plane. The line extending from the mesial marginal ridge of the first permanent molar to the cusp tip of the primary canine, following the arch, was considered the occlusal plane. When the primary canine was absent, the lateral permanent incisor was used to determine the occlusal plane. The occlusal table of the primary molars was constructed by drawing a line from the distal marginal ridge to the mesial marginal ridge of the primary molar [22,23]. A distance of more than 2 mm between the above two planes was considered hypo-occlusion.

The agenesis area was categorized into the anterior, premolar, and molar areas. The anterior area included the central incisor, lateral incisor, and canine, while the molar area included the first and second molars. The prevalence of dental anomalies according to the agenesis area was also investigated. Panoramic radiographs were assessed, and two investigators examined the records and diagnosed the dental anomalies simultaneously. Consensus was obtained in case of divergent diagnoses.

Statistical analysis

Even for the simultaneous occurrence of anomalies in the same subject, a diagnosis of dental anomalies was considered as a single statistical unit. The statistical analysis was performed using SPSS for Windows (ver. 23, IBM, Chicago, IL). The chi-squared test and Fisher's exact test were used to statistically compare the prevalence of dental anomalies associated with tooth agenesis. The significance level for statistical testing was set at 5% ($p < 0.05$). The odds ratio (OR) was calculated at 95% confidence intervals (CIs) to measure the strength of associations between tooth agenesis and other dental anomalies.

Results

The overall prevalence of tooth agenesis was approximately 9.0% (197/2197), and there were no significant gender differences.

Table 2 shows the prevalence of dental anomalies in subjects with tooth agenesis in comparison with the control group. In the sample of 195 patients with tooth agenesis, there was a significantly higher prevalence of microdontia of the maxillary lateral incisors (OR = 5.9), distoangulation of the mandibular second premolars (OR = 5.1), delayed development of permanent teeth (OR = 8.9), and hypo-occlusion of the primary molars (OR = 2.9). In contrast, the prevalence of supernumerary teeth was higher in the control group.

Table 2. Prevalence of dental anomalies in subjects with tooth agenesis compared with the control group.

Dental anomaly	Tooth agenesis group	Non-agenesis group	p Value	OR (95% CI)
Supernumerary tooth[a]	10.8% (21/195)	16.8% (101/600)	0.041*	0.596 (0.36–0.98)
Small Mx I2[a]	17.7% (32/181)	3.5% (21/600)	0.000**	5.921 (3.32–10.57)
Ectopic eruption of M1[a]	10.1% (13/129)	6.3% (23/367)	0.151	1.676 (0.82–3.42)
Distoangulation of MnP2[b]	6.5% (9/138)	1.3% (8/600)	0.001*	5.163 (1.96–13.64)
Delayed tooth development[a]	10.8% (21/195)	1.3% (8/600)	0.000**	8.931 (3.89–20.52)
Hypo-occlusion of primary molar[a]	11.8% (14/119)	4.3% (14/322)	0.005**	2.933 (1.35–6.36)

*$p < 0.05$. **$p < 0.01$.
[a]Chi-square test.
[b]Fisher's exact test.
Mx I2: maxillary lateral incisor; M1: first molar; MnP2: mandibular second premolar; OR: odds ratio.

Table 3. Number of subjects and prevalence of dental anomalies according to agenesis area.

	Agenesis area					
Dental anomaly	Incisors ($N = 94$)		Premolars ($N = 118$)		Molars except the third molar ($N = 8$)	
Small Mx I2	24.5%	0.000**	16.1%	0.000**	12.5%	0.257
Control prevalence value = 3.5%	(23)		(19)		(1)	NS
Distoangulation of MnP2	2.1%	0.633	5.9%	0.006††	12.5%	0.113
Control prevalence value = 1.3%	(2)	NS	(7)		(1)	NS
Delayed tooth development	4.3%	0.066	16.9%	0.000††	0.0%	0.899
Control prevalence value = 1.3%	(4)	NS	(20)		(0)	NS
Hypo-occlusion of primary molar	4.3%	1.000	11.0%	0.01*	12.5%	0.314
Control prevalence value = 4.3%	(4)	NS	(13)		(1)	NS

*$p < 0.05$, Chi-square test.
**$p < 0.01$, Chi-square test.
††$p < 0.01$, Fisher's exact test.
Mx I2: maxillary lateral incisor; M1: first molar; MnP2: mandibular second premolar.

The prevalence of ectopic eruption of the first molars was not different from the reference values observed.

In the study group, the number of subjects and prevalence of dental anomalies according to agenesis area are shown in Table 3. Microdontia of the maxillary lateral incisors occurred more often in patients with anterior or premolar agenesis than with molar tooth agenesis. The prevalence of distoangulation of the mandibular second premolars, delayed development of permanent teeth, and hypo-occlusion of the primary molars was significantly higher in the premolar agenesis group.

Discussion

Previous retrospective studies which investigated tooth agenesis, except third molars, reported that prevalence rates vary from 2.2% to 11.3% in different populations [4,24]. In this study, the prevalence of tooth agenesis in a Korean population was relatively high, approximately 9.0%.

In this study, we analyzed the association between tooth agenesis and other dental anomalies in children and adolescents by comparing them with an age- and sex-matched control group. Previous studies on DAPs designated their control groups according to the existing prevalence, although this method has a limitation. There are ethnic differences in the prevalence of tooth agenesis [4,24]; thus, this study used control groups from the same race and contemporary population.

Several studies did not find differences in the frequency of supernumerary teeth in subjects with tooth agenesis [5,7,25]. In this study, however, the prevalence of supernumerary teeth was higher in the control group. Compared with the incidence of mesiodens, reported as up to 3.5% [1], higher frequencies of supernumerary teeth were observed in both groups. This result might be because the evaluation was performed retrospectively rather than from a prospectively planned random sampling of the general population. To confirm this, future studies would need to select their control groups from more general populations.

In accordance with a previous study [12], the prevalence of microdontia of the maxillary lateral incisor in the agenesis group was significantly higher in this study. In addition, among the subgroup of incisor agenesis, significant association was only seen in this type of anomaly. Moreover, considering only the subsample with unilateral agenesis of the maxillary lateral incisor, 10 of 20 (50.0%) had microdontia of its antimere, which supports the findings of the classic association in the literature [26].

Several reports have provided varying opinions on the interrelation between tooth agenesis and ectopic eruption of permanent first molars [6,7,27]. In our study, the present data showed no difference in the prevalence of ectopic eruption of the first molars between the control and study groups. It appears that various local factors such as the tooth size-arch length discrepancy, location of the maxilla, and angle of the eruption path may contribute to inducing ectopic eruption of the first molar [1].

Symons and Taverne [28] observed distoangulation of the mandibular second premolar tooth bud and generalized delayed development in a family presenting with multiple teeth, which suggested the possibility of the same genetic aetiology. Using a sample of patients with unilateral agenesis of the mandibular second premolar, Shalish et al. [20] showed that the contralateral germ presented more than 10°

of distal angulation. The present data showed a significantly increased prevalence of mandibular second premolar distoangulation in patients with premolar agenesis. Although the previous studies support the existence of genetic influences in mandibular second premolar distoangulation, the criteria for mandibular second premolar distoangulation were not clearly defined in many studies, and the change in the tooth axis resulting from growth was overlooked. Wasserstein et al. [21] demonstrated that, given time and developmental changes, teeth become more upright. Moreover, 60° is the minimum value for the early stage of normal developing mandibular second premolars. Therefore, 60° was used as a basis for distoangulation of the mandibular second premolar in this study. Future studies will be required to ascertain the criterion that takes the tooth's developmental stage into account.

In accordance with previous studies [26,29,30], we found that the prevalence of localized delayed dental development was significantly higher in the tooth agenesis group, especially when premolar agenesis was present; 18 of 21 subjects with localized developmental delays had second premolar agenesis of its antimere. However, since second premolars present greater developmental variability, additional studies will be required to determine whether developmental delay indicates incomplete expression of the same gene in tooth agenesis.

The results of the present study correspond with those of earlier studies, which reported an association between tooth agenesis and hypo-occlusion of primary molars [7,8,31]. In particular, 13 of 14 patients with hypo-occlusion had second premolar agenesis. These findings demonstrate that agenesis of the second premolar is strongly interrelated with hypo-occlusion of the primary molars.

Recently, direct evidence was gathered for the genetic basis of tooth agenesis, thanks to the mapping of human disease genes [32]. The site of agenesis occurs variably depending upon the affected genes and types of mutations. The aforementioned DAPs seem to be a result of defects in a specific gene being expressed in various ways and causing various types of dental anomalies [5–13]. When the occurrence of dental anomalies was analyzed according to the number of congenitally missing teeth, no particular tendency was found; based on such results, genetic influences on dental anomalies including tooth agenesis seem to be location specific.

Interestingly, the aforementioned dental anomalies were apparently associated with premolar agenesis. Agenesis of incisors only has a significant association with microdontia of maxillary lateral incisors. Considering the affected regions of individual anomalies, it appears that the concomitant occurrence of dental anomalies including tooth agenesis has site-specific patterns.

However, no differences were found in the frequency of dental anomalies between the control and molar agenesis group. Since agenesis in the molar region is infrequent [33], it is difficult to conclude that the relation of permanent molar agenesis and DAPs is independent. To confirm this, further genetic studies focusing on site-specific expression of tooth agenesis and associated dental anomalies are needed to fully elucidate the genetic mechanism of DAPs.

Clinically, when multiple dental anomalies are present, multidisciplinary treatment plans should be considered. Therefore, early diagnosis is essential to establishing a comprehensive treatment plan. The present study suggests the possibility that other accompanying dental anomalies can be predicted earlier through DAPs. As hypo-occlusion of the deciduous molars and microdontia of the lateral incisors can be observed in early mixed dentition, it would provide clues to detecting related dental anomalies in earlier phases.

The limitations of this study include a small number of subjects with molar agenesis, and that panoramic radiographs were used as the main diagnostic tools. Although this study suggests the presence of genetic influences in DAPs, further familial and genetic research is required to fully elucidate the genetic influences on the concomitant occurrence of dental anomalies.

In conclusion, microdontia of the maxillary lateral incisors, distoangulation of the mandibular second premolars, delayed development of permanent teeth, and hypo-occlusion of the deciduous molars were associated with congenital tooth agenesis; furthermore, we could confirm that location-specific patterns existed in which different dental anomalies occur simultaneously.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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References

[1] McDonald RE, Avery DR, Dean JA. McDonald and Avery's dentistry for the child and adolescent, 9th ed. St. Louis (MO): Mosby Elsevier; 2011. p. 109, 590–598.
[2] Grahnén H. Hypodontia in the permanent dentition: a clinical and genetical investigation. Odontol Revy. 1956;7:1–100.
[3] Fekonja A. Hypodontia in orthodontically treated children. Eur J Orthod. 2005;27:457–460.
[4] Larmour CJ, Mossey PA, Thind BS, et al. Hypodontia – a retrospective review of prevalence and etiology. Part I. Quintessence Int. 2005;36:263–270.
[5] Garib DG, Peck S, Gomes SC. Increased occurrence of dental anomalies associated with second-premolar agenesis. Angle Orthod. 2009;79:436–441.
[6] Bjerklin K, Kurol J, Valentin J. Ectopic eruption of maxillary first permanent molars and association with other tooth and developmental disturbances. Eur J Orthod. 1992;14:369–375.

[7] Baccetti T. A controlled study of associated dental anomalies. Angle Orthod. 1998;68:267–274.

[8] Shalish M, Peck S, Wasserstein A, et al. Increased occurrence of dental anomalies associated with infraocclusion of deciduous molars. Angle Orthod. 2010;80:440–445.

[9] Peck L, Peck S, Attia Y. Maxillary canine-first premolar transposition, associated dental anomalies and genetic basis. Angle Orthod. 1993;63:99–109.

[10] Langberg BJ, Peck S. Tooth-size reduction associated with occurrence of palatal displacement of canines. Angle Orthod. 2000;70:126–128.

[11] Peck S, Peck L, Kataja M. Prevalence of tooth agenesis and peg-shaped maxillary lateral incisor associated with palatally displaced canine (PDC) anomaly. Am J Orthod Dentofacial Orthop. 1996;110:441–443.

[12] Baccetti T. Tooth anomalies associated with failure of eruption of first and second permanent molars. Am J Orthod Dentofacial Orthop. 2000;118:608–610.

[13] Peck S, Peck L, Kataja M. Concomitant occurrence of canine malposition and tooth agenesis: evidence of orofacial genetic fields. Am J Orthod Dentofacial Orthop. 2002;122:657–660.

[14] Peck S. Dental Anomaly Patterns (DAP): a new way to look at malocclusion. Angle Orthod. 2009;79:1015–1016.

[15] Mostowska A, Biedziak B, Jagodzinski PP. Novel MSX1 mutation in a family with autosomal-dominant hypodontia of second premolars and third molars. Arch Oral Biol. 2012;57:790–795.

[16] Rasool M, Schuster J, Aslam M, et al. A novel missense mutation in the EDA gene associated with X-linked recessive isolated hypodontia. J Hum Genet. 2008;53:894–898.

[17] Demirjian A, Nyström M, Chaillet N. Comparison of dental maturity in children of different ethnic origins: international maturity curves for clinicians. J Forensic Sci. 2005;50:1–11.

[18] Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45:211–227.

[19] Kurol J, Bjerklin K. Resorption of maxillary second primary molars caused by ectopic eruption of the maxillary first permanent molar: a longitudinal and histological study. ASDC J Dent Child. 1981;49:273–279.

[20] Shalish M, Peck S, Wasserstein A, et al. Malposition of unerupted mandibular second premolar associated with agenesis of its antimere. Am J Orthod Dentofacial Orthop. 2002;121:53–56.

[21] Wasserstein A, Brezniak N, Shalish M, et al. Angular changes and their rates in concurrence to developmental stages of the mandibular second premolar. Angle Orthod. 2004;74:332–336.

[22] Odeh R, Mihailidis S, Townsend G, et al. Prevalence of infraocclusion of primary molars determined using a new 2D image analysis methodology. Aust Dent J. 2016;61:183–189.

[23] Sajnani AK, King NM. Early prediction of maxillary canine impaction from panoramic radiographs. Am J Orthod Dentofacial Orthop. 2012;142:45–51.

[24] Polder BJ, Van't Hof MA, Van der Linden FP, et al. A meta-analysis of the prevalence of dental agenesis of permanent teeth. Commun Dent Oral Epidemiol. 2004;32:217–226.

[25] Garib DG, Alencar BM, Lauris JRP, et al. Agenesis of maxillary lateral incisors and associated dental anomalies. Am J Orthod Dentofacial Orthop. 2010;137:732e1.

[26] Alvesalo L, Portin P. The inheritance pattern of missing, peg-shaped, and strongly mesio-distally reduced upper lateral incisors. Acta Odontol Scand. 1969;27:563–575.

[27] Kurol J, Bjerklin K. Ectopic eruption of maxillary first permanent molars: a review. ASDC J Dent Child. 1986;53:209–214.

[28] Symons AL, Taverne AA. A family case report: disturbances in tooth form and eruption of the second premolar. Aust Orthod J. 1996;14:168–171.

[29] Baba-Kawano S, Toyoshima Y, Regalado L, et al. Relationship between congenitally missing lower third molars and late formation of tooth germs. Angle Orthod. 2002;72:112–117.

[30] Navarro J, Cavaller M, Luque E, et al. Dental anomaly pattern (DAP): Agenesis of mandibular second premolar, distal angulation of its antimere and delayed tooth formation. Angle Orthod. 2013;84:24–29.

[31] Kurol J. Infraocclusion of primary molars: an epidemiologic and familial study. Commun Dent Oral Epidemiol. 1981;9:94–102.

[32] Pemberton TJ, Das P, Patel PI. Hypodontia: genetics and future perspectives. Braz J Oral Sci. 2005;4:695–706.

[33] Chung CJ, Han JH, Kim KH. The pattern and prevalence of hypodontia in Koreans. Oral Dis. 2008;14:620–625.