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ORIGINAL ARTICLE

The pattern and prevalence of hypodontia in Koreans

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OBJECTIVE: The objective of this study was to evaluate the pattern and prevalence of hypodontia in the Korean population along with its association with the dental and skeletal polymorphisms.

SUBJECTS AND MATERIALS: The diagnostic materials including casts, panoramic radiographs, and lateral cephalograms of 1622 Korean subjects (611 males, 1011 females) were used to evaluate the pattern and prevalence of hypodontia as well as its association with the congenital absence of the third molar. The changes in the tooth size and skeletal characteristics of the hypodontia group were evaluated using cast/cephalometric analysis and compared with the standard values of normal occlusion in Koreans.

RESULTS: The prevalence of hypodontia in Koreans was 11.2%. The mandibular lateral incisor and second premolar were the most frequently absent. Congenital absence of the third molar was observed more frequently in the hypodontia group than in the non-hypodontia group. The prevalence of hypodontia in Class III malocclusion was significantly higher than in Class I or Class II malocclusion.

CONCLUSION: The pattern and prevalence of hypodontia can vary in different ethnic groups. In Koreans, the special features of hypodontia were its association with a higher level of congenital missing third molars and skeletal Class III malocclusion.

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Keywords: hypodontia; congenital missing; third molar; dental anomaly

Introduction

Hypodontia is the congenial absence of one or more primary or permanent teeth excluding the third molar, and is one of the most common developmental dental anomalies in humans (Endo *et al*, 2006b; Shapiro and Farrington, 1983; Zhu *et al*, 1996). The prevalence and location of hypodontia varies among different ethnic groups ranging from 3.4% to 10.1% (Endo *et al*, 2006a; Buenviaje and Rapp, 1984; Zhu *et al*, 1996; Polder *et al*, 2004). Although hypodontia has been diagnosed more often in recent studies (Mattheeuws *et al*, 2004), there is limited evidence to suggest a trend of increasing hypodontia throughout the twentieth century (Flores-Mir, 2006). The most commonly affected site/tooth also appears to vary among ethnic groups (Zhu *et al*, 1996). For the Caucasian population, the mandibular second premolar and the maxillary lateral incisor are the most frequently affected (Muller *et al*, 1970; Polder *et al*, 2004) while the mandibular lateral incisor and the mandibular second premolar are the most common for the Asian population (Davis, 1987, Endo *et al*, 2006a). However, a Medline search in 2007 with the mesh terms 'hypodontia and prevalence' did not find any reports on the prevalence of hypodontia in the permanent dentition of the Korean population without congenital syndromes.

Clinically, an early diagnosis of hypodontia is important because aesthetic, physiological and functional problems such as malocclusion, periodontal damage, and a lack of alveolar growth can be caused by hypodontia (Kokich and Kokich, 2006). The management of absent teeth generally involves a multidisciplinary team approach. The edentulous space can be left open for an eventual restoration, or closed by orthodontic means (Kokich and Kokich, 2006; Zhu *et al*, 1996). However, special care is needed during treatment planning because hypodontia can be associated with changes in the craniofacial morphology (Endo *et al*, 2006b; Sarnas and Rune, 1983; Graber, 1978; Dermaut *et al*, 1986) and morphologic variations in the dentition such as a decrease in the mesio-distal diameter of the remaining teeth (Baum and Cohen, 1971a,b), which may affect the establishment of the overall occlusion. Other treatment options include autotransplantation (Bauss *et al*, 2002) or protraction (Chung *et al*, 2007) of the third molars, which are otherwise extracted, to substitute for the edentulous region or to increase the

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number of occluding teeth. Although agenesis of one or more third molar teeth was associated with a higher prevalence of other missing teeth (Garn *et al*, 1962), for treatment purposes, it would be highly advantageous to be able to predict the presence or the absence of later developing third molars in the case of hypodontia from an early stage.

Therefore, this study evaluated the pattern and prevalence of hypodontia in the Korean population. In addition, its association with the presence of the third molars, dental morphology of the whole dentition and skeletal characteristics were examined.

Material and Methods

Subjects

In all, 1622 patients with mixed to permanent dentition (611 males, 1011 females), who visited the Department of Orthodontics, Yongdong Severance Dental Hospital, Yonsei University, Seoul, Korea from Sep. 1999 until Aug. 2002 for regular oral and orthodontic check ups, were selected based on the presence of full orthodontic diagnostic materials including orthodontic files, panoramic radiographs and orthodontic casts. Subjects with congenital anomaly, history of extraction of the permanent dentition, trauma, prior orthodontic treatment or referred patients specifically for the treatment of hypodontia were excluded. Among the subjects, patients with more than one congenitally missing tooth (excluding the third molars) were assigned as the hypodontia group whereas those without any congenital missing tooth (excluding the third molars) were assigned as the non-hypodontia group.

To evaluate the congenital missing of the third molars, patients under the age of 10 and those with difficulties in differentiating the second molar from the third molar because of the incomplete root formation of the second molars were excluded (Baba-Kawano *et al*, 2002; Moorrees *et al*, 1963). A total of 883 subjects remained and were evaluated for the absence of third molars using dental casts and panoramic radiographs.

All materials were obtained under informed consent according to ethical principles, including the World Medical Association's Declaration of Helsinki.

The diagnosis of hypodontia

The diagnosis of hypodontia and the data sets to describe the pattern of the hypodontia, such as the location and the number of missing teeth were recorded during the intra-oral exams, and again confirmed using casts and panoramic radiographs, as previously verified (Endo *et al*, 2006a; Wisth *et al*, 1974). A tooth was considered congenitally missing when it could not be observed in the dental arch and the absence of crown mineralization was confirmed in the panoramic radiographs (Endo *et al*, 2006b).

Evaluation of dental morphology

The sizes of the existing permanent teeth (first molar – first molar) in the subjects diagnosed with hypodontia (hypodontia group) were measured using digital callipers (Mitutoyo, Tokyo, Japan). The tooth size was defined as the maximum mesio-distal diameter of each tooth observed from the occlusal plane (Bolton, 1962). The tooth size of the hypodontia group was measured bilaterally, and the mean value of each tooth was compared with the Korean normal standard values of the corresponding permanent tooth obtained from 94 Korean adults with a Class I normal occlusion, which was defined as the Normal occlusion group (norms) (Kim *et al*, 2001a).

Hypodontia and its association with skeletal morphology

From a total of 1622 subjects, 11 belonging to the non-hypodontia group were excluded because of the absence of lateral cephalograms. The lateral cephalograms of the remaining 1611 subjects were traced and the anterior-posterior relationship of the maxilla and the mandible was classified as skeletal Class I, II and III using the measurement variables, the ANB angle and the Wits appraisal. Vertical skeletal relationship was classified as being Hypo-divergent, Normal and Hyper-divergent using the angle measurements including the mandibular plane angle to the Frankfort-Horizontal plane and the gonial angle. The Korean cephalometric standards of the measurement variables were derived from the Korean norms of the same age and diagnosed accordingly (Kim *et al*, 2001b).

Statistical evaluation

Statistical analysis was performed using the SPSS statistical software package (SPSS inc., Chicago, IL, USA). The differences in the pattern of hypodontia between gender, involvement of the right and the left sides, the upper and the lower arches were evaluated using a Chi-square test. The changes in the tooth size of the hypodontia group and the Korean norms (Kim *et al*, 2001a) were evaluated using a student *t*-test. The presence of a third molar and the changes in the skeletal morphology between the hypodontia group and the non-hypodontia group were also evaluated using a student *t*-test.

Measurement errors

All the materials were evaluated twice by the same examiner at a 1-month interval, and 100% reproducibility was obtained in the identification of hypodontia and its pattern.

To insure proper measurement procedures of the tooth size, one examiner randomly selected 20 casts from the norms (Kim *et al*, 2001a) and re-measured the tooth size. Comparison between the original tooth size data of the norms and that of the examiner did not indicate significant difference when compared using a paired *t*-test.

Results

The pattern of hypodontia in the Korean orthodontic population

Among the 1622 subjects, 182 subjects were diagnosed with hypodontia in the permanent dentition (excluding

the third molars). Therefore, the overall prevalence of hypodontia was 11.2% in the Korean orthodontic population. There was no significant difference in the prevalence between males (11.1%) and females (11.3%). Most of the subjects in the hypodontia group had unilateral hypodontia (total of 129 subjects, 70.9%), which was significantly higher than the bilateral symmetrical hypodontia (total of 53 subjects, 29.1%). Hypodontia was found significantly more in the mandible (total of 90 subjects, 49.5%) than in the maxilla (total of 53 subjects, 29.1%) or in both arches (total of 39 subjects, 21.4%) (Table 1). Among the hypodontia group, the prevalence of subjects with one, two, three, or four missing tooth/teeth were 48.9%, 30.7%, 9.6% and 5.7%, respectively. The prevalence of advanced hypodontia, which is defined as five or more congenitally missing permanent teeth, excluding the third molars (Endo *et al*, 2006a) was 5.1%.

A total of 329 permanent teeth were missing, indicating an average of 1.8 missing teeth per individual with hypodontia. The most common missing teeth were the mandibular lateral incisor (total of 67 missing, 20.4%) and the second premolar (total of 67 missing, 20.4%) followed by the maxillary second premolar (total of 47 missing, 14.3%), maxillary first premolar (total of 37 missing, 11.3%) and maxillary lateral incisor (total of 35 missing, 10.6%). There were no missing teeth in the molar region (Table 2).

Table 1 Pattern and prevalence of hypodontia in Korean orthodontic population, ***$P < 0.001$

Pattern of hypodontia	*Male (n = 611)*	*Female (n = 1011)*	*Total (n = 1622)*	*Frequency (%)*
Unilateral	51	78	129	70.9 ***
Bilateral	17	36	53	29.1
Maxilla	22	31	53	29.1
Manbile	28	62	90	49.5 ***
Maxilla + Mandible	18	21	39	21.4
Total	68	114	182	100
Prevalence (%)	11.1	11.3	11.2	

Table 2 Distribution of hypodontia in Korean orthodontic population

Distribution of hypodontia		*Left side*	*Right side*	*Total*	*Prevalence (%)*
Maxilla	Incisor (U1)	2	3	5	1.5
	Lateral incisor (U2)	19	16	35	10.6
	Canine (U3)	14	6	20	6.1
	First premolar (U4)	17	20	37	11.3
	Second premolar (U5)	23	24	47	14.3
	First molar (U6)	0	0	0	0
	Second molar (U7)	1	1	2	0.6
Mandible	Incisor (L1)	7	14	21	6.4
	Lateral incisor (L2)	27	40	67	20.4
	Canine (L3)	3	2	5	1.5
	First premolar (L4)	9	10	19	5.8
	Second premolar (L5)	36	31	67	20.4
	First molar (L6)	0	0	0	0
	Second molar (L7)	2	2	4	1.2

Table 3 Prevalence of congenital missing third molars in non-hypodontia and hypodontia groups, ***$P < 0.001$

Third molar measurements	*Non-hypodontia group (n = 773)*	*Hypodontia group (n = 110)*	*Total (n = 883)*
Individuals with missing third molar	212	53	265
Number of missing third molar	400	127	527
Average number of missing third molar/individual	1.9	2.4	2.0
Prevalence (%)	27.4	48.2 ***	30.0

Hypodontia is associated with the absence of the third molars

From the 1622 subjects, 883 who met the inclusion criteria were evaluated. Among them, 265 subjects (30.0%) had a minimum of one missing third molar. 212 subjects (27.4%) from the non-hypodontia group (total of 773) and 53 subjects (48.2%) from the hypodontia group (total of 110) had a minimum of one missing third molar. There was a significantly higher prevalence of missing third molars in the hypodontia group than in the non-hypodontia group ($P < 0.001$). An average of 1.9 third molar was missing from the hypodontia subjects in the non-hypodontia group while 2.41 third molars were missing from the hypodontia group (Table 3).

Hypodontia is not associated with changes in tooth size

Tooth size was defined as the maximum mesio-distal diameter of each tooth observed from the occlusal plane. The overall tooth sizes of the hypodontia group and the norms were similar in both males and females (Table 4).

Hypodontia is associated with skeletal Class III malocclusion

The subjects with lateral cephalograms (total of 1611) were classified as having a skeletal Class I, II or III malocclusion based on the cephalometric variables ANB angle and Wits appraisal. The prevalence of hypodontia in those with a Class I, Class II and Class III malocclusion was 10.5%, 7.4% and 16.0%, respectively. The prevalence of hypodontia in those with a Class III malocclusion was significantly higher than the average (11.3%) (Table 5).

Hypodontia and its association with the vertical skeletal relationship were evaluated based on cephalometric variables such as the mandibular plane angle and the gonial angle. There was similar prevalence of hypodontia among the Hyper-divergent (11.2%), Normal (11.4%) and Hypo-divergent (10.3%) groups (Table 5).

Discussion

The congenital absence of teeth can be described by several terms. Hypodontia denotes the congenital absence of one or more primary or permanent teeth. On the other hand, agenesis of numerous teeth is

Table 4 Comparison of mesio-distal tooth width between normal occlusion group and hypodontia group

		Male				*Female*			
		Normal occlusion group		*Hypodontia group*		*Normal occlusion group*		*Hypodontia group*	
Tooth size		*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Maxilla	Incisor (U1)	8.5	0.4	8.5	0.5	8.2	0.5	8.3	0.5
	Lateral incisor (U2)	6.9	0.4	6.7	0.6	6.7	0.5	6.8	0.7
	Canine (U3)	8.0	0.3	8.1	0.5	7.7	0.3	7.8	0.4
	First premolar (U4)	7.4	0.3	7.5	0.4	7.3	0.4	7.3	0.5
	Second premolar (U5)	6.9	0.3	7.0	0.5	6.8	0.4	6.8	0.4
	First molar (U6)	10.4	1.0	10.5	0.6	10.2	0.4	10.2	0.5
Mandible	Incisor (L1)	5.4	0.3	5.4	0.5	5.2	0.3	5.3	0.4
	Lateral incisor (L2)	6.0	0.3	6.1	0.4	5.8	0.3	5.9	0.4
	Canine (L3)	6.9	0.3	7.0	0.5	6.6	0.3	6.6	0.4
	First premolar (L4)	7.3	0.3	7.4	0.4	7.1	0.4	7.2	0.4
	Second premolar (L5)	7.1	0.4	7.2	0.9	7.0	0.4	7.1	0.5
	First molar (L6)	11.1	0.7	11.2	0.6	11.0	0.5	11.0	0.7

Table 5 Skeletal features of non-hypodontia and hypodontia groups in anterior-posterior and vertical dimensions, $^{***}P < 0.001$

Skeletal features		*Non-hypodontia*	*Hypodontia*	*Prevalence of hypodontia (%)*
Anterior-posterior relationship	Class I	979	103	10.5
	Class II	256	19	7.4
	Class III	376	60	16.0 ***
Vertical relationship	Hyper-divergent	376	42	11.2
	Normal	1167	133	11.4
	Hypo-divergent	68	7	10.3
Total		1611	182	11.3

commonly associated with specific syndromes and severe systematic abnormalities are classified as oligodontia. Anodontia indicates a total absence of dental structures (Zhu *et al*, 1996). Hypodontia is reported to be associated with etiologic factors such as physiological obstruction or disruption of the dental lamina, space limitation, functional abnormalities of the dental epithelium or its failure to initiate the underlying mesenchyme (Stewart *et al*, 1982), systemic condition and genetic factors (Zhu *et al*, 1996).

The prevalence of hypodontia in the Korean orthodontic population in this study was 11.2%, which is slightly higher than previous reports for Caucasians and Japanese (Muller *et al*, 1970; Wisth *et al*, 1974; Endo *et al*, 2006a), while the severity based on the number of missing teeth per individual was mild. The higher prevalence of hypodontia in this study might partly be because of the fact that the evaluation was performed retrospectively on Korean orthodontic population rather than from a prospectively planned random sampling of the general population. Hypodontia can induce secondary problems of occlusion such as tipping or rotation of the adjacent teeth, which may require orthodontic treatment. Nevertheless, orthodontic materials including the long term radiographs and casts are the best for diagnosing hypodontia, and evaluation of the orthodontic population would provide valuable information of hypodontia similar to the previous studies (Endo *et al*, 2006a; Muller *et al*, 1970; Wisth *et al*, 1974). To reduce the discrepancies between the general and the orthodontic population, subjects referred from general dentists with chief complaints directly associated with hypodontia were excluded.

Interestingly, more than 40% of the hypodontia in Koreans involved the lateral incisor (20.4%) and the second premolar (20.4%) of the mandible, which made the mandible more susceptible to hypodontia than the maxilla. This is slightly different from Caucasians who have more frequent involvement in the maxilla because of the high frequency of missing maxillary lateral incisors (Muller *et al*, 1970).

The presence of the third molar may influence the biomechanical considerations whilst planning orthodontic treatment and the overall treatment stability. In particular, for patients with hypodontia, the third molars can be aligned into occlusion by orthodontic means to substitute for the congenitally missing tooth/teeth. Unfortunately, 48.2% of the hypodontia subjects also indicated congenital absence of the third molar, which was significantly higher than the ones without hypodontia (27.4%). Similar to that of other reports, the mean frequency of congenital absence of the third molar was 30% (Mok and Ho, 1996). Based on our results, the congenital absence of the third molar was strongly associated with hypodontia (Garn *et al*, 1963; Zhu *et al*, 1996).

While some studies have reported that the tooth size and the dental arch width are not related to the presence of hypodontia (Wisth *et al*, 1974), others have reported conflicting results indicating that hypodontia

is associated with dental anomalies such as a decrease in the size of the incisors and the canines, microdontia, conical or tapered teeth (Zhu *et al*, 1996; Forgie *et al*, 2005). According to our results, the mean mesio-distal widths of the permanent teeth were similar to the Korean standard tooth sizes from the normal occlusion group (norm). However, changes in tooth morphology such as peg lateralis were occasionally observed in our hypodontia subjects indicating a tendency for high variations (standard deviation) compared to the norms. These results support the hypothesis that hypodontia is not associated with changes in the overall tooth size, while some possibilities still exist in the changes in tooth morphology especially in the maxillary lateral incisors.

The specific skeletal characteristics of hypodontia include tendency towards a skeletal Class III pattern and a reduced anterior lower facial height (counter-clockwise rotation of the mandible) (Endo *et al*, 2006b; Sarnas and Rune, 1983; Forgie *et al*, 2005; Nodal *et al*, 1994). The prevalence of hypodontia in Koreans was also significantly high in Class III subjects compared with Classes I or II. However, there was no specific trend observed in the vertical dimension for the hypodontia subjects with a similar prevalence in Hyper-divergent, Normal and Hypo-divergent groups. The hypodontia group in this study had an average of 1.8 teeth missing, which is mild compared with other studies that examined the skeletal features in the case of advanced hypodontia (Endo *et al*, 2006b). The skeletal characteristics of hypodontia become more significant as the severity of hypodontia worsened, particularly when multiple teeth were missing (Endo *et al*, 2006b). Therefore, less prominent skeletal characteristics might be because of the mild features of hypodontia in these Korean subjects.

The etiology of hypodontia is considered to be a multi-factorial condition with genetics and environmental influences playing a role (Forgie *et al*, 2005). Mutations in genes such as MSX, PAX 9 or TGFA are reported to cause hypodontia in different racial groups (Vastardis *et al*, 1996; Vieira *et al*, 2004). Among the homeobox genes, MSX 1 and 2 are required for direct epithelial-mesenchymal interactions that initiate tooth formation (Jowett *et al*, 1993). In addition, PAX 9 and TGFA are associated with tooth agenesis with interaction between MSX 1 and PAX 9 (Vieira *et al*, 2004). Our limited findings do not show the cause of hypodontia nor indicate ways of preventing hypodontia. However, these results are expected to provide clinicians with helpful information that can assist in treatment planning.

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