Comparison of Mesiodistal Crown Dimension and Arch Width in Subjects with and without Hypodontia

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ABSTRACT

Objective: Tooth agenesis is one of the most common anomalies in the development of the human dentition and may have wider associations in the development of the dentition including tooth size. This study aimed to compare mesiodistal crown dimension and arch widths between subjects with hypodontia and subjects without hypodontia (control group).

Materials and Methods: Dental casts were measured of 55 hypodontia patients and 55 patients with total permanent dentition (control group). Tooth agenesis was evaluated for hypodontia, excluding the third molars, from the panoramic radiograph. Mesiodistal crown dimensions were recorded by measuring all erupted teeth on study models with a digital Mitutoyo caliper (Mitutoyo UK Ltd, United Kingdom).

Results: Patients with hypodontia had smaller mesiodistal tooth dimensions than the control group, and this difference was statistically significant ($p < 0.05$) for all teeth in both genders. Upper lateral incisors, lower central incisors, and lower second molars showed the highest difference in tooth dimension. Also, the intercanine and intermolar arch widths in the hypodontia group were statistically significantly reduced ($p < 0.05$) compared with the control group.

Conclusions: The findings indicate that the mesiodistal crown dimensions and arch widths are reduced in hypodontia patients. This should be taken into account when planning orthodontic treatment.

CLINICAL SIGNIFICANCE

Congenital absence of permanent teeth has direct clinical implications. Early detection of the number of missing teeth and evaluation of the tooth size and arch width is of immense value in the planning and managing treatment with a multidisciplinary team approach to achieve an aesthetic and functional dentition and reduce the complications of hypodontia.

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INTRODUCTION

A congenital anomaly affecting the formation of the dentition that results in a reduction in the usual number of the human permanent dentition (a total of 32 teeth in both jaws) and/or the deciduous dentition (20 total teeth in both jaws) is commonly referred to as aplasia.[1,2] The term hypodontia is used when one to five teeth, excluding the third molars, are absent. When six or more teeth, excluding the third molars, are absent, this condition is called oligodontia. Anodontia is an extreme case, denoting the complete absence of teeth. Tooth agenesis is one of the most common anomalies in the development of the human dentition.[3] Recent studies have shown that the occurrence of hypodontia has increased during the 20th century.[1]

Although missing primary teeth are relatively uncommon, when one tooth is missing, it is usually a maxillary incisor. Studies suggest that this anomaly occurs in 0.1% to 0.9% of the population, with equal frequencies in males and females.[4] Epidemiological

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studies suggest the high probability of missing permanent teeth when the deciduous teeth were missing.[5]

The reported prevalence of hypodontia in different populations has varied between 2.3 and 10.1% in the permanent dentition, excluding third molars.[6–8] The absence may be either unilateral or bilateral. Females are more often affected than males.[8] Some studies showed that the upper lateral incisor was the most frequently absent tooth followed by the lower second premolar, which occurred almost equally as agenesis of the upper second premolar.[9–11] While others revealed that the lower second premolar was the most frequently absent tooth followed by the upper lateral incisor.[5,12]

The etiology of hypodontia is multifactorial with major genetic and environmental factors. Hereditary or familial history has been suggested as the primary cause of hypodontia. Various genes including PAX9, MSX1 and AXIN2 have been implicated in the etiology of hypodontia. A novel mutation in the AXIN2 gene has been identified as being involved in certain forms of familial tooth agenesis.[2,13,14] The AXIN2 gene regulates the Wnt signaling pathway, which is involved in the cellular proliferation, differentiation and morphogenesis of most organs. The roles of MSX1, PAX9, AXIN2, BARX homeobox 1 (BARX1), and BARX homeobox 2 (BARX2) genes in processes other than odontogenesis are being investigated. For example, the link between the AXIN2 gene and colon cancer has been described,[15] and AXIN2 genes also may play a role in ovarian cancer.[16,17] Hypodontia is also often seen in syndromes, particularly those involving ectodermal anomalies, and in nonsyndromic conditions such as cleft lip/alveolus with or without cleft palate. Tooth agenesis is probably caused by several independent defective genes, acting alone or in combination with others, which eventually lead to specific phenotypes.

In addition, environment has been considered as a contributing factor of hypodontia. The failure of tooth bud cell proliferation from the dental lamina may be due to infection (e.g., rubella,[18] osteomyelitis), trauma, drugs (e.g., thalidomide), chemotherapy, or radiotherapy at a young age.[19]

Hypodontia creates significant challenges to the clinicians in both diagnosis and management. Comprehensive management requires careful multidisciplinary approach and the treatment should result in appropriate contact points between neighboring teeth.[20] A few of the fundamental factors in the diagnosis are the spacing condition, tooth size, arch form and its dimensions, as well as the tooth-arch discrepancies. A coordinated proportion between the mesiodistal dimensions of the upper and lower teeth is necessary for good intercuspation.[21]

The aim of this study was to measure the mesiodistal crown dimensions on study models in patients with hypodontia and compare the findings with a control group (patients with total permanent dentition, except third molars) to determine whether tooth size was different in the hypodontia patients from the controls. Also, the maxillary and mandibular intercanine and intermolar arch widths were measured in both groups to identify the relationship between arch width in these two groups.

MATERIALS AND METHODS

The study was reviewed and approved by the Institutional Review Board of University Clinical Centre Maribor.

The material for the present study included the records (anamnestic data, study model, and panoramic radiograph) of 110 patients with permanent dentition before orthodontic therapy from the Department of Orthodontics, Maribor, Slovenia between May 2009 and May 2011. The selection criteria were the good quality study models, all permanent teeth (except third molars) erupted in the upper and lower arches, absence of any dental deformity or severe mesiodistal tooth abrasion, no restorations extending to the mesial or distal surfaces, or enamel stripping of the anterior or posterior teeth.

The hypodontia group comprised 55 patients (25 males and 30 females) with a mean age of 14.7 years (SD 1.3).

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The control group consisted of 55 patients (26 males and 29 females) with a mean age of 14.1 years (SD 1.8).

Tooth agenesis was evaluated for hypodontia, excluding the third molars, from the panoramic radiograph. A tooth was registered as congenitally missing when no trace could be found on radiographs, and the treatment records confirmed that the tooth had not been extracted. Subjects in which an accurate diagnosis of hypodontia could not be established were excluded. Patients with developmental anomalies (cleft lip, alveolus and/or palate), syndromes (Down's syndrome), history of previous orthodontic treatment, or extraction of permanent teeth were excluded from the study.

The mesiodistal dimension of maxillary and mandibular teeth and maxillary and mandibular intercanine and intermolar arch widths were recorded. Measurements were obtained systematically under standardized conditions, from the upper right quadrant to the upper left quadrant, then from the lower right quadrant to the lower left quadrant. The mesiodistal distance was measured as the greatest distance between the contact points on the interproximal surfaces of the tooth crown with a digital caliper (Mitutoyo Caliper Model CD-15DP, Code 500-341, serial no. 0001090, with an accuracy of 0.01 mm, Mitutoyo UK Ltd, United Kingdom) held parallel to the occlusal and buccal surfaces. Where teeth were rotated or had no adjacent tooth, dimensions were obtained by measuring between the points where the contact with the neighboring tooth would normally be. Each tooth and arch width was measured twice, by the same person on different occasions, and the mean value of the two measurements was used.

Statistical analysis was performed using the Statistical Package for Social Sciences version 15.1. for Windows (SPSS Inc., Chicago, IL, USA). The mean value, SD and coefficient of variation were calculated for the two groups. We determined the difference in mesiodistal tooth width between the hypodontia and the control group and the difference in arch width between the hypodontia and the control group using the Student's *t*-test with a *p*-value of <0.05 as a standard for a statistically significant difference.

RESULTS

Results are based on the analysis of the mesiodistal measurements of the permanent teeth, and the maxillary and mandibular intercanine and intermolar arch widths of patients with and without hypodontia.

The descriptive statistics for the maxillary mesiodistal crown dimensions of the hypodontia group and the control group are presented in Table 1. Table 2 shows the descriptive statistics for the mandibular mesiodistal crown dimension of the teeth in the hypodontia group and the control group.

The comparison of mesiodistal crown dimensions between the hypodontia group and the control group shows that the difference is statistically significant, both in maxillary and mandibular arch. All mesiodistal crown dimensions showed a significant reduction in the hypodontia group over those in the control group. The percentage reduction in the tooth dimensions of the male hypodontia patients ranged from 5% to 15.6% in the mesiodistal dimension. Likewise, percentage reduction in the tooth dimensions of the female hypodontia patients ranged from 3% to 15.5% in the mesiodistal dimension.

The percent differences in mesiodistal dimensions were greater for all teeth. Certain teeth within the dentition were also more severely affected by the difference in tooth dimensions than others. The greatest percentage difference was observed on maxillary lateral incisors, mandibular central incisors, and mandibular second molars.

Mean maxillary and mandibular intercanine and intermolar arch widths for the hypodontia and the control group are presented in Table 3. The intercanine and intermolar arch widths in the hypodontia group were statistically significantly reduced ($p < 0.05$) in upper and lower jaws compared with the control group. Measurements showed that the maxillary intercanine and intermolar arch widths are more reduced in males, and the mandibular intercanine and the intermolar arch widths are more reduced in females.

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TABLE 1. Mean and SD of mesiodistal tooth dimensions (mm) of upper teeth in hypodontia patients and patients control group

Tooth type[†]	Gender	Hypodontia group			Control group			% Difference
		Mean	SD	CV	Mean	SD	CV	
11	M	8.32*	0.81	9.7	9.21	0.46	5.0	−9.7
	F	8.25*	0.72	8.7	9.13	0.51	5.6	−9.3
21	M	8.41*	0.91	10.8	9.16	0.61	6.6	−8.2
	F	8.35*	0.89	10.7	8.96	0.40	4.5	−6.8
12	M	6.42*	0.78	12.1	7.61	0.68	8.9	−15.6
	F	6.41*	0.77	12.0	7.59	0.58	7.6	−15.5
22	M	6.51*	0.71	10.9	7.63	0.58	7.6	−14.7
	F	6.45*	0.82	12.7	7.27	0.54	7.4	−11.3
13	M	7.61*	0.56	7.3	8.04	0.46	5.7	−5.3
	F	7.57 *	0.38	5.0	8.01	0.56	7.0	−5.5
23	M	7.53*	0.52	6.9	7.95	0.41	5.2	−5.3
	F	7.52	0.59	7.8	7.77	0.43	5.5	−3.2
14	M	6.77*	0.66	9.7	7.48	0.44	5.9	−9.5
	F	6.72*	0.52	8.7	7.53	0.59	7.8	−10.8
24	M	6.65*	0.48	7.2	7.41	0.35	4.7	−8.9
	F	6.71*	0.44	6.6	7.36	0.42	5.7	−8.8
15	M	6.42*	0.68	10.6	6.87	0.63	9.2	−6.5
	F	6.25*	0.75	12.0	6.92	0.59	8.5	−9.7
25	M	6.49	0.60	9.2	6.78	0.55	8.1	−9.0
	F	6.33*	0.61	9.6	6.91	0.62	8.9	−8.4
16	M	9.91*	0.48	4.8	10.64	0.51	4.8	−6.9
	F	9.95*	0.42	4.2	10.49	0.43	4.1	−5.1
26	M	10.02*	0.44	4.4	10.72	0.52	4.9	−6.5
	F	9.81*	0.52	5.3	10.47	0.63	6.0	−6.3
17	M	8.97*	0.63	7.0	9.51	0.48	0.5	−5.7
	F	8.92*	0.52	5.8	9.39	0.42	4.4	−5.0
27	M	9.19*	0.66	7.2	9.82	0.39	4.0	−6.4
	F	9.02*	0.57	6.3	9.71	0.46	4.7	−7.1

CV = coefficient of variation; M = male; F = female.
*$p < 0.05$ when mean mesiodistal dimension compared with control group.
[†]Federation Dentaire International notation. (The FDI World Dental Federation notation system uses a two-digit numbering system in which the first number represents a tooth's quadrant and the second number represents the number of the tooth from the midline of the face.)

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TABLE 2. Mean and SD of mesiodistal tooth dimensions (mm) of lower teeth in hypodontia patients and patients control group

Tooth type[†]	Gender	Hypodontia group			Control group			% Difference
		Mean	SD	CV	Mean	SD	CV	
41	M	5.19*	0.67	12.9	5.98	0.37	6.2	−13.2
	F	5.07*	0.52	10.3	5.73	0.40	7.3	−11.5
31	M	5.15*	0.70	13.6	6.08	0.49	8.1	−15.3
	F	5.11*	0.68	13.3	5.93	0.43	7.2	−13.4
42	M	5.68*	0.39	6.7	6.11	0.27	4.4	−7.0
	F	5.61*	0.50	8.9	6.07	0.23	3.6	−7.6
32	M	5.54*	0.55	9.9	6.14	0.33	5.8	−9.8
	F	5.73	0.49	8.5	5.91	0.42	7.1	−3.0
43	M	6.57*	0.47	7.1	6.98	0.39	5.6	−5.9
	F	6.31*	0.35	5.5	7.31	0.26	3.6	−7.5
33	M	6.59*	0.46	7.0	7.02	0.44	6.3	−6.1
	F	6.49*	0.42	6.5	6.93	0.48	6.9	−6.3
44	M	6.74*	0.37	5.5	7.18	0.49	6.8	−6.1
	F	6.75*	0.21	3.1	7.27	0.32	4.4	−7.2
34	M	6.82*	0.50	7.3	7.22	0.46	6.4	−5.5
	F	6.82	0.27	3.9	7.06	0.47	6.7	−3.4
45	M	6.78*	0.71	10.5	7.19	0.36	5.0	−5.7
	F	7.07*	0.40	5.7	7.63	0.47	6.2	−7.3
35	M	6.88*	0.67	9.8	7.24	0.38	5.2	−5.0
	F	6.67*	0.92	13.7	7.22	0.46	6.4	−7.6
46	M	10.03*	0.66	6.5	10.98	0.53	4.8	−8.6
	F	9.92*	0.49	4.9	10.87	0.49	4.5	−8.7
36	M	10.21*	0.66	6.4	11.09	0.54	4.9	−7.9
	F	9.87*	0.68	6.9	10.90	0.58	5.3	−9.4
47	M	8.06*	0.52	6.5	9.33	0.34	9.6	−13.6
	F	7.91*	0.56	7.0	9.21	0.35	9.6	−14.1
37	M	8.13*	0.49	6.0	9.36	0.42	9.5	−13.1
	F	8.09*	0.53	6.5	9.29	0.39	9.6	−12.9

CV = coefficient of variation; M = male; F = female.
*$p < 0.05$ when mean mesiodistal dimension compared with control group.
[†]Federation Dentaire International notation. (The FDI World Dental Federation notation system uses a two-digit numbering system in which the first number represents a tooth's quadrant and the second number represents the number of the tooth from the midline of the face.)

TABLE 3. Mean and SD of dental arch widths (mm) in the hypodontia and control groups

Dental arch widths	Gender	Hypodontia group			Control group		
		Mean	SD	CV	Mean	SD	CV
Maxillary intercanine width (mm)	M	31.09*	2.94	9.5	34.14	1.59	4.7
	F	30.18*	2.43	8.1	33.30	1.98	5.9
Mandibular intercanine width (mm)	M	26.76*	2.49	9.3	29.17	1.55	5.3
	F	25.38*	2.86	11.3	28.37	1.69	6.0
Maxillary intermolar width (mm)	M	46.23*	3.45	7.4	48.69	2.09	4.3
	F	45.68*	2.78	6.1	48.81	2.14	4.4
Mandibular intermolar width (mm)	M	46.28*	2.81	6.1	48.23	1.96	4.1
	F	46.15*	2.14	4.7	48.18	1.91	3.9

CV = coefficient of variation; M = male; F = female.
*$p < 0.05$ when mean arch width dimension compared with control group.

DISCUSSION

Patients with hypodontia had smaller average mesiodistal tooth crown dimensions compared with the control group. The association between hypodontia and microdontia is well established. Reduction in tooth size and form have been reported together with congenitally missing teeth by Brook and colleagues[22] and McKeown and colleagues.[23] The more teeth that are missing the greater the possibility of clinically apparent microdontia in an individual and the greater the possibility of reduced crown widths of the existing teeth as reported by Brook and colleagues.[22] A most striking example in crown size reduction associated with hypodontia is a peg-shaped upper lateral incisor reported by Baccetti.[24] The presence of peg-shaped maxillary lateral incisors was frequently associated with absence of the contralateral incisor. Peg-shaped maxillary lateral incisors were observed in 8.9% of hypodontia patients,[25] although this anomaly only affected 1.6% of the general population.[26] The present study supports this theory because the maxillary lateral incisor was observed to have the greatest reduction in mesiodistal width.

The presence of hypodontia does not just affect the size of the tooth, but it appears to also influence the level of variability in tooth dimensions. The tooth dimensions of the hypodontia patients generally showed a higher variability than those of the control group.

For hypodontia, in this study, the teeth showing the greatest difference in tooth dimensions in both males and females are the upper lateral incisor, lower central incisor, and lower second molar. This suggests that these teeth may be more susceptible to disturbances during development than the other teeth in the dentition. Such a finding is consistent with the theory of morphogenetic fields, which proposes that the earliest forming teeth in each part of the dentition are the least variable in morphology. As the lower central incisor, upper lateral incisor, lower second premolar, and lower second molar are not key teeth in their respective fields, under the morphogenetic field theory; they would be expected to show greater variation from the norm, as is observed here.[27] In this study, the coefficients of variation observed in the unaffected individuals also show a pattern, which supports the morphogenetic field theory, with first molars and upper central incisor appearing to show a particularly low level of variability, and the upper lateral incisor, lower central incisor, and lower second premolars showing a higher level of variability.

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Some studies found few differences in dental arch dimensions between patients with tooth agenesis and controls.[12,25] Nevertheless, Bu and colleagues[28] suggested that oligodontia patients have greater reductions in their dental arch dimensions than those with hypodontia. Salmon and Le Bot[26] reported decreased arch widths in a large French male group with missing and small maxillary lateral incisors. However, they measured only arch dimensions in the maxilla and evaluated only lateral incisors absence. In the present study, there was a statistically significant reduction in dental arch widths for both jaws in the hypodontia group compared with the control group.

Mandibular intercanine arch width was in male reduced 2.41 mm and 2.99 mm in female. The intercanine width in the maxilla was reduced by 3.05 mm in male and 3.12 mm in female, which was the biggest mean reduction of dental intercanine arch widths. This might be due to mesial drift of canine and posterior teeth after the early loss of the deciduous maxillary lateral incisor in incisors hypodontia. Similarly, the mandibular intermolar width in the mandible was reduced by 1.95 mm in male and 2.03 mm in female because of the retention of the deciduous second molar in the mandible, when the permanent second premolar was absent.

CONCLUSION

The mesiodistal crown widths of the maxillary and mandibular teeth as well as the intercanine and intermolar arch widths were all smaller in the hypodontia group than the control group. These differences were found to be statistically significant.

Congenital absence of permanent teeth has direct clinical implications. Early detection of the number of missing teeth and evaluation of the tooth size and arch width is of immense value in the planning and managing treatment with a multidisciplinary team approach to achieve an aesthetic and functional dentition and reduce the complications of hypodontia.

DISCLOSURE

The author does not have any financial interest in any of the companies whose products are included in this article.

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