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Mesiodistal dimensions of teeth in Serbian orthodontic patients with hypodontia

Мезиодисталне димензије зуба ордодонтских пацијената са хиподонцијом у српској популацији

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**SUMMARY**

Introduction/Objective Hypodontia is a common dental anomaly that occurs either in a non-syndromic form or as a part of various syndromes. It is considered a multifactorial condition with genetic, epigenetic and environmental influences, the interplay of which can lead to various anomalies in tooth size and number. The aim of this study was to assess mesiodistal tooth dimensions in Serbian hypodontia orthodontic patients and compare them to healthy controls using digital study models.

Methods Fifty subjects (30 females, 20 males) divided into two groups – 25 with hypodontia (15 females, 10 males) and 25 gender-matched controls (15 females, 10 males) were included in the study. Alginate impressions were taken and plaster models poured, digitized and imported into the software where mesiodistal dimensions were obtained.

Results Intra-operator reliability was high. All teeth in the hypodontia group had smaller mesiodistal dimensions compared to controls. Statistical significance was noted for all teeth except for upper canines. No statistically significant differences were found between males and females in neither the hypodontia nor the control group, except for lower canines, which were significantly smaller in both hypodontia and control females. The most commonly missing teeth were upper lateral incisors, and lower and upper premolars.

Conclusion Hypodontia group presented with smaller mesiodistal dimensions compared to controls. The greatest difference in mesiodistal dimensions was found in upper lateral incisors and lower first molars. Lower canines were significantly larger in males compared to females in both groups.

Keywords: hypodontia; tooth agenesis; mesiodistal dimensions; tooth size

**INTRODUCTION**

Tooth agenesis is a common dental anomaly that occurs either in a non-syndromic form or as a part of various syndromes. Non-syndromic hypodontia of permanent teeth is one of the
most common developmental dental anomalies in humans. Different terms, such as hypodontia, oligodontia and anodontia are used to describe it. Hypodontia is used when one to six teeth (excluding third molars) are congenitally missing. Oligodontia means that more than six teeth (excluding third molars) are missing, whereas anodontia denotes extreme cases of complete absence of teeth. Hypodontia is more common in permanent than in primary dentition.

According to the literature, prevalence of tooth agenesis in permanent dentition varies between 1.6% and 36.5% depending on the population [1]. Results of a recent systematic review on the prevalence of hypodontia, which included 93 studies from 2002 to 2012, concluded the prevalence of hypodontia was 6.4%. The same study found statistically significant differences in the geographic prevalence of hypodontia. It was highest in Africa (13.4%), followed by Europe (7%), Asia (6.3%) and Australia (6.3%) with the lowest prevalence in North America (5.0%) and Latin America and the Caribbean (4.4%). However, the authors did not find statistically significant differences in prevalence depending on the examined population, i.e. school children, dental patients and orthodontic patients. This study also showed that most commonly, one or two teeth were congenitally missing (about 81%), three to five teeth were missing in 14% of cases, while six or more teeth were missing in only 3% of cases [2].

Janosevic et al. [3] have reported the prevalence of hypodontia in Serbian children to be 6.28%, which is similar to hypodontia prevalence amongst other south-Slavic nations, i.e. in the Croatian (5.52%) [4], Slovenian (6.9%) [5] and Macedonian (7.52%) [6] populations. Several studies reported hypodontia to be more prevalent in females than in males [2, 7].

The etiology of tooth agenesis is still unclear. Hypodontia has been regarded as a multifactorial condition with genetic, epigenetic and environmental influences, the interplay of which can lead to various anomalies in tooth size and number [8]. Hundreds of genes have been connected with the patterning, morphogenesis and cell differentiation in teeth so far [9]. Numerous studies have reported on the connection between tooth number and tooth size anomalies, and most of them have concluded that tooth dimensions were smaller in patients with hypodontia compared to controls [10-12]. Furthermore, a reduction in tooth size has also been observed in unaffected relatives of hypodontia patients [13], indicating a genetic influence on the link between the number and size of teeth.

Tooth size discrepancies affect buccal interdigitation, overjet, overbite and midline position. Moreover, several authors have concluded that hypodontia impacts functional and psychosocial aspects of the patient’s well-being, therefore affecting their quality of life [14-
17]. Thus, the evaluation of tooth size and tooth number anomalies plays an important part in orthodontic diagnosis and treatment planning [13]. Both researchers and clinicians have used different techniques to evaluate and quantify tooth size and shape. The most common tool used for more than a century has been a caliper, which has been modernized into a digital caliper. Three-dimensional (3D) imaging and scanning has been introduced to orthodontics at the beginning of the 21st century. Laser scanners, CBCT scanners, stereophotogrammetry, amongst others, have been used for obtaining 3D images of teeth, jaws and soft-tissues for over a decade now [18, 19]. Apart from being used to store patients’ models and information electronically, 3D imaging has also found its place in virtual 3D diagnostics and tooth movement analyses by superimposition of pretreatment and posttreatment models [20, 21].

The aim of our study was to assess mesiodistal tooth dimensions in hypodontia patients and compare them to those of healthy controls using digital study models.

METHODS

Study sample

The study involved 50 subjects (30 females, 20 males) treated at the Department of Orthodontics Faculty of Dental Medicine University of Belgrade. The sample was divided into two groups – one consisted of 25 subjects (15 females, 10 males) with hypodontia and the other consisted of 25 gender-matched controls (15 females, 10 males) without hypodontia.

Inclusion criteria

For the hypodontia group:

- One or more congenitally missing teeth (excluding third molars)

- No evidence, reported by the patient or noted upon clinical examination, of any syndrome known to be associated with hypodontia
For the control group:

- No sign of hypodontia (excluding third molars)
- Gender-matched to the hypodontia group

Diagnosis of tooth agenesis was based on clinical examination, panoramic radiographs and anamnestic data. Deciduous teeth, erupting teeth, impacted teeth, teeth with large lesions or dental restorations and teeth with defects on the dental casts were excluded from the study. Sixty seven teeth were excluded from the hypodontia group, while 82 teeth were congenitally missing. Thirty-eight teeth were excluded from the control group. Upper and lower incisors, canines, premolars and first molars were measured. A total number of 451 teeth were measured in the hypodontia group and 562 in the control group. In the hypodontia group 56% of patients had one or two teeth congenitally missing, 28% had three to six teeth missing, and 16% had more than six teeth missing.

This research was approved by the Human Research Ethics Committee of the Faculty of Dental Medicine University of Belgrade (resolution number 36/31 from December 4th 2014).

**Data collection**

Alginate impressions were taken for patients in both groups. Plaster models were poured on the same day and study models were trimmed. Each study model was positioned on a stand and scanned by a single operator (MZ) using the NextEngine 3D scanner HD (Next Engine Inc., Santa Monica, CA; Figure 1). Digitized study models were saved as stereolitography (.stl) files and imported into the Geomagic Control software (Raindrop Geomagic Inc, Cary, NC), where they were converted to the .wrp format, a file format proprietary to Geomagic. Mesiodistal crown width was measured as the greatest distance between the contact points on the interproximal surfaces of tooth crowns (Figure 2). Upper and lower incisors, canines, premolars and first molars were measured on both the left and the right side of each dental arch and the dimensions were averaged. All measuring was done by the same operator (MZ). All teeth in the hypodontia group were measured twice, approximately one week apart. A total
number of 451 teeth from the hypodontia group were included in the intra-operator error study. The values for left and right teeth were averaged and compared between two measurements.

**Statistical analysis**

All recorded data was analyzed using the SPSS statistical software (IBM SPSS Statistics 20; IBM Corporation, NY). The Kolmogorov-Smirnov test revealed the sample was normally distributed, therefore parametric tests were used. The Independent samples t-test was used to evaluate whether the diagnosis (presence/absence of hypodontia) and gender had an effect on the measurements. Paired samples t-test was used to evaluate the differences between measurements. Level of significance was set at p<0.05.

**RESULTS**

Intra-operator reliability levels were high, with no statistically significant differences between the two sets of measurements (Table 1).

All teeth in the hypodontia group had smaller mesiodistal dimensions compared to controls (Tables 2 and 3). Statistically significant differences in mesiodistal dimensions between groups were noted for all teeth, except for upper canines (Table 2). Upper lateral incisors (Table 2) and lower first molars (Table 3) showed the greatest differences in mesiodistal dimensions between the hypodontia and the control group.

No statistically significant differences were found between males and females in neither the hypodontia (Tables 4 and 5) nor the control group (Tables 5 and 6), except for lower canines, which were significantly smaller in females in both the hypodontia (Table 5) and the control group (Table 7).

The most commonly missing teeth in our study sample were upper lateral incisors (35% of all congenitally missing teeth), followed by lower (24%) and upper (16%) second premolars.
DISCUSSION

The purpose of this study was to evaluate and compare mesiodistal dimensions of teeth in patients with and without hypodontia using 3D scans of dental casts and the Geomagic software. Results of our study showed that patients with hypodontia had significantly smaller mesiodistal crown dimensions compared to controls, except for upper canines where no statistical significance was found. This is in accordance with the results published by Brook et al [10], Gungor and Turkkahraman [11], Al Shahrani et al [22], Fekonja [23], and Kerekes-Mathe et al [24]. Brook et al [10] have also found no statistically significant differences for upper canines, and upper left and lower right first premolars in females. However, in their hypodontia male group, all teeth were significantly smaller compared to controls, except for lower right central incisors and upper right first and second premolars, which even showed an increase. They have found the difference in size to be greater in patients with more severe hypodontia [11]. Fekonja [23] has found teeth in the hypodontia group to be significantly smaller compared to controls as well, and so have Kerekes-Mathe et al [24]. Al-Shahrani et al [22] have similarly reported a decrease in tooth dimension in the hypodontia group compared to controls, with statistical significance present in the severe hypodontia group only, while Gungor and Turkkahraman [11] reported statistical significance for both the mild and the severe hypodontia group, the latter showing greater differences.

According to the results of our study, upper lateral incisors and lower first molars showed the greatest differences in mesiodistal dimensions between the hypodontia group and controls. The fact that upper lateral incisors showed the greatest difference is in line with the theory of morphogenetic fields (incisor, canine, premolar, molar), according to which “key teeth” (maxillary central incisor, mandibular lateral incisor, canine, first premolar, first molar) display the highest heritability, whereas those positioned more distally within the field show lower heritability, and therefore are more prone to morphological variability [25]. Several studies, including a recent one of the Croatian population[26], have confirmed this theory, while other authors failed to find proof for these trends [27]. The reasons stated in the research of authors who failed to find proof for the morphogenetic fields theory might explain the fact that in our research lower first molars, which are considered “key” teeth, showed greater variability and were significantly smaller in the hypodontia group compared to the control group. Gungor and Turkkahraman [11] found upper first premolars (mild hypodontia group) and upper lateral incisors (severe hypodontia group) to be the teeth with the greatest differences in mesiodistal
dimensions. According to the results published by Brook et al [10], upper lateral incisors were again the teeth with the smallest mesiodistal dimensions, followed by lower central incisors. These authors have also found upper first molars and lower canines to be markedly smaller in the female hypodontia group of their sample. On the other hand, Kerekes-Mathe et al [24] reported that in female subjects, upper first premolars had the smallest dimensions, followed by upper canines, upper central incisors, lower central incisors and lower second premolars. In male subjects of the same study, teeth with the smallest dimensions were upper central incisors, upper lateral incisors, upper canines, lower second premolars and lower central incisors respectively. According to a recent study by Khalaf et al. [2], upper lateral incisors were, again, the most affected in terms of tooth size reduction, whereas the least affected were lower first molars, which is opposite to our findings.

Comparing tooth sizes between genders in our sample has revealed that lower canines had significantly greater mesiodistal dimensions in males than in females in both groups. However, in the hypodontia group upper second premolars were significantly larger in females. This might not have been the case if larger samples had been available, since second premolars are often congenitally missing, and only five second premolars were available in the male hypodontia group, and eight in the female hypodontia group of our sample. Insignificantly larger mesiodistal dimension in females compared to males were found for upper first premolars and central incisors, and lower second premolars and first molars in the hypodontia group; and upper first molars and lower second premolars in the control group. Gungor and Turkkahraman [11] also found insignificantly larger upper central incisors in the female hypodontia group, while Fekonja [23] found insignificantly larger upper left first premolars and upper right first molars in the female hypodontia group. Kerekes-Mathe et al [24] reported significantly smaller tooth crown dimensions in females compared to males of the hypodontia group.

The most commonly missing teeth in our study sample were upper lateral incisors, followed by lower and upper second premolars. These results are in line with those published in the meta-analyses by Khalaf et al [2] and Polder et al [7], which reported the most commonly congenitally missing teeth were lower second premolars, upper lateral incisors and upper second premolars. Same results were published by Janosevic et al [3], where lower second premolars and upper lateral incisors were the most commonly missing teeth in the Serbian population sample.
Even though we did not evaluate the reliability or accuracy of digital versus plaster study model measurements, we thought we should mention that most studies published so far have found excellent reproducibility, reliability, and accuracy of measurements made on scanned digital models and the differences between measurements made on digital and plaster models were clinically acceptable and reproducible [28, 29]. The software used in our research, Geomagic, was also used by Zhou et al [30] who found the mean difference between the plaster and virtual model measurements were approximately 0.05 mm. That is both clinically and statistically insignificant and speaks in favor of the reliability of the measurements obtained in our study. High intra-operator reliability levels and no significant differences between measurements in our study also confirm the reliability of Geomagic software for obtaining mesiodistal tooth dimensions.

CONCLUSION

Hypodontia group presented with smaller mesiodistal dimensions compared to healthy controls. The greatest difference in mesiodistal dimensions was found in upper lateral incisors and lower first molars. Lower canines were significantly larger in males compared to females in both groups.

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Table 1. Intraoperator error assessment between two measurements in the hypodontia group

| Tooth | Maxilla | | | Mandible | | |
|-------|---------|-----|-----|-----------|-----|-----|
|       | n       | Error (mm) | SD  | n     | Error (mm) | SD  |
| I1    | 25      | 0     | 0.24 | 24    | -0.08   | 0.23 |
| I2    | 13      | 0.07  | 0.21 | 25    | 0.02    | 0.22 |
| C     | 15      | 0.08  | 0.31 | 20    | -0.01   | 0.29 |
| PM1   | 21      | 0.02  | 0.19 | 19    | 0.07    | 0.19 |
| PM2   | 13      | 0.02  | 0.24 | 12    | -0.01   | 0.15 |
| M1    | 24      | 0.02  | 0.17 | 24    | 0.10    | 0.33 |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar
Table 2. Mean values and standard deviations for the hypodontia and the control group – maxilla

| Tooth | Group      | n  | Mean | SD  | p            |
|-------|------------|----|------|-----|--------------|
| I1    | Hypodontia | 25 | 8.04 | 0.45| < 0.001***   |
|       | Control    | 25 | 8.59 | 0.48|              |
| I2    | Hypodontia | 13 | 5.47 | 0.74| < 0.001***   |
|       | Control    | 25 | 6.74 | 0.48|              |
| C     | Hypodontia | 15 | 7.44 | 0.54| 0.114        |
|       | Control    | 25 | 7.67 | 0.38|              |
| PM1   | Hypodontia | 21 | 6.43 | 0.46| 0.001**      |
|       | Control    | 14 | 7.03 | 0.44|              |
| PM2   | Hypodontia | 13 | 6.16 | 0.43| 0.003**      |
|       | Control    | 25 | 6.61 | 0.42|              |
| M1    | Hypodontia | 24 | 9.25 | 0.59| < 0.001***   |
|       | Control    | 25 | 10   | 0.53|              |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Table 3. Mean values and standard deviations for the hypodontia and the control group – mandible

| Tooth | Group       | n  | Mean | SD  | p       |
|-------|-------------|----|------|-----|---------|
|       | Hypodontia  |    |      |     |         |
| I1    | 24          | 5  | 0.40 |     | < 0.001*** |
| I2    | 25          | 5.4| 0.27 |     | < 0.001*** |
| C     | 20          | 5.59| 0.51|     | 0.029* |
| PM1   | 19          | 5.51| 0.57|     | 0.006** |
| PM2   | 12          | 5.33| 0.42|     | < 0.001*** |
| M1    | 24          | 9.38| 0.72|     | < 0.001*** |
|       | Control     |    |      |     |         |
| I1    | 25          | 5.4| 0.27 |     |         |
| I2    | 25          | 6.01| 0.32|     | < 0.001*** |
| C     | 25          | 6.89| 0.38|     |         |
| PM1   | 21          | 6.95| 0.39|     |         |
| PM2   | 25          | 6.96| 0.48|     |         |
| M1    | 24          | 10.44| 0.58|     |         |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Table 4. Mesiodistal dimensions of teeth by sex in the maxilla – hypodontia group

| Tooth | Sex | n  | Mean  | SD   | p      |
|-------|-----|----|-------|------|--------|
| I1    | Male| 10 | 7.86  | 0.45 | 0.104  |
|       | Female| 15 | 8.16  | 0.43 |        |
| I2    | Male| 5  | 5.56  | 0.61 | 0.753  |
|       | Female| 8  | 5.41  | 0.85 |        |
| C     | Male| 5  | 7.61  | 0.69 | 0.397  |
|       | Female| 10 | 7.35  | 0.47 |        |
| PM1   | Male| 7  | 6.34  | 0.25 | 0.541  |
|       | Female| 14 | 6.48  | 0.53 |        |
| PM2   | Male| 5  | 5.82  | 0.3  | 0.018* |
|       | Female| 8  | 6.37  | 0.37 |        |
| M1    | Male| 9  | 9.28  | 0.68 | 0.841  |
|       | Female| 15 | 9.23  | 0.55 |        |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Table 5. Mesiodistal dimensions of teeth by sex in the mandible – hypodontia group

| Tooth | Sex  | n  | Mean | SD  | p    |
|-------|------|----|------|-----|------|
| I1    | Male | 9  | 5.12 | 0.48 | 0.304 |
|       | Female | 15 | 4.94 | 0.35 |       |
| I2    | Male | 10 | 5.58 | 0.4  | 0.312 |
|       | Female | 15 | 5.43 | 0.36 |       |
| C     | Male | 7  | 6.90 | 0.48 | 0.040*|
|       | Female | 13 | 6.42 | 0.46 |       |
| PM1   | Male | 7  | 6.7  | 0.7  | 0.265 |
|       | Female | 12 | 6.39 | 0.48 |       |
| PM2   | Male | 5  | 6.2  | 0.21 | 0.395 |
|       | Female | 7  | 6.42 | 0.52 |       |
| M1    | Male | 9  | 9.23 | 0.96 | 0.434 |
|       | Female | 15 | 9.47 | 0.55 |       |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Table 6. Mesiodistal dimensions of teeth by sex in the maxilla – control group

| Tooth | Sex   | n   | Mean | SD  | p    |
|-------|-------|-----|------|-----|------|
| I1    | Male  | 10  | 8.68 | 0.54| 0.414|
|       | Female| 15  | 8.52 | 0.45|      |
| I2    | Male  | 10  | 6.94 | 0.34| 0.098|
|       | Female| 15  | 6.61 | 0.53|      |
| C     | Male  | 10  | 7.75 | 0.37| 0.454|
|       | Female| 15  | 7.63 | 0.40|      |
| PM1   | Male  | 9   | 7.13 | 0.46| 0.264|
|       | Female| 5   | 6.85 | 0.38|      |
| PM2   | Male  | 10  | 6.61 | 0.41| 0.977|
|       | Female| 15  | 6.61 | 0.44|      |
| M1    | Male  | 10  | 9.97 | 0.42| 0.810|
|       | Female| 15  | 10.02| 0.61|      |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Table 7. Mesiodistal dimensions of teeth by sex in the mandible – control group

| Tooth | Sex     | n  | Mean | SD  | p    |
|-------|---------|----|------|-----|------|
| I1    | Male    | 10 | 5.40 | 0.31| 0.982|
|       | Female  | 15 | 5.40 | 0.26|      |
| I2    | Male    | 10 | 6.01 | 0.31| 0.947|
|       | Female  | 15 | 6.01 | 0.33|      |
| C     | Male    | 10 | 7.12 | 0.42| 0.012*|
|       | Female  | 15 | 6.74 | 0.28|      |
| PM1   | Male    | 10 | 6.98 | 0.45| 0.742|
|       | Female  | 11 | 6.92 | 0.34|      |
| PM2   | Male    | 10 | 6.92 | 0.44| 0.762|
|       | Female  | 15 | 6.98 | 0.52|      |
| M1    | Male    | 9  | 10.66| 0.43| 0.140|
|       | Female  | 15 | 10.30| 0.63|      |

I1 – central incisor; I2 – lateral incisor; C – canine; PM1 – first premolar; PM2 – second premolar; M1 – first molar;

*p < 0.05;

**p < 0.01;

***p < 0.001
Figure 1. Scanning of a study model positioned on a stand with NextEngine 3D scanner HD
(Next Engine Inc., Santa Monica, CA)
Figure 2. Measuring the mesiodistal dimension of upper right first premolar in the Geomagic software