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Dental Arch Dimensions in Patients with Mild, Moderate and Severe Hypodontia and a Control Group

Khaled Khalaf

College of Dentistry, King Faisal University, PO Box 400, Al Ahsa 31982, Saudi Arabia

Abstract:

Objectives: *To compare maxillary and mandibular dental arch dimensions between subjects with mild, moderate and severe hypodontia and a control group.*

Method and Materials: *The study comprised 120 patients with hypodontia divided into three groups of 40 mild (≤2 teeth congenitally missing), 40 moderate (3-5 teeth congenitally missing) and 40 severe (≥6 teeth congenitally missing) hypodontia; and 40 age and sex matched controls. Maxillary and mandibular dental arch lengths, widths and depths were recorded on study models using digital callipers and compared between all hypodontia and control groups using Two-way ANOVA and Bonferroni's post-hoc tests of subgroup comparison.*

Results: *Two-way ANOVA revealed patients with hypodontia had significantly smaller maxillary and mandibular dental arch dimensions compared with controls ($p<0.05$). Furthermore, patients with severe hypodontia demonstrated smaller dental arch dimensions than those in the mild and moderate hypodontia subgroups, but the differences were statistically significant only between the severe and mild hypodontia subgroups ($p<0.05$). The most affected dental arch dimension in all hypodontia groups was the maxillary dental arch depth.*

Conclusions: *Patients with hypodontia had smaller dental arch dimensions than control. Reduction in dental arch dimensions appeared to be affected by the degree of hypodontia, with severe hypodontia having the greatest effect followed in descending order by moderate and mild hypodontia. The findings of this study will help to improve our clinical practice during the multidisciplinary management of this complex condition.*

Keywords: ***dimension, congenitally, missing, dental, arch, hypodontia.***

1. Introduction

Hypodontia is the congenital absence of one or more primary or permanent teeth. It has an overall prevalence of 6.4% [1] and thus it is considered to be one of the most common dental anomalies in humans. The severity of this condition varies and authors have subdivided patients affected by hypodontia into different categories based on the number of congenitally missing teeth [1]-[6]. When 6 or more teeth are congenitally missing, the condition is widely called oligodontia [1], [7]-[10]. In general, females were found to be more affected with this condition than males [1], [2], [4], [11]. Various authors have reported this condition to have a complex multifactorial aetiology, but with prominent genetic involvement [12]-[23].

Hypodontia patients often seek multi-specialty dental treatment complaining of aesthetic, functional and a negative impact on their psychosocial status [24]-[27]. The management of this condition, especially moderate and severe cases, requires a good knowledge about dental arch dimensions of patients with hypodontia to aid the diagnosis, treatment planning and coordination of treatment which is best undertaken in multidisciplinary clinics to achieve an optimal outcome [7], [24], [28]-[33].

Limited studies have been published to find out whether subjects with hypodontia have different dental arch dimensions when compared with controls [5]-[6], [34]-[37]. Furthermore, none of the previous studies have investigated the impact of the different severity of hypodontia on dental arch dimensions. Therefore, the aim of this study was to investigate the maxillary and mandibular dental arch dimensions namely arch length, widths and depth in mild, moderate and severe hypodontia subjects as compared to a control group.

2. Method and materials

A sample size calculation was carried out to determine the number of subjects required to compare subjects with mild, moderate and severe hypodontia to a matched control group. It was found that 40 subjects would be required in each subgroup to detect a clinically significant difference of 3 mm with 0.05 alpha and 0.2 beta. Thus, the hypodontia group comprised 120 patients divided into three subgroups

of 40 mild (≤2 teeth congenitally missing excluding third molars), 40 moderate (3-5 teeth congenitally missing excluding third molars) and 40 severe (≥6 teeth congenitally missing excluding third molars). The control group comprised 40 age and sex-matched subjects to those in the hypodontia subgroups, but with a full complement of the permanent dentition. Each subgroup contained 20 males and 20 females. All hypodontia patients were selected from the Joint Hypodontia Clinic at Aberdeen Dental Hospital, Aberdeen, UK and the control group was selected retrospectively and consecutively from the staff Orthodontic Treatment Waiting List. All subjects were of Caucasian origin, without general medical conditions or syndromes, had no supernumerary teeth, no previous extractions, no moderate or severe crowding and no previous orthodontic treatment. All patients' records including their panoramic radiographs were obtained and carefully examined to confirm the absence of teeth. Patients had to have the permanent canines and the first molars present in at least the maxilla or the mandible to allow recording dental arch measurements and comparison with other studies. The age range for the whole sample was 11.40-18.50 years. The mean age and standard deviation (SD) of the hypodontia and control groups were 14.47 years (1.75 years) and 14.91 years (SD 1.84 years) respectively. The frequency of hypodontia according to the number of congenitally missing teeth is shown in Figure 1.

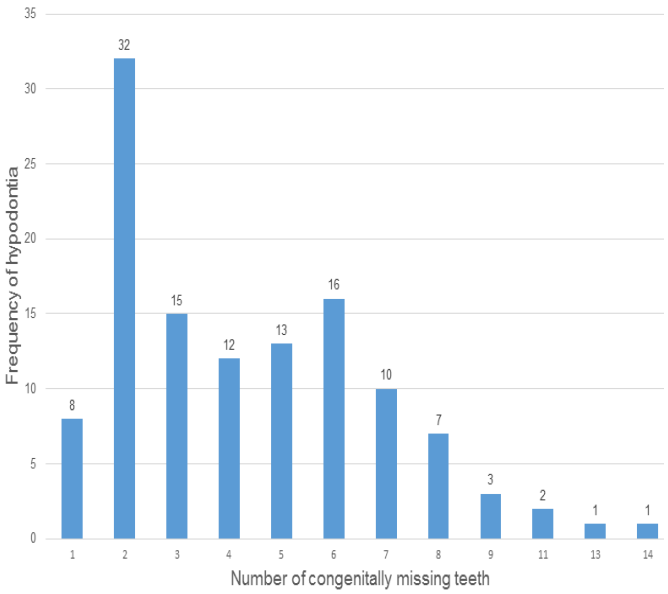

Figure 1. Frequency of hypodontia according to severity

Study models were collected for all subjects. The maxillary and mandibular dental arch measurements (8 variables) were recorded from the dental casts with the aid of a digital calliper (Digital Calliper, 0-150 mm, Linear Tools 2001) up to the 2nd decimal digit as described by Bishara et al [38] and as follows (Figure 2):

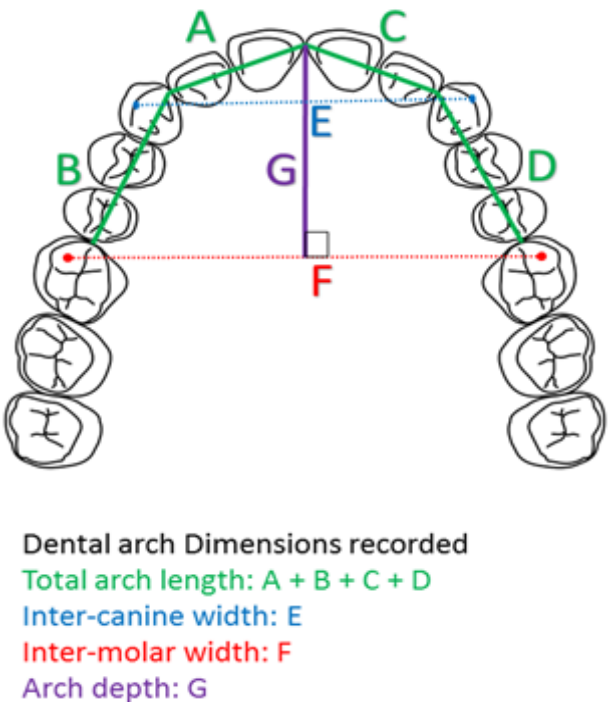

Figure 2. Dental arch dimensions recorded

The maxillary arch

1. Arch length: The sum of 4 linear distances
    a. Mesial of the 11 to mesial of 13
    b. Mesial of 13 to mesial of 16
    c. Mesial 21 to mesial of 23
    d. Mesial of 23 to mesial of 26
2. Inter-canine arch width: The distance between the tip of 13 to that of 23
3. Inter-molar arch width: The distance between the mesio-bucal cusp of 16 to that of 26
4. Arch depth: The perpendicular from the contact point of 11, 21 to the line measuring inter-molar arch width

The mandibular arch

The same measurements of the maxillary arch above were also recorded for the mandibular arch.

All measurements were carried out by one trained operator (KK) twice 4 weeks apart and the mean value of the two measurements was used. An intra-examiner reproducibility study was carried out using limits of agreement for all dental arch measurements taken from 20 randomly selected dental casts from both the hypodontia and control groups (10 each). There was no systematic bias as the paired sample t-test of the differences between the double recordings showed none of the differences were statistically significant ($P > 0.05$). With regards to the random error the method showed a high level of repeatability agreement with the percentage difference between the two measurements for all variables ranged from 1-3%.

Corresponding Author - Khaled Khalaf, College of Dentistry, King Faisal University

Statistical analysis

Statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS Inc., Chicago, Illinois, USA) version 23.0. Distribution of the data was tested using Kolmogorov-Smirnov test which showed a normal distribution ($P > 0.05$) and therefore, parametric tests were used. Statistical analysis of the differences in arch dimensions between groups was examined by two way analysis of variance (ANOVA). As the study involved multiple comparisons the subsequent p-values were corrected by multiplying the p-values by the number of tests (Bonferroni).

3. Results

Two-way ANOVA revealed no significant interaction between the two factor variables Group and Gender and therefore groups were compared regardless of genders. Males were found to have larger dental arch measurements than females, but none of the differences reached statistical significance ($p>0.05$).

Table 1 shows comparison of the dental arch measurements of the mild, moderate and severe hypodontia groups with controls and Table 2 shows Bonferroni's post-hoc tests of the subgroup comparisons of the dental arch measurements. Table 3 shows percentage reduction in the dental arch measurements of hypodontia patients compared with controls.

As it can be seen from Tables 1, 2 and 3 all dental arch measurement in moderate and severe hypodontia groups were statistically significantly smaller than those in the control group ($p<0.05$). Similarly all dental arch measurement in the mild hypodontia group were smaller than those in the control group, but only a few reached statistical significance, namely the mandibular arch length, the maxillary inter-canine arch width and the maxillary arch depth. In addition, severe hypodontia group showed the greatest reduction in dental arch measurements followed in descending order by moderate and mild hypodontia groups. The ranges for percentage reduction in dental arch dimensions of the mild, moderate and severe hypodontia groups were 0.85-6.58%, 2.42-9.40% and 3.62-12.78% respectively. Maxillary arch depth was found to be the most affected dental arch dimension in all hypodontia groups.

Table 1. Mean and SD of dental arch dimensions (mm) in the hypodontia and control groups

Dental arch dimension		Group I	Group II	Group III	Group IV
		Mean±SD	Mean±SD	Mean±SD	Mean±SD
Maxillary arch length	M	92.34±4.62	90.84±5.57	89.30±3.92	93.44±4.73
	F	91.82±4.82	88.33±6.35	85.95±9.02	93.40±2.81
Mandibular arch length	M	83.06±2.86	82.29±5.86	80.74±4.52	85.59±4.73
	F	82.08±2.55	81.68±6.18	80.33±7.25	84.57±5.52
Maxillary molar arch width	M	50.63±3.14	49.66±3.31	48.40±5.74	50.81±2.72
	F	48.03±4.14	48.63±3.91	47.80±2.54	49.92±3.25
Mandibular molar arch width	M	44.25±2.21	42.99±1.95	42.94±3.03	45.01±2.26
	F	43.62±3.22	43.20±2.72	42.95±3.32	44.11±3.69
Maxillary canine arch width	M	34.18±2.12	33.44±2.89	33.35±1.55	34.64±2.28
	F	33.04±2.69	32.04±2.26	31.60±2.52	34.52±3.07
Mandibular canine arch width	M	26.37±2.02	26.08±2.13	25.69±1.77	26.59±1.27
	F	26.04±2.17	25.34±1.77	24.58±2.21	26.27±1.41
Maxillary arch depth	M	31.11±3.94	30.86±3.49	29.22±3.38	33.71±2.78
	F	30.70±2.21	29.11±3.64	28.50±2.73	32.47±2.09
Mandibular arch depth	M	26.14±2.49	25.20±3.42	24.76±3.12	26.86±1.80
	F	25.99±2.75	24.87±2.94	24.20±2.67	26.11±1.72

M: male; F: female; SD: standard deviation; group I: mild hypodontia; group II: moderate hypodontia; group III: severe hypodontia; and group IV: normal controls.

Corresponding Author - Khaled Khalaf, *College of Dentistry, King Faisal University*

Table 2. Bonferroni's post-hoc tests of subgroup comparison of dental arch dimensions of the hypodontia and control groups

Dental arch dimension	Subgroup comparisons					
	I-II	I-III	I-IV	II-III	II-IV	III-IV
Maxillary arch length	*	**	NS	NS	**	**
Mandibular arch length	NS	*	*	NS	*	**
Maxillary molar arch width	NS	*	NS	NS	*	**
Mandibular molar arch width	NS	NS	NS	NS	*	*
Maxillary canine arch width	*	*	*	NS	**	**
Mandibular canine arch width	NS	**	NS	NS	*	**
Maxillary arch depth	*	**	**	*	**	**
Mandibular arch depth	*	**	NS	NS	**	**

*Group I: mild hypodontia; group II: moderate hypodontia; group III: severe hypodontia; and group IV: normal controls. *: significant p<0.05; **: highly significant p<0.001; NS: Not significant p>0.05.*

Table 3. Percentage reduction in the dental arch dimensions of hypodontia patients compared with controls

Dental arch dimension		Mild hypodontia	Moderate hypodontia	Severe hypodontia
Maxillary arch length	M	1.18	2.78	4.43
	F	1.69	5.43	7.98
Mandibular arch length	M	2.96	3.86	5.67
	F	2.94	3.42	5.01
Maxillary molar arch width	M	0.35	2.26	4.74
	F	3.79	2.58	4.25
Mandibular molar arch width	M	1.69	4.49	4.60
	F	1.11	2.06	2.63
Maxillary canine arch width	M	1.33	3.46	3.72
	F	4.29	7.18	8.46
Mandibular canine arch width	M	0.82	1.92	3.38
	F	0.88	3.54	6.43
Maxillary arch depth	M	7.70	8.45	13.32
	F	5.45	10.35	12.23
Mandibular arch depth	M	2.68	6.17	7.82
	F	0.46	4.75	7.32

M: male; F: female.

4. Discussion

For the purpose of this study subjects with hypodontia were split into three groups: mild with 1 to 2 teeth congenitally missing, moderate with 3 to 5 teeth congenitally missing and severe with 6 teeth or more congenitally missing to allow comparison with other studies [5], [6] as well as to investigate the impact of the most common classification of severity of the condition on the parameters studied.

In the present study it was found that males had greater dental arch measurements than females across all groups, but the differences were neither statistically nor clinically significant. Similar findings were found by Nelson and his co-workers [5] in their study comparing arch chord, inter-molar width and arch depth in the maxillary arch of mild/moderate, severe hypodontia groups and a control group. The same conclusion could also be withdrawn from Fekonja's study [37] who investigated inter-canine and inter-molar arch widths in a Slovenian subjects with and without hypodontia, although she did not report such gender differences in her study.

The reduction in arch length, width and depth seen between hypodontia subjects and controls agrees with the findings of Nelson et al [5] Bu et al [6] Le Bot and Salmon [35] and Fekonja [37] although none of these studies have investigated all dental arch dimensions nor did they investigate different severity of hypodontia as in the current study. Other investigators [34], [36] failed to find

Corresponding Author - Khaled Khalaf, *College of Dentistry, King Faisal University*

statistically significant differences in arch length and width measurements between hypodontia and controls, but the hypodontia group of their samples was mixed and predominantly of the mild type. Furthermore, Woodworth et al [36] did not use a sound control which make the conclusion of their findings questionable.

The current study has also shown that subjects with severe hypodontia had more percentage reduction in all dental arch dimensions than that in the moderate hypodontia group and this in turn had more percentage reduction than in the mild hypodontia group. This finding was in agreement with Bu's et al study [6] who suggested in their study of dental arch dimensions in oligodontia patients that patients with oligodontia had greater reduction in arch widths and length measurements than those with hypodontia. In contrast, Nelson et al [5] found a very small mean size difference (ranging from 0.35mm to 0.54mm) in upper inter-molar width, upper arch depth and upper arch chord between severe hypodontia group and mild/moderate hypodontia subjects. This may be attributed to the fact that Nelson and his colleagues have combined mild and moderate hypodontia subjects in one group and called it mild/moderate hypodontia group which might be predominantly of moderate severity with the majority of its subjects approaching the severe category.

The pattern of reduction of dental arch dimensions among the different hypodontia groups may be explained by a combination of the differences in the frequency of the congenitally missing teeth, the widely reported association between hypodontia and microdontia [3], [12], [22], [23] and the impact of the congenital absence of teeth on the developing dental arches [39], [40] thus resulting in mesial and inwards movements of teeth and smaller housing alveolar bones and as a consequence smaller dental arch dimensions.

In this study, it can be noted that the most affected dental arch dimension with size reduction was arch depth and the least affected one was arch width with an intermediate position for arch length dimension. The same finding was also reported by Nelson and colleagues [5] where the percentage reduction in arch depth, inter-molar arch width and arch length were 6.17%, 4.07% and 5.24% respectively. This is most probably due to the mesial drifting of teeth which affect arch depth, length and width in the same order found in the present study. Furthermore, the tendency for teeth to drift more mesially in the maxilla than in the mandible, can explain the general trend of size reduction of dental arch dimensions observed in the current study where the maxillary arch was found to be more affected than the mandibular arch.

The findings of this study will add useful information about the presence and pattern of size changes of the dental arches in hypodontia patients to help the multidisciplinary dental team to achieve the optimal diagnosis and management of patients with this complex condition by achieving an intra- and inter-dental arch harmony. The ultimate goal of the multidisciplinary dental team is to achieve an ideal occlusion with good tooth alignment and buccal inter-digitation, correct overjet, overbite and centreline coincidence.

5. Conclusions

1. Patients with hypodontia had smaller dental arch dimensions than control.
2. The more severe the hypodontia the greater reduction in dental arch dimension.
3. The most affected dental arch dimension in all hypodontia groups was the maxillary arch depth.

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Author Profile

Corresponding Author - Khaled Khalaf

Following the completion of a BDS and Specialty Training Programme in Orthodontics from Damascus University and a variety of practice and hospital posts Dr Khaled Khalaf joined a PhD Orthodontic and Postgraduate/SpR Training Programme at the Department of Child Dental Health and Charles Clifford Dental Hospital, Sheffield. He was then awarded a PhD in Orthodontics from the University of Sheffield and awarded Membership in Orthodontics of both the Royal Colleges of Surgeons of England and Edinburgh and a Fellowship in Dental Surgery (Orthodontics) of the Royal College of Surgeons in Ireland.

After a few practice and hospital posts Dr Khalaf was appointed as a Clinical Lecturer/ Senior Registrar in Orthodontics at Newcastle University and Newcastle Dental Hospital and James Cook University Hospital, Middlesbrough. During this time he gained the "CASAP Certificate" from Newcastle University (Postgraduate Certificate in Advanced Studies in Academic Practice) leading to a "Fellow of the Higher Education Academy". Furthermore, he gained the Intercollegiate Speciality Fellowship in Orthodontics of the Royal Surgical Colleges, UK and accreditation as a Consultant Orthodontist. He was then appointed as Associate Professor and Consultant Orthodontist at University of Aberdeen/ NHS Grampian, UK prior to joining King Faisal University, KSA.