An odontometric study of tooth size in normal, crowded and spaced dentitions

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ABSTRACT

Objective: To assess the mesio-distal tooth width in normal, crowded, or spaced dentitions.
Materials and Methods: A sample of 192 maxillary and mandibular dental casts of Libyan subjects was selected from a larger cohort. These subjects did not present with craniofacial anomaly, hypodontia, significant attrition, caries, restorations, or history of permanent tooth extraction or orthodontic treatment. The sample was divided into normal, crowded, and spaced groups according to tooth size/arch length discrepancy. Each group included 32 upper and lower dental casts with equal numbers of males (mean (SD) age = 14.7 (1.9) years) and females (mean (SD) age = 15.7 (2.5) years). The mesiodistal (MD) tooth width, sum of the MD tooth widths mesial to the first molars (TTM), sum of the MD width of the four incisors (I), and the sum of the MD width of canine and first and second premolars (CPP) were calculated for each group. The independent Student *t*-test was applied sequentially to detect significant differences between paired groups. The ANOVA test was undertaken to explore significant differences between the three groups. Pearson coefficient of correlation was used to evaluate the correlation between I and the corresponding CPP in maxillary and mandibular arches.
Results: MD tooth width, TTM, I, and CPP were significantly wider in the crowded compared to normal and spaced dentitions ($P<0.001$), except for the width of the upper left lateral incisors in both normal and crowded groups. Although there was a trend for smaller tooth widths in spaced dentitions compared to normal ones, this was only significant in the maxillary left central incisor, maxillary right and left lateral incisors, maxillary right first premolar, mandibular right lateral incisor, and mandibular right canine ($P<0.05$). However, the maxillary TTM, I, and CPP in the normal group were significantly greater than in the spaced group ($P<0.05$). Significant positive correlations existed between the mean values of I and CPP in both the maxillary and mandibular dentitions of all groups ($P<0.01$).
Conclusions: It appears that in the studied Libyan population, the MD tooth width is a significant component of crowding/spacing.

Key words: Crowded, Libyan, spaced, tooth size

INTRODUCTION

Odontometry is an anthropological science that can distinguish different groups and populations based on their dental parameters.[1] In orthodontics, odontometry is used to compute tooth size/arch length disparity to aid in planning individualized orthodontic management. This analysis is undertaken in each dental arch by computing differences between the required space [sum (∑) of the mesiodistal (MD) tooth width mesial to the first permanent molars] and space available [arch perimeter, measured by passing a brass wire along the occlusal line] in each arch.[2]

The aetiology of malocclusion can be broadly categorized under either hereditary, environmental, or a combination of both factors.[3] Exploring the aetiology of malocclusion is imperative for selecting the most appropriate treatment approach as well as the most appropriate retention device.[3,4] Crowding and

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spacing are considered the most common manifestations of malocclusion[2,5] and can occur as a result of either a shortage of the space required for tooth alignment or an excess of available space. Hence, tooth size and arch perimeter should generally correspond in cases of acceptable arch alignment.[2]

Tooth size varies among different populations and ethnicities[2,5,6] and is mainly influenced by heredity,[7-9] ethnicity,[10-12] and sex[13-15] as well as by secular and evolutionary trends.[16] The correlation between tooth size and crowding has been investigated by several researchers since the mid-twentieth century.[7-15,17-23] Lundstrom[17] observed an association between the presence of crowding and increased tooth width in 139 Swedish children. Doris *et al*.[18] noticed that dental arches having greater than 4 mm of crowding had consistently wider teeth than those with no or minimum tooth size/arch length discrepancy. Hashim and Al-Ghamdi[19] found significant discrepancy in tooth size between their normal and malocclusion groups although arch perimeter was similar in both samples. Puri *et al*.[20] reported significantly wider teeth in their crowded compared to their control group, and smaller tooth size in their spaced group, particularly the discrepancy was significant for the mandibular incisors. Lombardi[21] noticed a significant association between tooth size in the lower dental arch and post-orthodontic treatment relapse. On the other hand, Howe *et al*.[22] reported that MD tooth width was comparable in both crowded and normal dental arches, while noting that the arch perimeter was shorter in the crowded group.

In spite of the existence of several studies exploring the correlation between crowding/spacing and tooth parameters, there is still a need for further investigation of the association of tooth width and arch perimeter particularly for different populations. This is especially true for genetic and environmental contributions to variations in tooth size.[3,5,13,24] The aim of the present study was thus to evaluate the extent to which tooth size contributes to normal, crowded, or spaced dentition**.** A further aim was to investigate the correlation between the MD tooth width of canines and premolars (∑CPP), and the sum of the total tooth material (∑TTM), between and within normal, crowded, and spaced dentition groups.

MATERIALS AND METHODS

This study was undertaken at the Department of Orthodontics, Faculty of Dentistry, Benghazi-Libya. Ethical approval was secured from the Ministry of Health in Benghazi, Libya. The assessment tool consisted of dental casts selected from the archives of the Orthodontic Department and private practice, as well as from a cohort of dental casts obtained in another study.[25] The casts were from individuals of Libyan descent for at least two generations with no craniofacial anomaly or hypodontia. All permanent teeth were fully erupted up to the second molars without significant attrition, tooth caries, or restorations history of permanent tooth extraction and previous orthodontic treatment that might interfere with accurate tooth measurements.

A total of 192 dental casts were used for this study. Each of the normal, crowded, and spaced groups comprised 64 casts (equal sex ratio and equivalent units of the maxillary and mandibular casts). The sample size in the current study was comparable to samples included in odontometric studies using linear measurements. Brook *et al*.[26] concluded that discrimination between two groups of 20 subjects will provide an 80% power to identify a size difference of 0.90 mm. According to Brook *et al*.[26] this magnitude of size difference was considered reasonable. The sample size in the current study was enlarged because of the involvement of three groups and a desire to increase the power of the study.

The following measurements were recorded for each examined cast:

- The individual MD tooth width from the right to the left second premolars in each cast;
- ∑TTM: The sum of the MD tooth width from the right to the left second premolars in each cast;
- ∑I: The sum of the MD tooth width of the incisors;
- ∑CPP: The sum of the MD tooth width of the canine and premolars in each quadrant.

MD tooth width and determination of crowding/spacing

The MD tooth width of all teeth mesial to the first permanent molars in each cast was measured using an electronic digital caliper (BGS Germany Vernier Caliper 0-150) with an accuracy of 0.01 mm by one operator (S.O.) under natural and neon lights. The MD tooth width was utilized as the measurement between the anatomic contact points.[27]

Arch perimeter analysis[28] and Carey's analysis[29] were conducted on both the maxillary and mandibular dental arches, respectively. A brass wire (diameter 0.25 mm) was used to compute the arch perimeter. The brass wire was formed into a smooth, kink-free arc customized to fit the dental arch contour from the mesial marginal ridge of the right first permanent molar to the mesial marginal ridge of the left permanent molar, passing across the imaginary occlusal line in the maxillary and mandibular dental arches. The brass wire was then straightened and measured. The sum of the MD tooth width in each arch was subtracted from the measured corresponding arch perimeter. Group discrimination was based on intra-arch tooth size/arch perimeter discrepancy. Spacing was recorded as a positive, and crowding as a negative, score. Consequently, the sample was categorized on the basis of arch length/tooth size discrepancy as follows: A spaced dental arch was recorded when the arch length/tooth size discrepancy was +3 mm or more, while a crowded arch was recorded when the arch length/tooth size discrepancy was −3 mm or more. Cases with arch length/tooth size discrepancies of between −3 and +3 mm were designated normal.

Assessment of Method Error

Forty randomly selected dental casts were re-examined after a two-week interval to evaluate the reproducibility of the intra-operator measurement. The intraclass correlation coefficient (ICC) was 0.90, indicating an excellent level of reproducibility.

Statistical Analysis

The data were statistically analyzed utilizing Social Package of Statistical Science software (SPSS, version 17, Chicago, III). The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed. Mean and standard deviation (SD) were computed for each variable. An independent Student *t*-test was applied sequentially to detect significant differences between paired groups. Analysis of variance (ANOVA) was used to detect significant differences between the three groups and Fisher variance was calculated for the comparison of the three groups. Pearson coefficient of correlation was calculated to measure the correlation between groups. Statistical significance was set at the level $P < 0.05$.

RESULTS

Tables 1-3 present the descriptive statistics and unpaired Student *t*-test in the sequential pairwise comparison for MD tooth width in the three groups. Table 4 displays the descriptive statistics and unpaired Student *t*-test in the sequential pairwise comparison for ∑TTM, ∑I, and ∑CPP in three groups.

The mean values of the MD tooth width, ∑TTM, ∑I, and ∑CPP in the crowded group [Tables 1 and Table 4] were significantly wider than in the normal group ($P \leq 0.01$) except for the widths of the upper left lateral incisor ($P = 0.068$). In contrast, there were no significant differences in most of the mean values of the MD tooth width when the normal and spaced dentitions were compared [Table 2], except for the following teeth, which were significantly wider in the normal group: The upper right lateral incisor, upper right first premolar, upper left central and lateral incisors in the maxillary arch, and the lower right lateral incisor and the lower right canine in the mandibular arch ($P < 0.05$). Furthermore, the mean values of ∑TTM, ∑I, and ∑CPP were greater in the normal group compared to the spaced group [Table 4], but these differences were statistically significant only in the maxillary arch ($P < 0.001$). The mean value of the MD tooth width, ∑TTM, ∑I, and ∑CPP in the crowded group [Tables 3 and 4] were consistently significantly greater than in the spaced group ($P < 0.001$).

ANOVA revealed significant statistical discrepancies between the compared mean values of the MD tooth width of individual teeth [Tables 5 and 6] in the three examined groups (F value ranged from 17.10 to 40.19, $P < 0.0001$). Pearson's correlation coefficient detected significant positive correlation between the mean values of ∑I and ∑CPP in both the maxillary and mandibular dental arches of all groups (*r* value ranging between 0.455 and 0.758) at $P < 0.01$ [Table 7].

Table 1: Comparison of mean values of MD tooth width of teeth (SD) between normal and crowded dentitions

Arch	Tooth	Normal (*n*=32)	Crowded (*n*=32)	*P* value
		Mean (SD)	Mean (SD)	
Maxillary	R1	8.65 (0.45)	9.26 (0.60)	0.000
	R2	6.80 (0.47)	7.18 (0.68)	0.009
	R3	7.82 (0.41)	8.29 (0.55)	0.000
	R4	7.04 (0.38)	7.56 (0.47)	0.000
	R5	6.70 (0.37)	7.12 (0.46)	0.000
	L1	8.68 (0.47)	9.27 (0.61)	0.000
	L2	6.89 (0.46)	7.15 (0.65)	0.068
	L3	7.79 (0.47)	8.26 (0.55)	0.001
	L4	7.01 (0.32)	7.56 (0.47)	0.000
	L5	6.66 (0.36)	7.05 (0.52)	0.001
Mandibular	R1	5.35 (0.28)	5.78 (0.37)	0.000
	R2	5.91 (0.32)	6.42 (0.43)	0.000
	R3	6.85 (0.38)	7.29 (0.56)	0.000
	R4	6.97 (0.32)	7.62 (0.51)	0.000
	R5	6.90 (0.33)	7.60 (0.52)	0.000
	L1	5.35 (0.35)	5.81 (0.36)	0.000
	L2	5.80 (0.33)	6.36 (0.46)	0.000
	L3	6.76 (0.37)	7.32 (0.52)	0.000
	L4	6.98 (0.29)	7.64 (0.46)	0.000
	L5	6.96 (0.44)	7.68 (0.54)	0.000

MD – Mesiodistal; SD – Standard deviation

Table 2: Comparison of mean values of MD tooth width of teeth (SD) between normal and spaced dentitions

Arch	Tooth	Normal (*n*=32)	Spaced (*n*=32)	*P* value
		Mean (SD)	Mean (SD)	
Maxillary	R1	8.65 (0.45)	8.44 (0.51)	0.096
	R2	6.80 (0.47)	6.48 (0.46)	0.008
	R3	7.82 (0.41)	7.60 (0.45)	0.053
	R4	7.04 (0.38)	6.85 (0.34)	0.034
	R5	6.70 (0.37)	6.58 (0.43)	0.223
	L1	8.68 (0.47)	8.43 (0.50)	0.045
	L2	6.89 (0.46)	6.52 (0.42)	0.001
	L3	7.79 (0.47)	7.58 (0.39)	0.055
	L4	7.01 (0.32)	6.85 (0.37)	0.059
	L5	6.66 (0.36)	6.60 (0.39)	0.538
Mandibular	R1	5.35 (0.28)	5.31 (0.34)	0.597
	R2	5.91 (0.32)	5.86 (0.39)	0.047
	R3	6.85 (0.38)	6.62 (0.43)	0.032
	R4	6.97 (0.32)	6.89 (0.39)	0.393
	R5	6.90 (0.33)	6.99 (0.52)	0.421
	L1	5.35 (0.35)	5.28 (0.33)	0.444
	L2	5.80 (0.33)	5.78 (0.33)	0.746
	L3	6.76 (0.37)	6.60 (0.43)	0.106
	L4	6.98 (0.29)	6.88 (0.37)	0.219
	L5	6.96 (0.44)	7.05 (0.47)	0.462

MD – Mesiodistal; SD – Standard deviation

DISCUSSION

This study was a cross-sectional, retrospective, case-controlled study aimed at exploring differences in MD tooth width among normal, crowded, and spaced dentitions. Significant tooth size/arch length discrepancy might interfere with the achievement of acceptable orthodontic treatment outcome.[30] It has been observed that tooth size/arch length disparities exist in a large percentage of orthodontic patients.[31,32] Therefore, factors contributing to these discrepancies must be taken into consideration when selecting the appropriate treatment approach in crowded cases, whether this necessitates tooth extraction, tooth stripping, or arch expansion.[25]

The age group in the current study was selected to be relatively young to reduce the influence of tooth wear and attrition on tooth width measurements. Moreover, tooth measurement was conducted on study models which offers a significant improvement on direct intra-oral tooth measurement and allow remeasurement when required.[33,34] Racial variations in MD tooth width have been noted by previous researchers[5,11,13,24,35,36] and therefore variations in MD tooth width are likely to be population-specific. Moreover, males are consistently found to have larger teeth than females.[14,35,37-39] Therefore, each group examined in the current study comprised equal numbers of males and females to avoid sex bias on measurement outcome.

Table 3: Comparison of mean values of MD tooth width of teeth (SD) between crowded and spaced dentitions

Arch	Tooth	Crowded (n=32)	Spaced (n=32)	P value
		Mean (SD)	Mean (SD)	
Maxillary	R1	9.26 (0.60)	8.44 (0.51)	0.000
	R2	7.18 (0.68)	6.48 (0.46)	0.000
	R3	8.29 (0.55)	7.60 (0.45)	0.000
	R4	7.56 (0.47)	6.85 (0.34)	0.000
	R5	7.12 (0.46)	6.58 (0.43)	0.000
	L1	9.27 (0.61)	8.43 (0.50)	0.000
	L2	7.15 (0.65)	6.52 (0.42)	0.000
	L3	8.26 (0.55)	7.58 (0.39)	0.000
	L4	7.56 (0.47)	6.85 (0.37)	0.000
	L5	7.05 (0.52)	6.60 (0.39)	0.000
Mandibular	R1	5.78 (0.37)	5.31 (0.34)	0.000
	R2	6.42 (0.43)	5.86 (0.39)	0.000
	R3	7.29 (0.56)	6.62 (0.43)	0.000
	R4	7.62 (0.51)	6.89 (0.39)	0.000
	R5	7.60 (0.52)	6.99 (0.52)	0.000
	L1	5.81 (0.36)	5.28 (0.33)	0.000
	L2	6.36 (0.46)	5.78 (0.33)	0.000
	L3	7.32 (0.52)	6.60 (0.43)	0.000
	L4	7.64 (0.46)	6.88 (0.37)	0.000
	L5	7.68 (0.54)	7.05 (0.47)	0.000

MD – Mesiodistal; SD – Standard deviation

All teeth in the maxillary and mandibular crowded arches were significantly wider than the corresponding teeth in the normal group, except for the upper left lateral incisors, which did not show significant differences in both groups. A contributory factor in the latter case might be that the size of the lateral incisor is the most dimensionally variable and inconsistent among the measured teeth in the present study, as it is the most distal tooth in the incisor group.[5] Furthermore, a comparison between the MD width of the normal and spaced dentition revealed that the maxillary right and left lateral incisors were significantly wider in the normal dentition, while the only other teeth that showed size disparity between both groups were the upper right first premolar, the upper left central incisor, the lower right lateral incisor and the lower right canine. In this case, the level of significance of size discrepancy was higher between the upper lateral incisors than between the other teeth. This finding has not been reported in similar studies of other investigators[7,20,40] possibly due to the different ethnicity of the present sample or as a result of the generally accepted inconsistency of the lateral incisor shape and size.[5,16] It is worthwhile mentioning the maxillary lateral incisors were also among the most commonly missing teeth.[41] It has been reported[7,20,40] that maxillary canines had a smaller size discrepancy compared to the other maxillary teeth measured within their examined groups. The researchers linked canine size stability to its function, as the canines occupy a strategic position in the maxillary arch, linking incisors to premolars.[7,20,40] In the present study, there were significant discrepancies between the size of the maxillary and mandibular teeth including the canines between all the three groups. This might be a characteristic of the particular population examined.

Table 4: Comparison of the mean values of the sum of the total tooth material (∑TTM), the sum of the four incisors (∑I) and the sum of the canine, first, and second premolars (∑CPP) between normal and crowded groups, normal and spaced groups as well as between crowded and spaced groups

Arch	Combined mesurements	Normal	Crowded	Spaced	Normal and crowded	Normal and spaced	Crowded and spaced
		Mean (SD)	Mean (SD)	Mean (SD)	P value	P value	P value
Maxillary	TTM	74.05 (2.62)	78.69 (4.30)	71.93 (3.01)	0.000	0.004	0.000
	∑I	31.02 (1.41)	32.86 (2.24)	29.87 (1.58)	0.000	0.003	0.000
	∑CPP	43.02 (1.66)	45.83 (2.51)	42.06 (1.90)	0.000	0.034	0.000
Mandiblular	TTM	63.81 (2.38)	69.49 (3.50)	63.25 (3.25)	0.000	0.435	0.000
	∑I	22.41 (1.11)	24.34 (1.38)	22.23 (1.25)	0.000	0.541	0.000
	∑CPP	41.42 (1.62)	45.15 (2.46)	41.02 (2.19)	0.000	0.418	0.000

TTM – Total tooth material; CPP – Canine and first and second premolars; I – Incisors; SD – Standard deviation

MD tooth width was significantly greater in the crowded group compared to the spaced group. This led to significantly larger mean values of ∑TTM, ∑I, and ∑CPP in the crowded dentition compared to the corresponding mean values in the normal and spaced groups, suggesting that dental arches with larger teeth are crowded and that dental arches with smaller teeth tend to be spaced. Similar findings were reported in previous studies[18,20,23,40].

Table 5: Comparison of the mean values of the MD width of teeth (SD) in the maxillary arch as detected by ANOVA

Quadrant	*n*	Tooth type	Normal mean (SD)	Crowded mean (SD)	Spaced mean (SD)	ANOVA *P* value
Maxillary right	32	11	8.65 (0.45)	9.26 (0.60)	8.44 (0.51)	HS
	32	12	6.80 (0.47)	7.18 (0.68)	6.48 (0.46)	HS
	32	C	7.82 (0.41)	8.29 (0.55)	7.60 (0.45)	HS
	32	P1	7.04 (0.38)	7.56 (0.47)	6.85 (0.34)	HS
	32	P2	6.70 (0.37)	7.12 (0.46)	6.58 (0.43)	HS
Maxillary left	32	11	8.68 (0.47)	9.27 (0.61)	8.43 (0.50)	HS
	32	12	6.89 (0.46)	7.15 (0.65)	6.52 (0.42)	HS
	32	C	7.79 (0.47)	8.26 (0.55)	7.58 (0.39)	HS
	32	P1	7.01 (0.32)	7.56 (0.47)	6.85 (0.37)	HS
	32	P2	6.66 (0.36)	7.05 (0.52)	6.60 (0.39)	HS

HS, indicates highly significant ($P<0.001$); SD – Standard deviation; ANOVA – Analysis of variance; MD – Mesiodistal; I1, central incisor; I2, lateral incisor; C, canine; P1, first premolar; P2, second premolar

Table 6: Comparison of the mean values of the MD width of teeth (SD) in the mandibular arch as detected by ANOVA

Quadrant	*n*	Tooth type	Normal Mean (SD)	Crowded Mean (SD)	Spaced Mean (SD)	ANOVA *P* value
Mandibular right	32	11	5.35 (0.28)	5.78 (0.37)	5.31 (0.34)	HS
	32	12	5.91 (0.32)	6.42 (0.43)	5.86 (0.39)	HS
	32	C	6.85 (0.38)	7.29 (0.56)	6.62 (0.43)	HS
	32	P1	6.97 (0.32)	7.62 (0.51)	6.89 (0.39)	HS
	32	P2	6.90 (0.33)	7.60 (0.52)	6.99 (0.52)	HS
Mandibular left	32	11	5.35 (0.35)	5.81 (0.36)	5.28 (0.33)	HS
	32	12	5.80 (0.33)	6.36 (0.46)	5.78 (0.33)	HS
	32	C	6.76 (0.37)	7.32 (0.52)	6.60 (0.43)	HS
	32	P1	6.98 (0.29)	7.64 (0.46)	6.88 (0.37)	HS
	32	P2	6.96 (0.44)	7.68 (0.54)	7.05 (0.47)	HS

HS, indicates highly significant ($P<0.001$); SD – Standard deviation; ANOVA – Analysis of variance; MD – Mesiodistal; I1, central incisor; I2, lateral incisor; C, canine; P1, first premolar; P2, second premolar

It was apparent from the current research that the fluctuating asymmetry between paired MD tooth measurements in both the maxillary and mandibular dental arches was non-systematic and ranged between 0 and 11 mm, which was not statistically significant. This finding agrees with the results of similar studies[13,20,40-43] which concluded that the asymmetry between each tooth width and its antimere ranges over ±0.25 mm in the maxillary arch and ±0.20 mm in the mandibular arch, and that asymmetry is fluctuating and not systematic.

Despite the similarity in size of 70% (14 out of 20) of the total number of measured teeth in both the normal and spaced groups, the accumulative value of tooth width (∑TTM) was significantly greater in the normal dentition. Puri *et al*.[20] and Iida[44] reported comparable results and pointed out that dentitions with small teeth tended to have spaced dental arches.

Pearson correlation coefficient revealed significant correlation between ∑I and the corresponding ∑CPP in each of the three groups., i.e., as one of the variables increases, so does the other. These findings are in line with those of Puri *et al*.[20] and Garn *et al*.[14] The latter authors[14] observed that tooth size from the same morphological category (e.g., incisors) positively correlates with tooth size from the adjacent category (e.g., canine and premolars). A similar positive correlation between ∑I and the corresponding ∑CPP was noticed in other studies.[45-47]

CONCLUSIONS

- The MD widths of the individual teeth were significantly wider in the crowded group compared to the normal and spaced groups, except for the sizes of the upper left lateral incisor in both the normal and crowded groups.
- The maxillary and mandibular ∑TTM, ∑I, and ∑CPP were consistently significantly greater in the crowded group compared to the normal and spaced groups. While only the maxillary ∑TTM, ∑I, and ∑CPP were significantly greater in the normal group compared to the spaced group.
- The correlation of the ∑I and ∑CPP was significantly positive in crowded, normal, and spaced dentition groups.

Table 7: Correlation of the mean values of the sum of the four incisors (∑I) and the sum of the canine, first, and second premolars (∑CPP) in the normal, crowded, and spaced groups

Group	Arch	Number	Tooth width	Tooth width	Correlation	*t* test *P* value
Normal	Maxillary	32	∑I	∑CPP	0.455	0.009
	Mandibular	32	∑I	∑CPP	0.474	0.006
Crowded	Maxillary	32	∑I	∑CPP	0.558	0.001
	Mandibular	32	∑I	∑CPP	0.469	0.007
Spaced	Maxillary	32	∑I	∑CPP	0.501	0.003
	Mandibular	32	∑I	∑CPP	0.758	<0.001

CPP – Canine and first and second premolars; I – Incisors

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