Original article:

Comparative study of tooth size in Normal, Crowded and Spaced permanent dentitions in Gujarati population

[1]Dr Dolly Patel, [2]Dr Falguni Mehta, [3]Dr Sandip Thakkar , [4]Dr Vaibhav Gandhi

[1]Dean, AMC dental College and hospital, Khokhra, Ahmedabad.

[2]Head of Department, Govt. Dental Clg. and Hospital, Ahmedabad

[3]3rd year PG student, Govt. Dental Clg and Hospital, Ahmedabad

[4]3rd year PG student, Govt. Dental Clg and Hospital, Ahmedabad, India

Corresponding author: Dr Vaibhav Gandhi

ABSTRACT:

Introduction: The orthodontic ‘‘finishing’’ phase is recognized for the multitude of details necessary to achieve an excellent result. In some cases, the finishing phase is very difficult, requiring the production of complicatedbiomechanical forces to reach a satisfactory orthodontic solution. A high percentage of these finishing phase difficulties arise because of tooth size imbalances that could have been detected and consideredduring initial diagnosis and treatment planning.A comparative study of tooth size was carried out to examine theextent to which tooth size contributes to dental crowding or spacing.

Methods: A sample of 240 orthodonticstudy casts was selected from a larger sample. These casts met the selection criteria. The sample wasdivided into crowded, spaced, and normal dentition groups with 80 casts in each group. The criterion ofgrouping was based on the tooth size-arch length discrepancy in the arch. The data were statisticallyanalyzed.

Results: Mesiodistal crown dimensions of individual teeth, the sum of the incisors, and the sum ofthe canines and the premolars were uniformly larger in crowded arches than in normal and spaced dentitiongroups. Mesiodistal crown dimensions of individual teeth were smaller in the spaced arches compared with normal dental arches.Correlations of the combined mesiodistal crown dimensions of the incisors withthe combined mesiodistal crown dimensions of the canines and the premolars were positive in all 3 groups.

Conclusions: Mesiodistal tooth size is an important factor in the assessment of crowding or spacing and inorthodontic treatment planning.

Key-words: Tooth-size, Dentition, Biometric study, Tooth size-arch length discrepancy

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INTRODUCTION

Malocclusion is an increasingly common problem encountered inindustrialized countries. Indeed, malocclusion has been described as a “disease of civilization” (Corruccini and Kaul 1984)[1]because of its high prevalence in contemporary industrialized countries as compared to historic populations and, even, isolated cultures that continue to subsist on less-processed diets (Corruccini 1984).[2] Skeletal remains show that the present prevalence of malocclusion is several times greater than it was as little as a millennium ago (Proffit 1999).[3] Epidemiological estimates are that more than half of U.S. adolescents would decidedly benefit from orthodontic treatment (Kelly and Harvey 1977).[4]These national statistics show that only about 1 in 10 American youths have naturally-occurring good occlusions. Comparably, Buschang and Schulman (2003) reported that only one-fifth of the U.S. population between 8 and 50 years of age is without some degree of incisor irregularity.

A relevant issue in this context is causation: what factors are driving this high frequency of malocclusion? There is no single cause of malocclusion; most people develop occlusal problems because of a number of interacting

developmental issues (*e.g.,* Proffit 1986; Hartsfield 2000). [5-6]The most common forms of malocclusion are crowding and spacing. The important determinants of crowding and spacing in dental arches are the size of the teeth and the size of the bony bases.Although the causes of dental malocclusion are obscure in most instances, one contributing factor may be tooth size. Some previous studies have found the mesiodistal width of mandibular incisor teeth to be significantly greater in subjects with anterior dental crowding compared to subjects with ideal anterior alignment (Peck and Peck 1972, Norderval *et al.* 1975; Adams 1982).[7-9]In contrast, others have been unable to distinguish between crowded and noncrowded dentitions on the basis of mesiodistal tooth widths (Howe *et al.* 1983; Gilmore and Little 1984).[10-11]Dento-alveolar disproportion is usually ascribed to a discrepancy between MD crown dimensions and is a relevant topic to explore because it has an impact on prognosis, treatment methods, and retention. This study was an attempt to explore overall biomechanics of total tooth material as well as individual tooth in both maxillary and mandibular arch and compare them in three different patterns of tooth alignment i.e. normal, spaced and crowded permanent dentition group.

MATERIAL AND METHODS

This study was conducted in the Department of Orthodontics and Dentofacial Orthopedics at the Govt. Dental College and hospital,Ahmedabad, Gujarat. A large sample of dental casts of Gujarati subjects, males and females aged 15 to 25 years was collected. The dental casts were selected from the archives of the department of orthodontics of the patients undergoing orthodontic treatment hence all the details regarding age, sex etc. were available.

The casts met the following selection criteria:

(1)Pre treatment casts of subjects with no prior orthodontic treatment involving permanent dentition in either arch; (2) All permanent teeth in each arch were sufficiently erupted to permit measurements of the MD crown dimensions; and (3) Casts with worn out or mutilated dentition, or large coronal restorations, were not considered.For each cast, MD crown diameters of all teeth except the second and third permanent molars and arch perimeter were measured.

The crown diameters were taken as the distance between anatomic contact points.An electronic digital calliper (Digimatic calliper; Mitutoyo, Kawasaki, Japan) was used to measure the MD crown widths, with fine tips measuring within 0.01 mm. All measurements were made by 1 operator.

Arch perimeter analysisand Carey's analysiswere performed on the maxillary and mandibulararches, respectively. The measurements were made byadapting a length of brass wire (diameter, 0.25 in) to fitfrom the mesial marginal ridge of the left first permanent molar over the imagined correct positions of the canines and the incisors and over the center of the occlusal surfaces of the premolars to the mesial marginalridge of the right first permanent molar. The brass wire was made into a smooth arch, free from kinks, and in a simulated arch form.The sum of the MD crown diameters of the appropriateteeth was subtracted from the available archlength. Crowding was recorded as a negative score and spacing as a positive score.(fig.1)The grouping of the sample was done on the basis of tooth size-arch length discrepancy. Crowded arches were those with a space discrepancy of -3 mm or more, spaced arches were those with a space discrepancy of + 3 mm or more,and normal arches were those with a space discrepancy of 0 ±3 mm.Total 312 casts were analysed and 240 casts amongst themmet the criteria of grouping, and they were further divided

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into crowded, spaced, and normal dentition groups with 80 casts in each group. Each group comprised 40 maxillary and 40 mandibular casts, not necessarily of the same patient .They were further divided equally by sex.

All the data collected was tabulated according to groups and subjected to appropriate statistical analysis.

STATISTICAL SOFTWARE-The statistical analysis was carried out with the help of a statistical software S.P.S.S. (version 17) for windows i.e. Statistical package for social sciences, and the data was analyses accordingly.

Descriptive measures such as means, standard deviations, and standard errors of the mean were calculated for each variable. Unpaired *t* tests were used for comparison between the two groups e.g. between crowded and normal dentition, spaced and normal dentition etc. Analysis of variance (ANOVA) was performed, and the Fisher variance was calculated for comparison of all the three groups.

The Pearson coefficient of correlation was calculated to measure the correlation of Tot-A with Tot-B between groups.Separate measurements of each and every tooth were done. Their means were measured. Analysis of variance (ANOVA) was performed for comparison of MD width of each tooth between the all three groups. A level of significance ($P \leq .05$) was used for the statistical tests.

RESULTS

The mean values of TTM, Tot-A, and Tot-B were greater in crowded arches than in the normal dentition group. The difference was statistically significant in both arches (Table 2).

TABLE-2: Comparison of mean values of combined MD crown dimensions of incisors (Tot-A), combined MD crown dimensions of canines and premolars (Tot-B), and total tooth material (TTM) between crowded and normal groups

Arch	N	Combined Mesiodistal Width	Crowded		Normal		P Value	Result
			Mean	SD	Mean	SD		
Maxillary	40	TTM	98.97	4.539	93.90	3.830	<0.0001	S
	40	Tot-a	32.52	2.282	31.02	1.656	0.0012	S
	40	Tot-b	44.31	2.634	42.49	2.177	0.0013	S
Mandibular	40	TTM	90.55	3.434	84.13	3.600	<0.0001	S
	40	Tot-a	24.46	2.182	22.35	1.773	<0.0001	S
	40	Tot-b	43.48	2.243	40.33	2.072	<0.0001	S

The TTM was smaller in spaced arches than in normal arches, and the difference was statistically significant in both arches (Table 3).The mean value of Tot-A, Tot-B was smaller in the spaced arches compared with normal arches, the differences were statistically significant in the maxillary arch, however for mandibular arch Tot-B reading is statistically non-significant(Table 3).

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TABLE-3: Comparison of mean values of combined MD crown dimensions of incisors (Tot-A), combined MD crown dimensions of canines and premolars (Tot-B), and total tooth material (TTM) between spaced and normal groups

Arch	N	Combined Mesiodistal Width	Spaced		Normal		P Value	Result
			Mean	SD	Mean	SD		
Maxillary	40	TTM	88.97	5.333	93.90	3.830	<.0001	S
	40	Tot-a	28.76	2.413	31.02	1.656	<.0001	S
	40	Tot-b	39.13	4.063	42.49	2.177	<.0001	S
mandibular	40	TTM	81.99	2.837	84.13	3.600	0.0042	S
	40	Tot-a	21.12	1.380	22.35	1.773	0.0009	S
	40	Tot-b	39.78	1.833	40.33	2.072	0.2124	Ns

The mean values of TTM, Tot-A and Tot-B were greater in crowded arches compared with the spaced dentition group. The difference was highly significant in both arches (Table 4).

TABLE-4: Comparison of mean values of combined MD crown dimensions of incisors (Tot-A), combined MD crown dimensions of canines and premolars (Tot-B), and total tooth material (TTM) between crowded and spaced groups

Arch	N	Combined Mesiodistal Width	Crowded		Spaced		P Value	Result
			Mean	SD	Mean	SD		
Maxillary	40	TTM	98.97	4.539	88.97	5.333	0	S
	40	Tot-a	32.52	2.282	28.76	2.413	0	S
	40	Tot-b	44.31	2.634	39.13	4.063	0.00002	S
mandibular	40	TTM	90.55	3.434	81.99	2.837	0	S
	40	Tot-a	24.46	2.182	21.12	1.380	<0.0001	S
	40	Tot-b	43.48	2.243	39.78	1.833	<0.0001	S

Analysis of variance amongst all three groups was statistically significant (Table 5, 6).

Table-5**:** Comparison Of Mean Values Of Combined MD Crown Dimensions Of Incisors (Tot-A), Combined MD Crown Dimensions Of Canines And Premolars (Tot-B), And Total Tooth Material (TTM) Between Crowded, Normal And Spaced Groups (ANOVA)

PARAMETER	DENTITION	N	Mean	Std. Deviation	Std. Error	F value	P value	Results
TTM(in mm)	Crowded dentition	80	94.76	5.82439	0.65119			
	Normal dentition	80	89.01	6.14903	0.68748			
	Spaced dentition	80	85.48	5.51135	0.61619	51.547	<0.0001	S
Tot-A(in mm)	Crowded dentition	80	28.49	4.62032	0.51657			
	Normal dentition	80	26.68	4.68137	0.52339			
	Spaced dentition	80	24.94	4.31330	0.48224	12.208	<0.0001	S
Tot-B(in mm)	Crowded dentition	80	43.89	2.46645	0.27576			
	Normal dentition	80	41.41	2.37481	0.26551			
	Spaced dentition	80	39.46	3.14885	0.35205	54.894	<0.0001	S

TABLE-6**:** Comparison Of Mean Values Of Combined MD Crown Dimensions Of Incisors (Tot-A), Combined MD Crown Dimensions Of Canines And Premolars (Tot-B), And Total Tooth Material (TTM) in between two groups**.**

Dependent Variable	(I) GROUP_C	(J) GROUP_C	Mean Difference (I-J)	Std. Error	p value	Results
TTM(in mm)	Crowded Dentition	Normal Dentition	5.74	0.922	<0.0001	S
	Crowded Dentition	Spaced Dentition	9.28	0.922	<0.0001	S
	Normal Dentition	Spaced Dentition	3.54	0.922	0.0005	S
Tot-A(in mm)	Crowded Dentition	Normal Dentition	1.81	0.718	0.0335	S
	Crowded Dentition	Spaced Dentition	3.55	0.718	<0.00001	S
	Normal Dentition	Spaced Dentition	1.74	0.718	0.0422	S
Tot-B(in mm)	Crowded Dentition	Normal Dentition	2.49	0.425	<0.0001	S
	Crowded Dentition	Spaced Dentition	4.44	0.425	<0.0001	S
	Normal Dentition	Spaced Dentition	1.95	0.425	<0.0001	S

Statistically significant positive correlation was seen between Tot-A and Tot-B in both arches for all 3 groups (Table 7).

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TABLE-7 **:** Correlation between combined MD crown dimensions of incisors and combined MD crown dimensions of canines and premolars

Group	Arch	N	Combined Width of incisors	Combined width of canines and premolars	Pearson correlation	p value	Result
Crowded	Maxillary	40	Tot a	Tot b	0.391	0.013	S
	Mandibular	40	Tot a	Tot b	0.615	0.082	S
Spaced	Maxillary	40	Tot a	Tot b	0.517	0.001	S
	Mandibular	40	Tot a	Tot b	0.14	0.032	S
Normal	Maxillary	40	Tot a	Tot b	0.332	0.037	s
	Mandibular	40	Tot a	Tot b	0.826	0.001	s

The MD crown dimensions of all individual teeth in the crowded dentition group were greater when compared with the corresponding teeth in the normaland spaced dentition group.

TABLE-8: Comparison of MD width of teeth in maxillary arch

			CROWDED (N-80)		NORMAL (N-80)		SPACED (N-80)		ANOVA	
SIDE	N	TOOTH	MEAN	SD	MEAN	SD	MEAN	SD	p value	Result
	40	I-1	8.98	0.51	8.46	0.55	8.39	0.77	0.0034	S
	40	I-2	7.31	0.45	6.84	0.54	6.69	0.63	0.00001	S
	40	C	7.88	0.39	7.62	0.37	7.52	0.53	0.01575	S
	40	PM-1	7.22	0.37	6.98	0.43	6.84	0.55	0.0004	S
RIGHT	40	PM-2	7.12	0.38	6.88	0.37	6.51	0.51	0.0015	S
	40	I- 1	8.99	0.49	8.44	0.54	8.32	0.69	0.0024	S
	40	I-2	7.32	0.57	6.81	0.66	6.68	0.62	0.00058	S
	40	C	7.84	0.52	7.66	0.49	7.51	0.48	0.01423	S
	40	PM-1	7.24	0.62	6.96	0.43	6.85	0.53	0.0008	S
LEFT	40	PM-2	7.14	0.45	6.81	0.41	6.68	0.71	0.0038	S

DISCUSSION

Malocclusion is an increasingly common, multifactorial problem inindustrialized countries (Corruccini 1984, 1999; Proffit 1986, 1998)[1-3]Many malocclusions are some combination of skeletal and dental disharmonies (*e.g.,* Ackerman and Proffit 1969; Proffit and Ackerman 1973), [12, 13] but the most prevalent problem involves insufficient supporting bone (arch size) to accommodate the ideal arrangement of teeth (tooth size), creating tooth-size arch-size discrepancies (TSASD). Although the causes of dental malocclusion are obscure in most instances, one contributing factor appears to be tooth size. That is, going back to some of the earliest large, quantified studies on the topic (*e.g.,* Seipel 1946; Lundström 1949), [14, 15] it is evident that crowding and TSASD is now a leading issue in many malocclusions. MD tooth size is an

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important consideration in orthodontic diagnosis and treatment planning. Moorrees and Reed [16]pointed out that a harmonious relationship between tooth dimensions and arch length results in satisfactory alignment and optimum occlusion of the teeth, and disproportion between these elements predisposes to crowding or spacing in the dental arch. Our purpose in this study was to determine whether well aligned arches differ from crowded or spaced arches in tooth-size dimensions. Racial bias in MD crown dimensions was reported by various authors.In this study, we made every effort to adhere to the guidelines regarding the race of the sample. Many investigators related sex with the MD crown dimensions of teeth and hence the relationship with crowding.

According to Garn et al, [17.18]tooth sizes differ according to sex; ie, male teeth are somewhat larger than female teeth. Since the determination of this difference was not a purpose of our study, we compensated for these differences by choosing equal numbers of males and females in the 3 groups.

Some previous studies found the mesiodistal width of the mandibular incisor teeth to be significantly greater in subjects with anterior dental crowding as compared to subjects with ideal anterior alignment (*e.g.,* Peck and Peck 1972; Norderval *etal.* 1975; Adams 1982)[7-9]. In contrast, others have been unable to distinguish between crowded and noncrowded dentitions on the basis of mesiodistal tooth dimensions (*e.g.,* Howe *et al.* 1983; Gilmore and Little 1984)[10-11]. The mean values of TTM, Tot-A, and Tot-B were significantly greater in crowded arches compared with the normal dentition group (Table 2).

The mean values of TTM, Tot-A, and Tot-B were significantly greater incrowded arches than spaced dentition (Table 6, 9).We expected this because crowded arches have been shown to have greater MD crown dimensions, and spaced arches smaller dimensions, when compared with normal arches, respectively.

A statistically significant positive correlation was seen between Tot-A and Tot-B in both arches for all 3 groups (Table 9). This means that, if the combined MD crown dimensions of the incisors (Tot-A) are large, the combined MD crown dimensions of the canines and the premolars (Tot-B) tend to be large also. These findings agree with those of Garn et al[22],who established that various morphologic classes do not have negative correlations as expected. The MD widths of all the teeth in the crowded group were greater when compared with the corresponding teeth in the normal dentition group (Table 10, 11). These findings partially agree with the study of Doris et al[20],who observed that the maxillary lateral incisor, the maxillary second premolar, the mandibular canine, and the first and second premolars were larger in crowded arches.

MD crown dimensions of all teeth in the spaced group were smaller than the corresponding teeth in normal dentition group (Table 10, 11). Maximum variation was seen for the lateral incisors, the maxillary right lateral incisor (P =.00001), and the maxillary left lateral incisor (P =.00058).

We found that the maxillary canines had little variation in the 3 groups (Table11, 12); this agrees with the studies of Lundstrom[15]and Horowitz et al.[23]They established that a comparatively low genetic component of variability in the canines can be related to function because these teeth occupy strategic locations in the dental arch, connecting the premolar series with the incisor series. Dahlberg[24],in his adaptation of Butler's field concept of human dentition, also supported this finding and considered the canine morphologically stable concerning the expression and retention of ancestral patterns.

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Having demonstrated that mesiodistal tooth size is a statistically significant risk factor for malocclusion, how to manage TSASD clinically becomes germane. The issue of proper coupling of the teeth often arises during the final "detailing" phase of orthodontic treatment .

Ideal buccal segment occlusion is admittedly difficult to achieve, especially in first-premolar extraction cases where the risk of Bolton discrepancies is higher.Additionally, there may be insufficient or excessive overjet and/or overbite. If the orthodontist performed a tooth-size analysis during the treatment planning phase, these problems should have been (1) anticipated, (2) discussed with the patient, and (3) managed through an appropriate course of treatment.

CONCLUSION

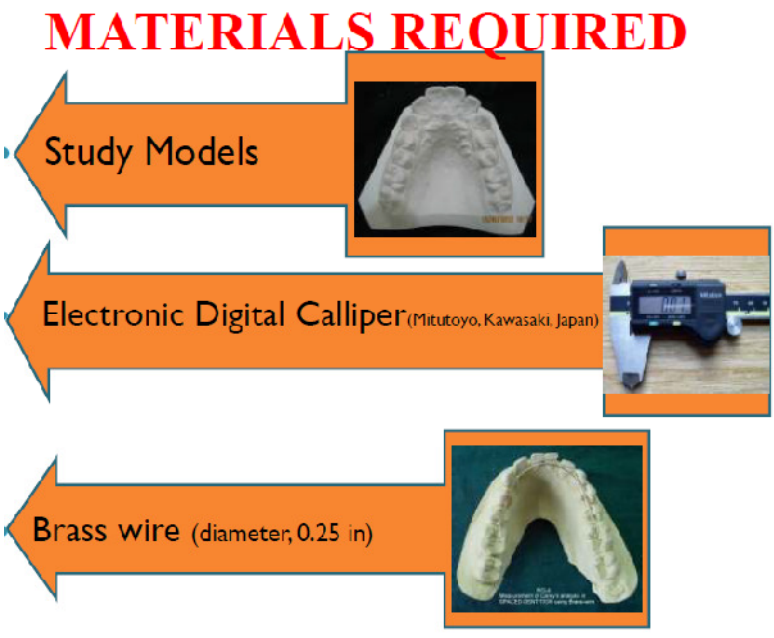
1. The correlation of the combined MD crown dimensions of incisors with the combined MD crown dimensions of canines and premolars was significantly positive in crowded, spaced, and normal dentition groups.

2. The MD crown dimensions of the individual teeth, the sum of the incisors, and the sum of the canines and the premolars were uniformly larger in crowded arches compared with normal dental arches, and the differences were statistically significant.

3. The TTM and the MD crown dimensions of the individual teeth were smaller in spaced arches compared with normal dental arches. Particularly, the difference was significant for the mandibular incisors. Therefore, the mandibular incisors are responsible for spacing in each arch.

4. MD crown dimensions of individual teeth, TTM, combined MD widths of incisors, and combined MD widths of canines and premolars were greater in crowded arches than in spaced dentition, and the difference was highly significant.

5.The lateral incisors had a strong component of variability in all 3 groups. Canines had little variation in MD crown dimensions.



(Fig.1-materials required in study)

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