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Original Article

Intermaxillary tooth size discrepancy in a Pakistani population: A stereomicroscope versus digital caliper

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ABSTRACT

Objective: Comprehensive diagnosis and treatment planning are essential in a successful orthodontic practice. The purpose of this study is to determine and compare intermaxillary tooth size discrepancy (IMTSD) using traditional digital caliper (DC) measurement on plaster dental models and stereomicroscopic digital dental models (SM). **Materials and Methods:** The samples were randomly selected from different states of Pakistan. Total 7168 variables were measured on plaster dental casts (128) and SM digital dental models (128) according to the selection criteria. For IMTSD, the 6 variable measured as for anterior tooth size (maxilla, mandibular), overall tooth size (maxilla, mandibular), Bolton's anterior ratios (BAR), and Bolton's overall ratios (BOR). The independent *t*-test and ANOVA were used for statistical analyses. **Results:** Significant sexual disparities in the sum of anterior tooth size and overall tooth size via DC and SM methods. No significant sexual disparities for BAR and BOR. No statistically significant differences were found in BAR and BOR between DC and SM. No significant differences were found on IMTSD ratio among different arch length and arch perimeters groups. **Conclusions:** Norms were developed based on DC and SM for IMTSD. Sexual disparities were observed in the sum of teeth size. However, no significant differences in BAR and BOR for IMTSD between the two methods.

Key words: Arch length, arch perimeters, digital dental models, intermaxillary tooth size discrepancy

INTRODUCTION

Comprehensive diagnosis and treatment planning are essential in a successful orthodontic practice. Dental model analysis plays a vital role in diagnosis and subsequent treatment planning. An intermaxillary tooth size discrepancy (IMTSD) is a disproportion among the sizes of the individual teeth.[1] IMTSD evaluation is an important factor to be considered for orthodontic diagnosis and treatment planning.[2] Ideal occlusion with the absence of IMTSD is considered as "seventh key of occlusion."[3] Tooth size disproportion is the lack of accord between the intermaxillary tooth size or group of teeth. Any disharmony in the tooth size can lead to either spacing in one arch or effect the functional relationships.[2]

Patient with significant IMTSD values inhibits ideal occlusion at the finishing stage of the orthodontic treatment. Bolton did IMTSD ratio evaluation on 55 dental models from University of Washington; he calculated the tooth size relation involving maxillary

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and mandibular teeth and proposed the values of Bolton's anterior ratio (BAR) from both canine to canine (3–3) and Bolton's overall ratios (BOR) from the first molar to first molar (6–6). The mean BAR 77.2% and BOR 91.3% was required to achieve the good occlusion with ideal overjet and overbite and coinciding midline.[1,4] Bolton proposed the following formula to calculate the IMTSD ratios:

$$\text{BAR} = \frac{\text{sum of the mandibular } 3-3}{\text{sum of maxillary } 3-3} \times 100$$

$$\text{BOR} = \frac{\text{sum of the mandibular } 6-6}{\text{sum of maxillary } 6-6} \times 100$$

Variations in tooth size and tooth size proportion have been associated with different ethnic background and malocclusion groups.[5-9] IMTSD is common in numerous populations.[2,10,11] From a clinical perspective, perfect equivalence should exist between the mesiodistal tooth sizes of the maxillary and mandibular arches for the surety of ideal interdigitation, overbite, and overjet at the culmination of orthodontic treatment.[12-14]

More orthodontists are using digital dental models for diagnostic records and assessment of patients' orthodontic conditions. This trend will probably accelerate and become more common as digital models alleviate or solve many problems and difficulties associated with storage, retrieval, reproduction, communication, and breakage of conventional plaster casts.[15]

IMTSD has never been evaluated using digital models on Pakistani population. However, we for the 1st time evaluating IMTSD through digital models using stereomicroscope (SM).

The aims of this study were to:

- Determine and investigate sexual dimorphism in measurements obtained by conventional digital caliper (DC) and by SM digital dental model
- Evaluate and compare the IMTSD via two methods
- Determine the disparities on IMTSD ratio in different arch length and arch perimeters groups.

MATERIALS AND METHODS

The study was approved by the Human Ethics Research Committee at the Universiti Sains Malaysia (USM/JEPeM/140376). Oral examinations were carried out with a cautious assortment of participants. Cross-examination of subjects was performed to minimize selection bias and error; experienced orthodontists and dentists participated throughout the screening sessions. The sample was randomly collected from different states within Pakistan. The sample size was calculated to give a power of 80% with alpha 0.05. A total of 128 subjects (64 men and 64 women), with the ages ranged from 18 to 24 years were selected.

Inclusion criteria

Pakistani ancestors for three generations, full set of permanent teeth from the right first molar to left first molar, bilateral Class I molar and canine relationships with Class I incisor according to British Standards Institute.

Exclusion criteria

Malocclusion, crowding, crossbites, proximal caries, restorations or abrasion, abnormal tooth morphology, and previous or ongoing orthodontic treatment.

Samples collection

Dental impressions of the upper and lower arches of each subject were taken with alginate impression material (Zhermack Orthoprint alginate ISO 1563–ADA 18, Italy) and poured with dental stone (Type III hard plaster quick stone, China) in accordance with the manufacturer's instructions.

Measurements of intermaxillary tooth size discrepancy data

The mesiodistal teeth size on the plaster models were evaluated using an orthodontic-style DC (Mitutoyo, Japan) [Figure 1] to measure the greatest mesiodistal widths to the nearest 0.01 mm.[2,13,16,17]

Figure 1: Tooth size measurement via Digital Caliper on plaster model

SM were created using the Hirox digital SM (HIROX KH7700 Japan). The device was proven as a valid and reliable tool for such measurements with the accuracy of 0.1 × 10^{-6}.[18] The mesiodistal teeth widths were measured on the digital model from the occlusal side on via Image File Viewing Software [Figure 2].[13]

Total 7168 variables were measured on plaster dental casts and Hirox digital models.

The following dependent variables were gathered
Max 3–3 = (Sum of maxillary canine to canine), Max 6–6 = (Sum of maxillary first molar to first molar), Man 3–3 = (Sum of mandibular canine to canine), Man 6–6 = (Sum of mandibular first molar to first molar), BAR = (Bolton Anterior ratio) and BOR = (Bolton overall ratios).

Measurements of arch length and arch perimeter of maxilla and mandible

Arch length

A linear line connecting between the mesiobuccal cusp tips of first permanent molar and the extended line from both side anteriorly to the center point between the central incisors [Figure 3].

Arch perimeter

The sum of segmental linear lines from the right and left side of the arches [Figure 4].[13]

The subjects were further grouped as follows:

1. Arch length group (increased, average, decreased) [Figure 3][13]
   The number of subject for increased, average, and decrease arch length group of maxilla and mandible were 43, 43, and 42, respectively
2. Arch perimeters group (smaller, medium, larger) [Figure 4][13]
   The number of subject for smaller, medium and larger arch perimeter group of maxilla, and mandible were 43, 43, and 42, respectively.

This grouping of arch length and arch perimeters were done based on the data values of mean ± 2 standard deviation (SD), >2 SD and <2 SD grouped in average/medium group, increased/larger group and decrease/smaller group, respectively.[13]

Error study

Twenty percent of the dental cast were randomly selected for intra-observer errors. The time interval between the first and second reading were approximately 2 weeks. The method error was analyzed by the Dahlberg's formula[19]

$$ME = \sqrt{\Sigma (x_1 - x_2)^2 / 2n}$$; n = number of sample.

Statistical analysis

Data collected by the investigators were first entered to Excel (Microsoft, Redmond, Wash ington, USA).

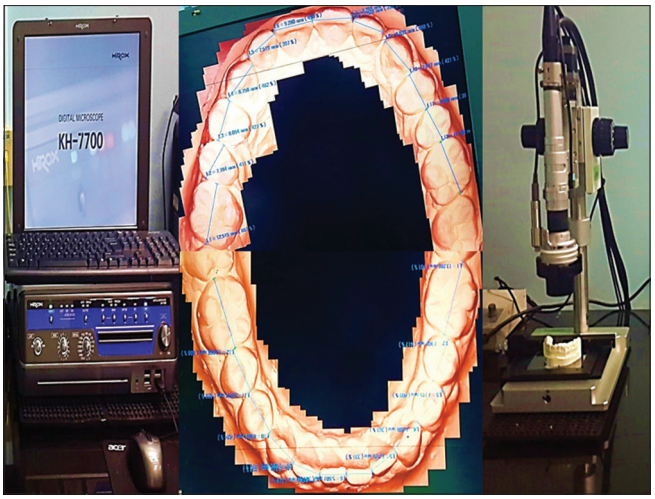

Figure 2: Methods of the digital models tooth size measurements using hirox digital stereomicroscope

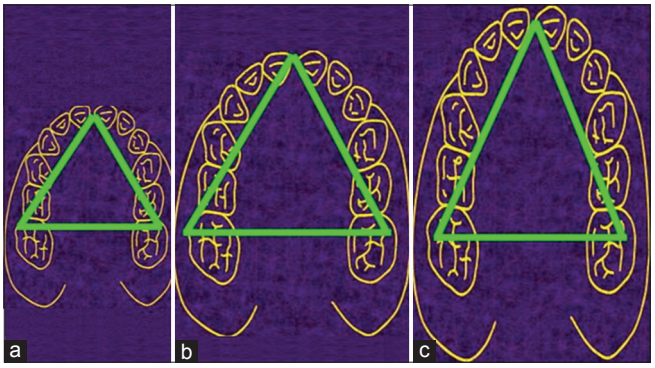

Figure 3: Graphical presentations of arch length groups (a) decreased (b) average (c) increased

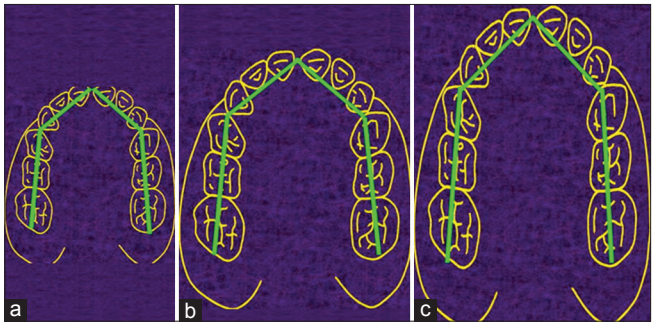

Figure 4: Graphical presentations of arch perimeter groups (a) smaller (b) medium (c) larger

Collected data were screened for any missing values or outliers and the validity of distribution assumptions. The maxillary to mandibular tooth width ratios according to the formulas published by Bolton were also calculated.[1] All statistics were performed in SPSS (IBM SPSS Statistics Version 22.0, Chicago, USA). To summarize the data, means and SDs of sum of tooth size and IMTSD in groups were calculated. An independent samples *t*-test was use to evaluate differences for IMTSD, sum of maxillary and mandibular anterior/overall tooth size in males and females. ANOVA was performed to determine potential differences in the arch length and arch perimeters groups. $P \leq 0.05$ was considered statistically significant.

RESULTS

Error of the method for digital caliper and stereomicroscopic measurements

The method error was analyzed by the Dahlberg's formula, showed the values of 0.006, 0.007, for sum of mesiodistal tooth size for anterior and overall teeth size, respectively via DC. The SM showed 0.005, 0.004, for the above variables, respectively.

Intermaxillary tooth size discrepancy norms via digital caliper

Table 1 show the descriptive statistics including mean values, SDs for the sum of maxillary canine to canine and first molar to the first molar with significant greater value for male in relation to females obtained via DC (***$P \leq 0.001$), (**$P \leq 0.01$) and (*$P \leq 0.05$). There were no significant differences observed in the BAR and BOR ratio for male and female via DC methods.

Intermaxillary tooth size discrepancy norms via stereomicroscope

Table 2 shows the descriptive statistics including mean values, SDs for the sum of maxillary canine to canine and first molar to the first molar with significant greater value for male in relation to females obtained via SM (***$P \leq 0.001$), (**$P \leq 0.01$) and (*$P \leq 0.05$). There were no significant differences observed in the BAR and BOR ratio for male and female via SM methods.

Intermaxillary tooth size discrepancy digital caliper versus stereomicroscopic

Table 3 shows the descriptive statistics including mean values, SDs for the DC and SM. There were no significant differences observed for all values between two methods.

Table 1: Digital caliper: Bolton's anterior ratio and Bolton's overall ratio of tooth size discrepancy

	Sex	Mean	SD	SE	CI		*P*
					Lower	Upper	
Max 3-3	Male	47.1	2.2	0.3	0.8	2.3	0.001***
	Female	45.5	2.4	0.3			
Max 6-6	Male	94.9	4.0	0.5	1.2	4.0	0.001***
	Female	92.3	4.3	0.5			
Man 3-3	Male	37.2	2.2	0.3	0.3	1.7	0.004**
	Female	36.2	1.8	0.2			
Man 6-6	Male	87.8	4.0	0.5	0.6	3.2	0.005**
	Female	85.9	3.7	0.5			
BAR	Male	79.0	4.4	0.5	−1.9	0.9	0.477
	Female	79.5	3.6	0.5			
BOR	Male	92.5	3.1	0.4	−1.5	0.4	0.26
	Female	93.1	2.4	0.3			

**$P \leq 0.01$, ***$P \leq 0.001$. BAR: Bolton's anterior ratio, BOR: Bolton's overall ratio, Max 3-3: Sum of maxillary canine to canine, Max 6-6: Sum of maxillary first molar to first molar, Man 3-3: Sum of mandibular canine to canine, Man 6-6: Sum of mandibular first molar to first molar, CI: Confidence interval, SD: Standard deviation, SE: Standard error

Table 2: Stereomicroscope digital models: Bolton's anterior ratio and Bolton's overall ratio of tooth size discrepancy

Variables	Sex	Mean	SD	SE	CI		*P*
					Lower	Upper	
Max 3-3	Male	47.23	2.18	0.25	0.76	2.32	0.001***
	Female	45.69	2.47	0.31			
Max 6-6	Male	95.19	3.93	0.45	1.22	3.97	0.001***
	Female	92.59	4.24	0.53			
Man 3-3	Male	37.14	1.76	0.20	0.28	1.51	0.005**
	Female	36.24	1.92	0.24			
Man 6-6	Male	87.86	3.84	0.44	0.49	3.05	0.007**
	Female	86.09	3.74	0.47			
BAR	Male	78.68	2.82	0.33	−1.87	0.39	0.197
	Female	79.42	3.88	0.49			
BOR	Male	92.32	2.40	0.28	−1.53	0.13	0.10
	Female	93.02	2.54	0.32			

**$P \leq 0.01$, ***$P \leq 0.001$. BAR: Bolton's anterior ratio, BOR: Bolton's overall ratio, Max 3-3: Sum of maxillary canine to canine, Max 6-6: Sum of maxillary first molar to first molar, Man 3-3: Sum of mandibular canine to canine, Man 6-6: Sum of mandibular first molar to first molar, CI: Confidence interval, SD: Standard deviation, SE: Standard error

Intermaxillary tooth size discrepancy in relation to arch length and arch perimeter groups

Figures 5 and 6 show no significant difference for IMTSD ratios (BAR and BOR) in relation to various arch length and arch perimeter groups of maxilla and mandible.

DISCUSSION

In orthodontic diagnosis and treatment planning, the evaluation of the IMTSD is an indispensable

step, and this relationship is generally determined by measurement via plaster dental casts[1,2,10] and digital dental models.[13,18,20] Orthodontists ought to evaluate tooth size disparities before the initiation of orthodontic treatment. Various linear measurements evaluated via conventional calipers and digital dental models.[13,18,20-22] Digital dental models are considered, a valid and reliable tool for different tooth size measurements.[18,22-25] Tooth size measurements were done with the accuracy of 1×10^{-2} mm using DC on the plaster models, emodels, and anatomodels, and SureSmile software with 0.1 mm.[26] IMTSD ratio were globally evaluated by various types of digital models on different populations are shown in Figure 7.[13,15,20,25,26] This study used SM digital models with the accuracy of 0.1×10^{-6} mm.[18]

As Alam *et al*., on the malay population via cone-beam computed tomography digital models found significant differences in relation to arch length and perimeter,[13] this study also investigated the BAR and BOR in relation to the various groups of arch length and arch perimeter with differnces in results. These racial differences are interesting and may suggest that some polygenetic inheritance on the formation of tooth size and dental arches may differ among populations and races and/or may be due to differences in sample sizes. To clarify the reasons of these findings, future research on genetics is needed.

For the 1st time, IMTSD was evaluated on Pakistani population via SM. Norms were developed based on DC and SM for IMTSD. The subjects of this study and that of Bolton's study were diverse. This study consists of 128 samples (64 male, 64 female), none of them were orthodontically treated and were having normal occlusion. The study was done on the younger group to minimize the aging effect on dentition. While in Bolton's study, there were 55 models with excellent occlusion. Among them 44 were orthodontically treated (nonextraction cases), 11 were untreated. Our study investigates the Pakistani population intermaxillary BAR and BOR via DC and

Table 3: Digital caliper versus stereomicroscope: Bolton's anterior ratio and Bolton's overall ratio of tooth size discrepancy

Variables	Tools	Mean	SD	SE	CI		*P*
					Lower	Upper	
Max 3-3	DC	46.39	2.44	0.21	−0.71	0.44	0.656
	SM	46.52	2.43	0.21			
Max 6-6	DC	93.72	4.32	0.37	−1.28	0.74	0.60
	SM	93.99	4.26	0.36			
Man 3-3	DC	36.72	2.09	0.18	−0.47	0.46	0.985
	SM	36.72	1.88	0.16			
Man 6-6	DC	86.91	3.96	0.34	−1.05	0.80	0.788
	SM	87.04	3.88	0.33			
BAR	DC	79.24	4.04	0.34	−0.66	1.10	0.624
	SM	79.02	3.36	0.28			
BOR	DC	92.78	2.76	0.23	−0.48	0.76	0.66
	SM	92.64	2.48	0.21			

DC: Digital caliper, SM: Stereomicroscope, BAR: Bolton's anterior ratio, BOR: Bolton's overall ratio, Max 3-3: Sum of maxillary canine to canine, Max 6-6: Sum of maxillary first molar to first molar, Man 3-3: Sum of mandibular canine to canine, Man 6 first 6: Sum of mandibular first molar to first molar, CI: Confidence interval, SD: Standard deviation, SE: Standard error, BOR: Bolton's overall ratio

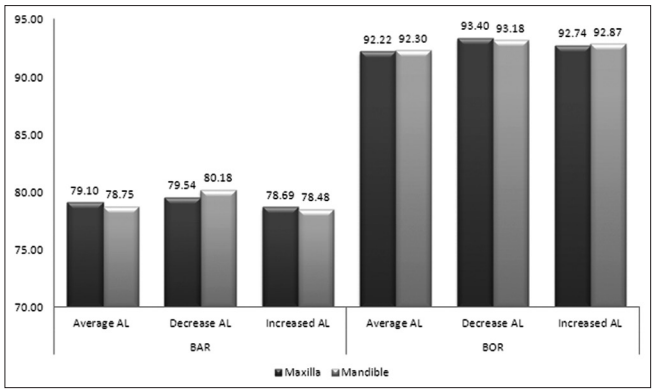

Figure 5: Bolton's anterior ratios and Bolton's overall ratios in relation to various arch length groups of maxilla and mandible

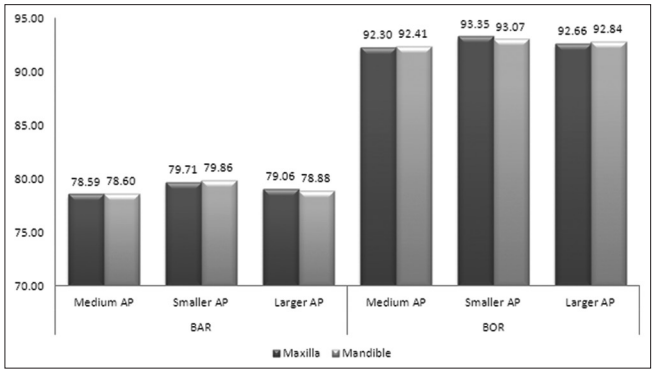

Figure 6: Bolton's anterior ratios and Bolton's overall ratios in relation to various arch perimeter groups of maxilla and mandible

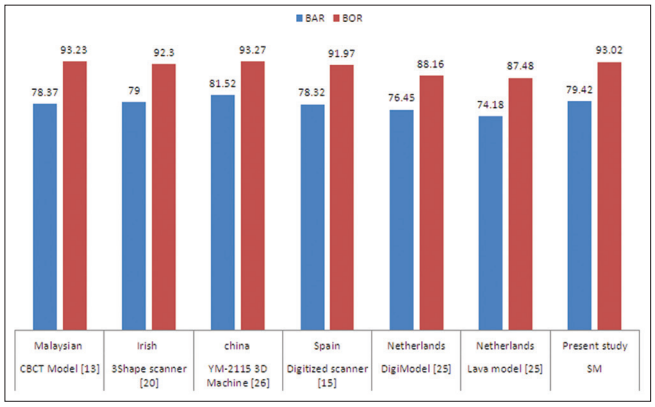

Figure 7: Global Bolton's anterior ratios and Bolton's overall ratios results with various methods of models measurements

SM methods. The BAR male 79.24 with SD of 4.04 and for female 79.02 with SD of 3.36. BOR is 92.78 for male with SD of 2.76 and 92.64 for female with SD of 2.48. BAR and BOR for male and female showed no significant sexual dimorphism.[2,10,27-29] Hence, no significant gender disparities were observed for the BAR and BOR via both methods for this study. However, other studies have reported significant sexual dimorphism for tooth size discrepancies.[8,30,31] Batool *et al*., however they investigated all types of malocclusion group via conventional technique and found the mean value of 91.10 ± 2.93 and 79.34 ± 5.19 for BOR and BAR.[32]

However, for establishing norms and treatment guidelines, we studied normal Class I occlusion using SM digital dental models for the 1st time in Pakistani population. Benefits of SM digital model as to solve many problems and difficulties associated with storage, retrieval, reproduction, communication, and breakage of conventional plaster casts. Digital measurements can be obtained for IMTSD with the high accuracy, reliability, and simplicity. The investigated norms and database need to be checked for its clinical applicability. Consequently, needs to be investigated on other population for the ethnic and racial difference in tooth size, arch dimension, BAR, and BOR.

CONCLUSIONS

- Sexual disparities were observed in the sum of anterior and overall teeth size of maxillary and mandibular arches
- No significant differences in BAR and BOR between gender were found
- No differences were observed in measurements obtained between methods using DC and digital SM measurements
- No significant differences were found on IMTSD ratio (BAR and BOR) among different arch length and arch perimeters groups.

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Conflicts of interest

There are no conflicts of interest.

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