

Intermaxillary Tooth Size Discrepancy in a Selected Group of Yemeni Participants with Skeletal Class III Malocclusion

Discrepancia en el Tamaño de los Dientes Intermaxilares en un Grupo Seleccionado de Participantes Yemeníes con Maloclusión Esquelética Clase III

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SUMMARY: Intermaxillary tooth size discrepancy (ITSD) varies among different populations and among malocclusion classes. The current study aimed to investigate the percentages and ratios of tooth size anterior and overall discrepancies among Yemeni adults with skeletal class III malocclusion. Furthermore, the association between sex and sides of dental arches on the measured variables was explored. This perspective cross-sectional study used the data of patients in the Department of Postgraduate Orthodontic Clinics, College of Dentistry, Sanaa University. The assessed patients were 13–28 years old. Mesiodistal tooth width (MDTW), anterior ratio (AR) of tooth size, and overall ratio (OR) were measured and calculated from 100 study models and divided equally between classes III and I skeletal malocclusion groups. Patients with class I skeletal malocclusions were included in the control group. Measurements were carried out using a digital caliper. A p value of <0.05 indicated statistical significance. The ARs of patients with skeletal class I malocclusion was 78.18, and the AR discrepancy rate was 24 %. Patients with skeletal class III malocclusion had a significantly greater mean AR value (79.64) and higher AR discrepancy rate (44 %). The percentages of ORs in skeletal classes I and III were 20 % and 18 %, respectively. These results revealed no significant difference in OR between the malocclusion groups. Moreover, no statistically significant difference in tooth size discrepancy was found between sexes or between the right and left sides of the dental arch. The results confirmed the tendency toward increased frequency of AR discrepancy in skeletal class III malocclusion. The mean values of ARs in Yemeni orthodontic patients presented with skeletal classes III and I malocclusions were higher than Bolton's ratio. Clinicians should include Bolton's tooth size analysis in their diagnosis and treatment planning workup.

KEY WORDS: Intermaxillary tooth size discrepancy; Boltons' ratios; Skeletal class III malocclusion; Sex; Side of dental arch.

INTRODUCTION

Facial symmetry and aesthetics are essential to orthodontic treatment. Dental arch modification should be accomplished in accordance with the face and tooth size (Ko *et al.*, 2022; Harun *et al.*, 2023; Silinevica *et al.*, 2023). Thus, a complete diagnosis with proper planning, periodic assessment and awareness of treatment results are essential to improve treatment outcomes of teeth and facial asymmetry (Ko *et al.*, 2022). Apart from aesthetics, occlusion with normal and correct tooth size proportion

are necessary to achieving good occlusion with satisfactory intercuspatation of teeth, correct overjet, and overbite (Bennett & McLaughlin, 1997).

Different methods were used in measuring intermaxillary tooth size discrepancy (ITSD). Intra-arch asymmetries were assessed and measured, and the mesiodistal tooth width (MDTW) of each tooth was compared with its contralateral. More than 90 % of cases

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had discrepancies of 0.25 mm or greater between the left and right sides of an individual arch, and more than 80 % had discrepancies of 0.5 mm or greater (Othman & Harradine, 2006; Babu *et al.*, 2011).

In 1949, Neff was the first to create a mathematical formula for determining ITSD before orthodontic treatment; he compared the widths of maxillary and mandibular anterior teeth and produced a ratio called the “anterior coefficient” and documented a range of 1.17–1.41 for the anterior coefficient, concluding that achieving an ideal occlusion with overbite of 20 % requires a coefficient range of 1.20–1.22 and a high anterior coefficient is associated with deep overbite (Neff, 1949; Omar *et al.*, 2018).

In 1962, Bolton (1962) analyzed the relationship between the MDTWs of the maxillary and mandibular arches of class I subjects with normal or an “ideal” occlusion; he used the MDTW from the permanent first molar on the right side to the one on the left sides of maxillary and mandibular teeth; an anterior ratio (AR) of 77.26 ± 1.6 was obtained through the collective measurement of six anterior mandibular and maxillary teeth, and an overall ratio (OR) of $91.3 \% \pm 1.91 \%$ was obtained from the MDTWs of 12 mandibular and maxillary teeth (Bolton, 1962). Bolton’s analysis is the simplest and most clinically useful among known methods for measuring ITSD, facilitating treatment planning and determination of functional and aesthetic outcomes of orthodontic cases (Abd Rahman *et al.*, 2023).

Several studies investigated the relationship between ITSD and various racial groups (Al-Khateeb & Abu Alhaija, 2006; Sakoda *et al.*, 2017; Machado *et al.*, 2018; Mohammad *et al.*, 2018; Alshahrani *et al.*, 2020; Hussein *et al.*, 2022; Zylfiu-Latifi *et al.*, 2023; Abd Rahman *et al.*, 2023), this resulted in a normal for different racial groups were established. Other studies investigated ITSD in different malocclusion groups, and showed a statistically significant differences revealed larger ARs in patients with skeletal class III malocclusion (Sperry *et al.*, 1977; Crosby & Alexander, 1989). According to Nie & Lin (1999) not only class III surgical but also class III nonsurgical groups had a greater frequency of ITSD with mandibular tooth size excess than other malocclusion groups.

Determining whether ITSD is present before a treatment is important. This approach enables orthodontists to develop treatment plans that consider ITSD rather than control it at the finishing stage (Ahmad, 2015; Ruan *et al.*, 2024). No studies have investigated the relationship between ITSD and skeletal class III

malocclusion in Yemeni orthodontic patients. Thus, pertinent orthodontic data related to clinical orthodontic practice in Yemen is of vital importance.

The current study was conducted to investigate the percentages of and variations in ITSD between skeletal classes III and I malocclusions and determine variations in the MDTW of individual teeth and ITSD in relation to sex and dental arch’s sides. The null hypothesis states that differences in the ITSD and MDTWs of individual teeth between the right and left sides and between sexes are nonsignificant in skeletal classes III and I malocclusion groups.

MATERIAL AND METHOD

Study design, Setting, and Ethical Approval. This current cross-sectional retrospective study aimed to investigate ITSD on a selected group of Yemeni adults with skeletal class III malocclusion. The records of individuals seeking for orthodontic treatment at Postgraduate Orthodontic Clinics, Faculty of Dentistry, Sana’a University, Sana’a City from January to December 2023 were examined. The participants signed consent forms, and the study was conducted in compliance with the Declaration of Helsinki guidelines. Ethical approval was obtained from the medical ethics committee of the Faculty of Dentistry, Sana’a University (Re, OMF:10/05/2024).

Sample Size Calculation. Sample size was calculated on the basis of power analysis, with 5 % significance level and 80 % power. A difference of 0.03 mm in 30 cases per sex group or 0.04 mm in 20 cases per sex group was detected at a standard deviation of 0.04 mm (Al Moaleem *et al.*, 2023; Al-Arwali *et al.*, 2024). The final sample comprised 100 model cases (50 with skeletal class III and 50 with skeletal class I malocclusion).

Inclusive and Exclusive Criteria. The inclusion criteria were as follows: age of 13–28 years; fully erupted permanent teeth (from permanent first molar to the contralateral one); crowding or spacing of ≤ 4 mm; study models with good quality; class I subjects: skeletal class I relationship (ANB 2° – 4°); relationship between angle’s class I molars and canines; class III subjects: concave facial profile, skeletal class III relationship (ANB $< 0^\circ$), relationship between angle’s class III molars and canines. Cases with extensive proximal restoration or buildup; interproximal stripping or attrition; previous prosthetic or orthodontic treatment; impacted canine; low-quality study models, that is, chipped off teeth; orthognathic surgery; and facial syndromes were excluded.

Participants Screening. After obtaining an ethical clearance, documents were screened, and the recorded data of 230 patients were obtained, including dental history, intraoral photographs, extraoral photographs, study models, panoramic radiographs (orthopantomograms), and lateral cephalometric radiographs. The demographic information of the participants was collected, including age, sex (male or female), and type of malocclusion (class III or I). The same inclusion criteria were used.

Identification and Coding of Study Models. For blinding, the identification and coding of study models were performed by a research assistant who was blinded to the study objectives. Two study models (maxillary and mandibular) were established and had sticker codes. The study models (maxillary and mandibular) of skeletal classes III and I malocclusion groups were combined after color coding. The examiner conducted measurements on each study model randomly and blindly, without knowing to which malocclusion group it belonged or to whom.

Measurements of Mesiodistal Teeth Width and Data Collections. The measurements of maxillary and mandibular teeth (1st molar at right side to 1st molar in left side from the study models collected were carried out by using an electronic digital caliper (CD-6" ASX; Mitutoyo Corp., Kanagawa 213-8533, Japan) to an accuracy of 0.01 mm. Steps for the measurements of MDTW were performed with a previously described

method (Hunter & Priest, 1960; Al-Khateeb & Abu Alhaija, 2006; Shahid *et al.*, 2016; Mollabashi *et al.*, 2019; Zylfiu-Latifi *et al.*, 2023).

The largest mesiodistal diameters of each crown were identified on the study model with a sharp pencil (Pilot 0.3 tip width, H-323, JAPAN) for maxillary (Fig. 1A) and mandibular teeth (Fig. 1B). By using an electronic digital caliper, the tips were held and pointed on the marked points from the facial aspect of the teeth and held perpendicular to the long axis of the measured tooth. The caliper beaks were then closed until they came into gentle contact with the predetermined points of the tooth. Then, the readings were recorded for maxillary teeth (Fig. 1C) and mandibular teeth (Fig. 1D).

The measurements conducted twice by the same investigator under natural and neon light at least 24 h between first and second measurements, and then the average values were recorded. The mean MDTWs of the incisors, canines, premolars, and first molars on right and left sides were recorded on an Excel spreadsheet (Microsoft Excel for Microsoft 365 MSO, Version 2204).

Calculation of Anterior Ratios and Overall Ratios. The mean AR values were calculated using Bolton's formula: $(\text{sum mandibular anterior teeth}) / (\text{sum maxillary anterior teeth}) \times 100 = \text{AR}$. The mean OR values were calculated also with Bolton's formula: $(\text{sum mandibular 12 teeth}) / (\text{sum maxillary 12 teeth}) \times 100 = \text{OR}$

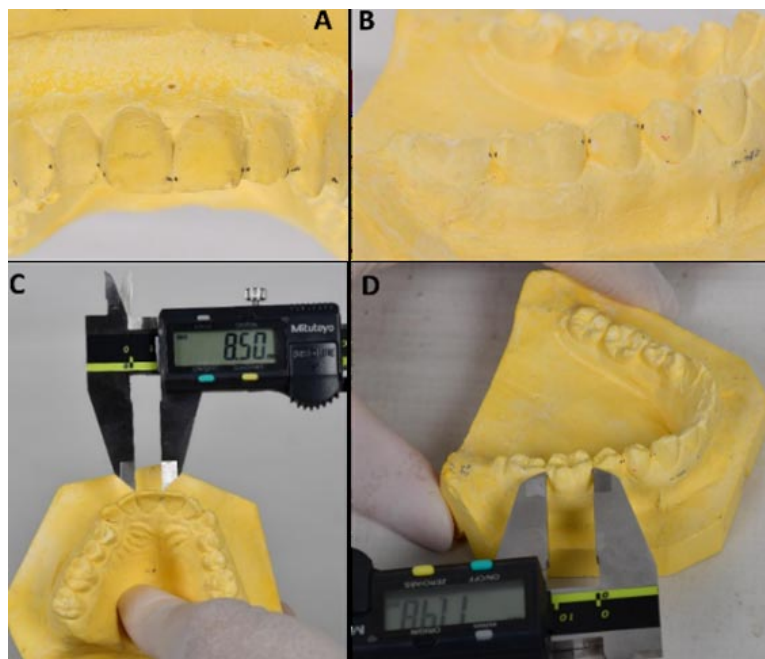


Fig. 1. Points of the measurement of the mesiodistal tooth width for maxillary anterior teeth (A), posterior mandibular teeth. During measurements of maxillary right central incisor (C), mandibular right first molar(D).

Determination Percentages of Discrepancies in Anterior Ratios and Overall Ratios. Clinical significance (outside ± 2 SD) was defined as previously suggested (Crosby & Alexander, 1989; Bishara *et al.*, 1989; Endo *et al.*, 2007). Measurements were < 87.47 (outside -2) and > 95.13 (outside +2 SD) for OR, and < 73.89 (outside -2 SD) and > 80.51 (outside +2 SD) for AR. The total number of cases in the malocclusion group (50) were divided by the number of cases with tooth size ratios outside ± 2 SD in the same group. Each result was multiplied by 100 to yield the rate of discrepancy in ARs or ORs in skeletal classes III and I malocclusion groups.

Calibration and Reliability. Before the study, intra-examiner calibration was performed, which involved the measurement of 20 study cast (maxillary and mandibular) by a single researcher. The first and second reading were performed one month apart. The results were assessed according to the correlation coefficient, and the agreement rate was high (0.948).

Statistical Analysis. The data collected and entered in an Excel sheet were arranged, categorized, and transferred to Statistical Package for Social Science (SPSS) version 25 for data analysis. The mean and SD values were calculated for each variable for classes III and I malocclusion groups and case categories. The MDTWs, ARs, and ORs for skeletal classes III and I malocclusions in the right and left sides of the arches were compared with Student t-test, one-way ANOVA, and Mann–Whitney tests. The values of both sexes were also compared with the same tests. A p value <0.05 indicated statistical significance for all tests.

RESULTS

Participant characteristics. The sample size was 100, and the mean age was 16.3 ± 1.37 years. Of the 50 male participants, 26 (52 %) and 27 (54 %) were classes III and I, respectively. As for the 50 female participants, 24 (48 %) and 23 (46 %) were classes III and I, respectively (Fig. 2).

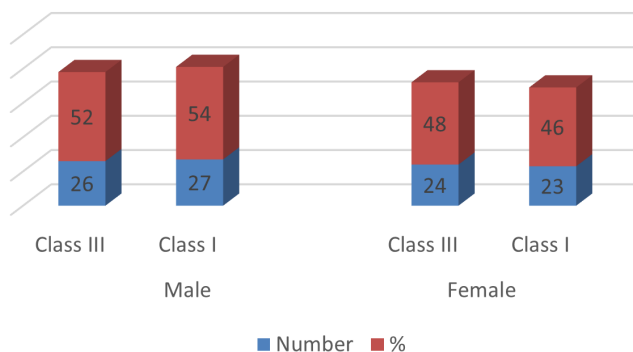


Fig. 2. Participants characteristics.

Right and Left Side Comparisons. The mean and \pm SD values for the MDTWs of classes III and I malocclusions in the right and left sides of maxillary and mandibular dental arches and the mean \pm SD values for total number of sample ($n = 100$) are presented in Table I. No significant differences in the mean and SD of MDTWs were found between the right and left sides of the dental arch, and no significant differences in the mean MDTWs of the teeth and each side were found between the malocclusion groups (p value ≥ 0.050). Table II shows no significant differences in ARs and ORs between the right and left sides of the dental arches in classes III and I malocclusions ($p = 0.512$ for AR and $p = 0.493$ for OR).

Male to Female Comparisons. In males, the mean MDTW for maxillary lateral canines was high in class III, and the MDTWs of incisors and 1st molar were wide in the mandibular arch. In addition, males had wider canines than females and had skeletal class III lateral incisors. Meanwhile, only lateral incisors were wide in females with class I malocclusion. Regarding MDTW, difference in the size of canine in the maxillary was found between males and females, with p value of 0.039. In the mandibular arch, the p value was 0.005 (Table III). Comparisons of the ARs and ORs of males and females revealed no significant differences related to sex (Table IV).

Skeletal class III subjects showed significantly wider maxillary first and second premolars and first molar than the skeletal class I subjects. In the mandibular arch, class III subjects had the widest second premolar and first molar. In classes III and I groups, significant difference between posterior teeth was observed in both arches, with p value ranging from 0.001 for mandibular 2nd premolars and 0.013 for maxillary 1st premolars (Table V). The ARs and ORs of both malocclusion groups were compared. Significant differences in AR were found between classes III and I ($p = 0.047$), whereas no significant difference in OR was found ($p = 0.634$; (Table VI).

The percentages of ARs (outside ± 2 SD) in skeletal classes III and I malocclusion groups were 20 % and 12 %, respectively. The ORs (outside ± 2 SD) for skeletal classes III and I malocclusion groups were 7 % and 9 %, respectively (Table VII). The ARs and ORs of skeletal classes III and I malocclusion groups were significantly different from Bolton's ratios ($p = 0.000$; Table VIII).

DISCUSSION

Tooth size differences exist among various populations and malocclusion groups, and excess mandibular tooth structure was found in skeletal class III cases (Sakoda *et al.*, 2017). Individuals with skeletal class III malocclusion had large discrepancies in ARs and ORs (Machado *et al.*, 2018). Bolton's ratios of ITSD referred to Caucasians with normal occlusion, and specific standards for other population groups with different malocclusion classes should be established. The current study was a cross-sectional observational study exploring the percentages and variations in ITSD between skeletal classes III and I malocclusions, aiming to assess difference in ITSD between the right and left sides of the dental arches and between sexes.

The results of the current study revealed no significant differences in the mean MDTWs of classes III and I model between the right and left sides of the dental arch in both

Table I. Mean ± SD values of MDTW in the right, left sides, and mean of skeletal Class III and Class I groups in mm.

Arch	Tooth Type	Class III			Class I			Mean of MDTWs		
		Right (n=25)	Left (n=25)	P values	Right (n=25)	Left (n=25)	P values	Right (n=100)	Left (n=100)	P values
		Mean ±SD	Mean ±SD		Mean ±SD	Mean ±SD		Mean ±SD	Mean ±SD	
Maxillary	Central incisor	8.59 ±0.516	8.62 ±0.533	0.752	8.59 ±0.543	8.59±0.559	0.977	8.5 ± 0.527	8.61 (0.543)	0.843
	Lateral incisor	6.55 ±0.602	6.52 ±0.611	0.823	6.55 ±0.599	6.49 ±0.608	0.631	6.55±0.597	6.51±0.607	0.617
	Canine	7.67 ±0.505	7.64 ±0.463	0.717	7.66 ±0.449	7.67 ±0.423	0.945	7.67±0.476	7.65±0.441	0.822
	1 st premolar	6.88±0.541	6.96±0.546	0.487	6.73±0.493	6.73±0.559	0.977	6.81±0.521	6.84±0.561	0.607
	2 nd premolar	6.56±0.412	6.56±0.424	0.998	6.23±0.463	6.22±0.458	0.962	6.39±0.467	6.39±0.471	0.972
	1 st molar	10.12±0.643	10.34±0.424	0.271	9.95±0.470	9.90±0.481	0.581	10.04±0.567	10.12±0.973	0.454
Mandibular	Central incisor	5.47±0.471	5.44±1.257	0.756	5.38±0.441	5.37±0.424	0.974	5.42±0.456	5.40±0.441	0.802
	Lateral incisor	5.96±0.457	5.92±0.458	0.641	5.83±0.427	5.84±0.428	0.847	5.89±0.445	5.88±0.451	0.832
	Canine	6.72±0.477	6.81±0.475	0.364	6.76±0.481	6.72±0.536	0.685	6.74±0.477	6.76±0.506	0.744
	1 st premolar	6.97±0.479	6.98±0.502	0.934	6.93±0.539	6.93±0.554	0.977	6.95±0.508	6.96±0.562	0.938
	2 nd premolar	6.91±0.472	6.94±0.459	0.750	6.70±0.566	6.64±0.576	0.608	6.81±0.528	6.79±0.540	0.848
	1 st molar	11.04±0.544	11.11±0.548	0.510	10.79±0.545	10.65±1.498	0.549	10.91±0.556	10.88±0.1.145	0.803

Table III. Mean ± SD values of MDTW of males and females in skeletal Class III, Class I, and total groups in mm.

	Right (n=50) Mean ±SD	Left (n=50) Mean ±SD	Mean	P value
AR	79.15 ±2.937	78.67 ±6.737		0.512
OR	92.80 ±2.075	92.52 ±3.437		0.493

Table II. Comparison of ARs and ORs in right and left sides of the dental arch in total group in mm.

Arch	Tooth Type	Class III			Class I			Mean of MDTWs		
		Male (n=26)	Female (n=24)	P values	Male (n=27)	Female (n=23)	P value	Male (n=53)	Female (n=47)	P value
		Mean ±SD	Mean ±SD		Mean ±SD	Mean ±SD		Mean ±SD	Mean ±SD	
Maxillary	Central incisor	8.67±0.462	8.54 ±0.576	0.191	8.53 ±0.532	8.67 ±0.563	0.213	8.60 ±0.502	8.60 ±0.570	0.999
	Lateral incisor	6.67 ±0.573	6.39 ±0.609	0.023*	6.41 ±0.554	6.65 ±0.633	0.045*	6.54 ±0.576	6.52 ±0.631	0.858
	Canine	7.81 ±0.359	7.49 ±0.545	0.001*	7.64 ±0.499	7.69 ±0.420	0.599	7.72±0.413	7.59±0.459	0.039*
	1 st premolar	6.96±0.628	6.87±0.433	0.414	6.74±0.556	6.72±0.491	0.841	6.85±0.600	6.80±0.466	0.503
	2 nd premolar	6.62±0.400	6.49±0.426	0.118	6.18±0.466	6.28±0.447	0.254	6.40±0.487	6.39±0.447	0.922
	1 st molar	10.35±1.205	10.11±0.705	0.222	9.86±0.494	10.01±0.440	0.110	10.10±0.943	10.06±0.590	0.721
Mandibular	Central incisor	5.58±0.458	5.32±0.432	0.004*	5.30±0.400	5.46±0.454	0.083	5.44±0.449	5.38±0.446	0.399
	Lateral incisor	6.02±0.447	5.85±0.470	0.064	5.77±0.425	5.90±0.419	0.123	5.89±0.452	5.88±0.444	0.769
	Canine	6.90± 0.437	6.61±0.475	0.002*	6.78±0.525	6.68±0.485	0.325	6.84±0.485	6.65±0.478	0.005*
	1 st premolar	7.01±0.475	6.95±0.505	0.527	6.87±0.590	7.00±0.481	0.239	6.94±0.538	6.97±0.492	0.652
	2 nd premolar	6.92± 0.432	6.93±0.500	0.886	6.59±0.551	6.77±0.580	0.115	6.75±0.521	6.85±0.544	0.178
	1 st molar	11.19± 0.518	10.94±0.548	0.020*	10.50±0.1.354	10.99±0.696	0.023*	10.84±1.086	10.96±0.622	0.314

Table IV. Comparison of ARs and ORs among sexes in total group in mm.

	Male (n=53) Mean ±SD	Females (n=47) Mean ±SD	Total	P value
AR	78.94 ±6.468	78.89 ±3.224)	78.91 ±5.189)	0.948
OR	92.42 ±3.180	92.91 ±2.380)	92.66 ±2.835)	0.230

Table V. Comparison of MDTW for Class I and Class III malocclusion groups in mm.

Arch	Tooth Type	Class III (n=50) Mean ±SD	Class I (n=50) Mean ±SD	P values
	Central incisor	8.61 ±0.522	8.59 ±0.548	0.839
	Lateral incisor	6.54 ±0.604	6.52 ±0.601	0.865
	Canine	7.65 ±0.482	7.66 ±0.434	0.878
Maxillary	1 st premolar	6.92±0.542	6.73 ±524	0.013*
	2 nd premolar	6.56±0.416	6.22 ±458	0.000*
	1 st molar	10.23±0.999	9.93 ±474	0.006*
	Central incisor	5.45±0.462	5.37 ±430	0.221
	Lateral incisor	5.94±0.464	5.83 ±426	0.099
	Canine	6.76±0.476	6.74 ±507	0.693
Mandibular	1 st premolar	6.98±0.488	6.93 ±544	0.532
	2 nd premolar	6.93±464	6.67 ±569	0.001*
	1 st molar	11.07±545	10.72 ±1.123	0.006*

Table VI. Comparison of ARs and ORs between skeletal Class III and Class I malocclusion groups (%).

	Class III (n=50)	Class I (n=50)	P value
AR	79.64 ±3.159	78.18 ±6.563	0.047*
OR	92.76 ±2.475	92.56 ±3.165	0.634

Table VII. Distribution of subjects with ARs ITSD and ORs ITSD outside ±2mm from Boltons ratios (%).

	Outside -2 SD	-2 SD to +2 SD	Outside +2 SD
ARs			
	< 73.89	73.89–80.50	> 80.51
Class III	2 (2.0 %)	28 (28.0 %)	20 (20.0 %)
Class I	0 (0.0 %)	38 (38.0 %)	12 (12.0 %)
Total (100)	2 (2.0 %)	66 (66.0 %)	32 (32.0 %)
ORs			
	< 87.47	87.48–95.12	> 95.13
Class III	2 (2.0 %)	41 (41.0 %)	7 (7.0 %)
Class I	1 (1.0 %)	40 (40.0 %)	9 (9.0 %)
Total (100)	3 (3.0 %)	81 (81.0 %)	16 (16.0 %)

Table VIII. Comparisons ARs and ORs of skeletal Class III and Class I malocclusion groups to Bolton's AR.

Variable	Range	Mean	Standard Deviation	Differences	P value
Ars					
Bolton, 1958	74.5 % - 80.4	77.2 %	1.65		0.000*
Class III (This study)	68.8 % - 84.9	79.6 %	3.159	2.4 %	
Class I (This study)	74.3 % - 85.4	78.8 %	6.563	1.6 %	
ORs					
Bolton, 1958	87.5 % - 94.8	91.3 %	1.91		0.000*
Class III (This study)	86.6 % - 96.7	92.7 %	2.475	1.4 %	
Class I (This study)	81.2 % - 98.3	92.6 %	3.165	1.3 %	

malocclusion groups. Thus, the null hypothesis in relation to the ITSD of the MDTWs values of right and left sides between the skeletal classes III and I malocclusion groups was accepted. The same findings were reported in Yemenis, Sudanese, and Saudi populations, which had the same Arabian ethnicity (Alkofide & Hashim, 2002; Al-Gunaid *et al.*, 2012; Abdalla Hashim *et al.*, 2015). These findings were supported by other studies conducted on Chinese and Indian patients (Endo *et al.*, 2007; Johe *et al.*, 2010). Definite differences were found between the mean MDTWs of the right and left sides of individual teeth in Jordanians, Malaysians, and Pakistani (Al-Khateeb & Abu Alhajja, 2006; Shahid *et al.*, 2016; Abd Rahman *et al.*, 2023).

Concerning sex, males exhibited larger mean MD widths in maxillary and mandibular arches than females in the class III malocclusion group. Some of the MD widths in the maxillary and mandibular arches teeth significant varied between the class III and I malocclusion groups and between males and females. Thus, the null hypothesis was partially accepted in relation to the ITSD of the MDTWs of males and females in both malocclusion groups.

This finding agreed with that of a previous study conducted on Yemenis; males exhibited larger tooth width than females in both arches (Al-Gunaid *et al.*, 2012). The same finding was reported in Sudan and Pakistan (Shahid *et al.*, 2016; Alkofide & Hashim, 2022). However, these findings did not agree with the findings obtained by studies on Malaysian participants (Abd Rahman *et al.*, 2023). In the class I malocclusion group, the females showed only large lateral incisors. Difference in MD width was not significant when ARs and ORs for males and females were compared. This finding was consistent with those of Al-Gunaid *et al.* (2012), who examined Yemenis.

In the current study, the average OR and AR were 92.66 and 78.91, respectively, which were significantly higher than Bolton's ratios. These results respectively were extremely close to 92.1 and 78.08 (Yemen), 93.730 and 78.430 (Iran), 92.10 and 78.40 (Portugal), 91.20 and 78.20 (Jordan); 92.27 and 78.90 (Turkiye), and 92.80 and 78.45 (Hong Kong) (Lavelle, 1972; Al-Khateeb & Abu Alhajja, 2006; Oktay & Ulukaya, 2010; Al-Gunaid *et al.*, 2012; Machado *et al.*, 2018; Mollabashi *et al.*, 2019). A systematic review and meta-analysis reported that ethnicity and type of malocclusion influence tooth size (Machado *et al.*, 2020).

In the class I malocclusion group, the rates of AR and OR discrepancies were 24 % and 20 %, respectively. The AR discrepancy was marginally equal to the results of

Bolton (29 % of discrepancy in Caucasians) (Bolton, 1962). The percentages obtained in the present study was similar to those recorded by Alshahrani *et al.* (2020) (22 %) for Saudis, Sakoda *et al.* (2017) (20 %) for Mediterranean people, and Crosby & Alexander (1989) (22.9 %) for Americans. Higher values were reported by Richardson & Malhotra (1975) (33.7 %) and Freeman *et al.* (1996), (30 %) for Americans and O'Mahony *et al.* (2011) (37 %) for Irish. These differences can be related to difference in ethnicity or race.

The rates of AR and OR discrepancies in the skeletal class III malocclusion groups were 44 % and 18 %, respectively. These results act as gauges as to how crucial it is to conduct a thorough diagnosis before an orthodontic treatment. The ARs and ORs in the skeletal class III malocclusion group agreed with those of previous studies conducted on Kosovar adolescents (41.3 % and 20 %) and Iranian groups with skeletal class III malocclusion (35 % and 20 %) (Ahmadi *et al.*, 2023; Zylfiu-Latifi *et al.*, 2023). This percentage was higher than that documented by Araujo & Souki (2003) (26 %) for Brazilian and Uysal *et al.* (2005) (21.3 %) for Turkish.

The OR discrepancy rate in the skeletal class I malocclusion group of the present study was 20 %, which was comparable to the values reported by Hussein *et al.* (2022) (19.8 %) for Egyptians, and Johe *et al.* (2010) (17.7 %) for Americans. However, our rate was higher than that recorded for Peruvian (5 %) (Bernabé *et al.*, 2005), and Japanese populations (7.6 %) (Endo *et al.*, 2007) but lower than that documented by Akyalçin *et al.* (2006) (7.6 %) for a Turkish population. Other studies compared Bolton discrepancies between different malocclusion groups but did not mention the rate of discrepancy in each group of malocclusions (Fattahi *et al.*, 2006; Mohammad *et al.*, 2018; Alshahrani *et al.*, 2020).

Skeletal class III malocclusion had higher anterior ITSD (44 %) than OR discrepancy (18 %) owing to the presence of wide mandibular or small maxillary posterior teeth, which balance out excess tooth material in the mandibular anterior segment and return the OR to normal levels (Othman & Harradine, 2006). Compared with posterior teeth, maxillary and mandibular incisors had more variable MDWs (Uysal *et al.*, 2005; Machado *et al.*, 2018). This result concurs with Bolton's explanation that AR is important to the evaluation of ITSD during orthodontic treatment planning. Differences in the rates of AR and OR discrepancies between the current study and other studies might be attributed to varied sample size, methods of analysis, types of population, and racial groups. Variation in the prevalence of ITSD between different studies and

the original Bolton's study may be attributed to difference in ethnic background and genetics of the population samples (Johe *et al.*, 2010).

The skeletal class III subjects showed significantly larger MD widths in both arches and higher AR mean values. These results agreed with those of many studies that assessed the association between skeletal class III and tooth size discrepancy (Alkofide & Hashim, 2002; Fattahi *et al.*, 2006; Hussein *et al.*, 2022), suggesting that skeletal class III malocclusions are associated with tooth size excess in mandibular teeth. Significant differences were found between the ARs of the skeletal class III malocclusion group and those of the skeletal class I and Bolton. Furthermore, the results confirmed a tendency toward the increased frequency of AR discrepancy in skeletal class III malocclusions (Sperry *et al.*, 1977; Araujo & Souki, 2003; Fattahi *et al.*, 2006).

Bolton's ratios do not apply to Yemeni orthodontic patients presented with skeletal classes III and I malocclusions. This result was consistent with finding that malocclusion class and ethnicity influence tooth size. However, regular tooth size analysis should be performed given that many Yemeni subjects in the current study possessed ITSD that may have affected the final treatment results.

This study has some limitations. First, the sample size and age groups were limited because the participants were from one city only. Second, the measurements of Frankfort-mandibular plane angle (FMA), Frankfort mandibular incisor angle (FMIA), incisor-mandibular plane angle (IMPA), and maxillary incisor to Sella-Nasion angle (U1-SN) were not included. In addition, samples with class II malocclusions were not included. Studies that have a larger sample size, include participants from all cities of Yemen, use digital systems, and have wider age range of patients from different classes are needed. Moreover, future studies should investigate the relationship between Bolton ITSD and the other craniofacial characteristics of different classes: FMA, FMIA, IMPA, and U1-SN.

CONCLUSIONS

The following conclusions were obtained:

Subjects with skeletal class III malocclusions had a significantly greater AR mean value and higher rate of ITSD than those with class I malocclusions. A tendency toward increased frequency of AR discrepancy was observed in skeletal class III.

No statistically significant difference in mean OR was found between the skeletal classes III and I malocclusion groups.

No statistically significant differences in AR and OR ITSD was found between males and females or between the right and left sides of the dental arch.

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AL-SHARABI, M. G.; ZABARA, A. Q.M. Q.; ISHAQ, R. A. R.; AL MOALEEM, M. M.; ALDHELAI, T. A.; IBRAHIM, R. M. F. & AL MAKRAMANI, B. MA. Discrepancia en el tamaño de los dientes intermaxilares en un grupo seleccionado de participantes yemeníes con maloclusión esquelética clase III. *Int. J. Morphol.*, 43(2):517-526, 2025.

RESUMEN: La discrepancia en el tamaño de los dientes intermaxilar (ITSD) varía entre diferentes poblaciones y entre clases de maloclusión. El presente estudio tuvo como objetivo investigar los porcentajes y proporciones de las discrepancias anteriores y generales en el tamaño de los dientes entre adultos yemeníes con maloclusión de clase III esquelética. Además, se exploró la asociación entre el sexo y los lados de las arcadas dentales en las variables medidas. Este estudio transversal perspectiva utilizó los datos de pacientes del Departamento de Clínicas de Ortodoncia de Postgrado, Facultad de Odontología, Universidad de Sanaa. Los pacientes evaluados tenían entre 13 y 28 años. Se midieron y calcularon el ancho mesiodistal del diente (MDTW), la relación anterior (AR) del tamaño del diente y la relación general (OR) a partir de 100 modelos de estudio y se dividieron equitativamente entre los grupos de maloclusión esquelética de clases III y I. Los pacientes con maloclusiones esqueléticas de clase I se incluyeron en el grupo control. Las mediciones se realizaron utilizando un calibrador digital. Un valor p de <0,05 indicó significación estadística. El AR de los pacientes con maloclusión esquelética de clase I fue de 78,18, y la tasa de discrepancia del AR fue del 24 %. Los pacientes con maloclusión esquelética de clase III presentaron un valor medio de AR significativamente mayor (79,64) y una mayor tasa de discrepancia del AR (44 %). Los porcentajes de OR en las clases esqueléticas I y III fueron del 20 % y el 18 %, respectivamente. Estos resultados no revelaron diferencias significativas en el OR entre los grupos de maloclusión. Además, no se encontraron diferencias estadísticamente significativas en la discrepancia del tamaño dental entre ambos sexos ni entre los lados derecho e izquierdo de la arcada dental. Los resultados confirmaron la tendencia hacia una mayor frecuencia de discrepancia del AR en la maloclusión esquelética de clase III. Los valores medios de AR en pacientes yemeníes de ortodoncia con maloclusiones esqueléticas de clases III y I fueron superiores al índice de Bolton. Los odontólogos deben incluir el análisis del tamaño dental de Bolton en sus diagnósticos y la planificación del tratamiento.

PALABRAS CLAVE: Discrepancia en el tamaño de los dientes intermaxilares; Índices de Bolton; Maloclusión esquelética de clase III; Sexo; Arco dental.

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