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ORIGINAL ARTICLE

Overjet, overbite and dental midline shift as predictors of tooth size discrepancy in a Bangladeshi population and a graphical overview of global tooth size ratios

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Abstract

Objectives. This study aimed to measure and compare tooth size ratios in a Bangladeshi population across the following groups: those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy; and those with or without lip competence. It also presents a graphical overview of the anterior and overall ratios from the study and using available global data. ***Materials and methods.*** This study was performed on dental casts of 260 Bangladeshi individuals, comprising 114 males and 146 females (age range, 18–24 years, mean age = 20). The Bolton anterior ratio and overall ratio were determined for the following groups: those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy; and those with or without lip competence. ***Results.*** There were statistically significant differences in the anterior tooth size ratios between those with or without dental mid-line discrepancy, with a mean value of 78.83% and 80.05%, respectively. Statistically significant differences were also found in overall tooth size ratios between those with normal, increased or decreased overjet and also between those with normal, increased or decreased overbite. Graphical presentations of anterior and overall ratios from the present study and using global data showed variations between populations. ***Conclusion.*** In the Bangladeshi population, increased tooth size ratios in subjects with dental mid-line discrepancy (anterior ratio) and also in those with decreased overjet or decreased overbite (overall ratio) may be predictors of tooth size discrepancies. The graphical overview also suggests that different international ethnic groups display unique Bolton ratios.

Key Words: *overjet, overbite, dental mid-line shifting, tooth size ratio, Bangladeshi, Bolton analysis*

Introduction

Differences in tooth size have been associated with different ethnic backgrounds and occlusion status [1]. Case analysis of patients with occlusion requires reliable references that are based on larger samples with normal occlusion as a baseline. From a clinical perspective, a proper balance should exist between the mesiodistal tooth sizes of the maxillary and mandibular arches to ensure proper inter-digitation, overbite and overjet at the completion of orthodontic treatment [2,3]. To determine the possible functional and aesthetic extent of treatment, an orthodontist usually considers the proportional relationships between the maxillary and mandibular tooth sizes as an important index, especially in relation to the finishing phase [4,5]. Several methods have been described to estimate inter-arch tooth size relationships [4–6]. For example, Bolton's ratios allow the orthodontist to gain insight into the functional and aesthetic outcomes of a given case without the use of a diagnostic set-up.

Bolton's analysis is one of the most popular methods for determining tooth size abnormality. It is useful in aiding diagnosis as well as treatment planning. Bolton's analysis should be routinely performed for all orthodontic patients, with the findings included in the orthodontic treatment planning [7]. Clinically, Bolton's ratios have been used to determine the need for reduction of tooth size via inter-proximal stripping or for the addition of tooth size via prosthetic

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restoration [5]. An excellent orthodontic treatment result, involving optimal occlusion as well as ideal inter-cuspation, overjet and overbite, can often be jeopardized by tooth size discrepancies or problematic tooth anatomy. A generalized application of the Bolton analysis and of the proposed values for harmonious dentition is questionable and may be invalid for other populations, as different international ethnic groups may have different Bolton ratios [8]. The importance of tooth size discrepancy in treatment planning has been the subject of much discussion in the orthodontic literature.

To date, no study in the literature has comparatively analysed the tooth size ratios of Bangladeshi subjects across the following groups: those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy; and those with or without lip competence. Therefore, this study had the following goals:

(1) Determining sexual dimorphism in tooth size discrepancies in a Bangladeshi population.
(2) Determining and comparing tooth size discrepancies in groups with class I normal occlusion, crowding or spacing.
(3) Determining and comparing tooth size discrepancies in groups with normal, increased or decreased overjet.
(4) Determining and comparing tooth size discrepancies in groups with normal, increased or decreased overbite.
(5) Determining and comparing tooth size discrepancies in groups with or without dental mid-line discrepancy.
(6) Determining and comparing tooth size discrepancies in groups with or without lip competency.
(7) Displaying a graphical presentation of the anterior ratios from the present study and using global data.
(8) Displaying a graphical presentation of the overall ratios from the present study and using global data.

Materials and methods

Subjects

This study was performed using dental casts of 260 Bangladeshi individuals, comprising 114 males and 146 females (age range = 18–24 years, mean age = 20). The records belonged to 100 subjects with class I normal occlusion. Eighty-seven subjects had crowding and 73 subjects had spacing in the maxillary and/or mandibular arches. The subjects were categorized as follows:

(1) Occlusion: normal (class I molar relationship, with no crowding or individual tooth malocclusion), crowding (>3 mm) and spacing (>3 mm, localized or generalized) groups.
(2) Overjet: normal (2–3 mm), increased (>3 mm) and decreased (<2 mm) groups.
(3) Overbite: normal (2–3 mm), increased (>3 mm) and decreased (<2 mm) groups.
(4) Dental mid-line: no discrepancy (mid-line between the two maxillary central incisors coincides with the mid-line between the two mandibular central incisors) and discrepancy (mid-line between the two maxillary central incisors does not coincide with the mid-line between the two mandibular central incisors) groups.
(5) Lip competency: competent (lips are habitually in contact with each other at rest) and incompetent (lips remain parted during the relaxed position of the muscles of facial expression while the mandible is in the rest position) groups.

Distributions of the subjects with the aforementioned categories are presented in Table I. The inclusion criteria were the following: (1) subjects of confirmed Bangladeshi ethnic background, (2) existing and erupted permanent central incisors to the first permanent molar in each quadrant, (3) no previous orthodontic treatment, (4) all teeth assessed to be

Table I. Gender and orofacial demographics of the subjects in our study.

		n	Total
Sex			260
	Male	114	
	Female	146	
Occlusion			260
	Class I normal occlusion	100	
	Crowding	87	
	Spacing	73	
Overjet			260
	Normal	137	
	Increased	68	
	Decreased	55	
Overbite			260
	Normal	135	
	Increased	65	
	Decreased	60	
Mid-line shift			260
	Coincide	60	
	Not Coincide	200	
Lip competency			260
	Competent	198	
	In competent	62	

Table II. Sexual dimorphism of the anterior and overall ratios of tooth size discrepancy in the present study.

					95% CI		
	Sex	Mean	SD	SE	Lower	Upper	*p*
Anterior ratio	Female	79.66	3.86	0.36	78.94	80.37	0.66
	Male	79.86	3.67	0.30	79.26	80.46	
	Total	79.77	3.75	0.23	79.31	80.23	
Overall ratio	Female	92.03	2.53	0.24	91.56	92.50	0.66
	Male	92.19	3.09	0.26	91.68	92.69	
	Total	92.12	2.86	0.18	91.77	92.47	

SD, Standard deviation; SE, Standard error.

morphologically normal and (5) absence of any decay, inter-proximal restorations, attrition, erosion, abrasion, broken down crowns, cracks and/or fractures.

Tooth size measurements

Cast measurements were taken by a single calibrated operator using a sliding calliper with vernier scale and a graded gauge (Mitutoyo, Japan). Measurements were carried out with a reading accuracy of 0.1 mm. The mesiodistal dimension was recorded, involving the maximum mesiodistal dimension of each tooth when measurement was rendered parallel to the occlusal and labial surfaces.

Maxillary and mandibular tooth size relationships examined by the Bolton formulae [4,5] are presented as,

$$\text{Anterior ratio} = \frac{\text{Sum of the mesio-distal widths of mandibular anterior teeth}}{\text{Sum of the mesio-distal widths of maxillary anterior teeth}}$$

$$\text{Overall ratio} = \frac{\text{Sum of the mesio-distal widths of 12 mandibular teeth (first molar to first molar)}}{\text{Sum of the mesio-distal widths of 12 maxillary teeth (first molar to first molar)}}$$

Statistical analysis

After collection, the data were verified and analysed statistically using the SPSS 19 (Chicago, IL) software with a probability level of 0.05 considered to be statistically significant. Student *t*-test was used to determine statistically significant significance for tooth size discrepancy between male and female subjects. Analysis of variance (ANOVA) was used to determine statistically significant differences for tooth size discrepancy between:

(1) Occlusion: normal class I occlusion, crowding and spacing groups.
(2) Overjet: normal, increased and decreased groups.
(3) Overbite: normal, increased and decreased groups.
(4) Dental mid-line: discrepancy and no discrepancy groups.
(5) Lip competency: competent vs incompetent groups.

A post-hoc Scheffe test was used to determine which groups were different from each other. Fifty pairs (10 pairs from each group) of dental casts were randomly selected and re-measured 1 month after the initial measurements. There were no statistically significant differences between the two sets of measurements.

Results

No significant sexual dimorphism was observed for tooth size discrepancy (Table II). Figure 1 summarizes the mean values of the anterior tooth size ratios in those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy; and those with or without lip competence. ANOVA demonstrated that there were statistically significant differences among groups with or without dental mid-line discrepancy, with mean values of 78.83 % and 80.05 %, respectively.

Figure 2 summarizes the mean values of the overall tooth size ratios in those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy; and those with or without lip competence. ANOVA demonstrated that there were statistically significant differences among groups with overjet and overbite.

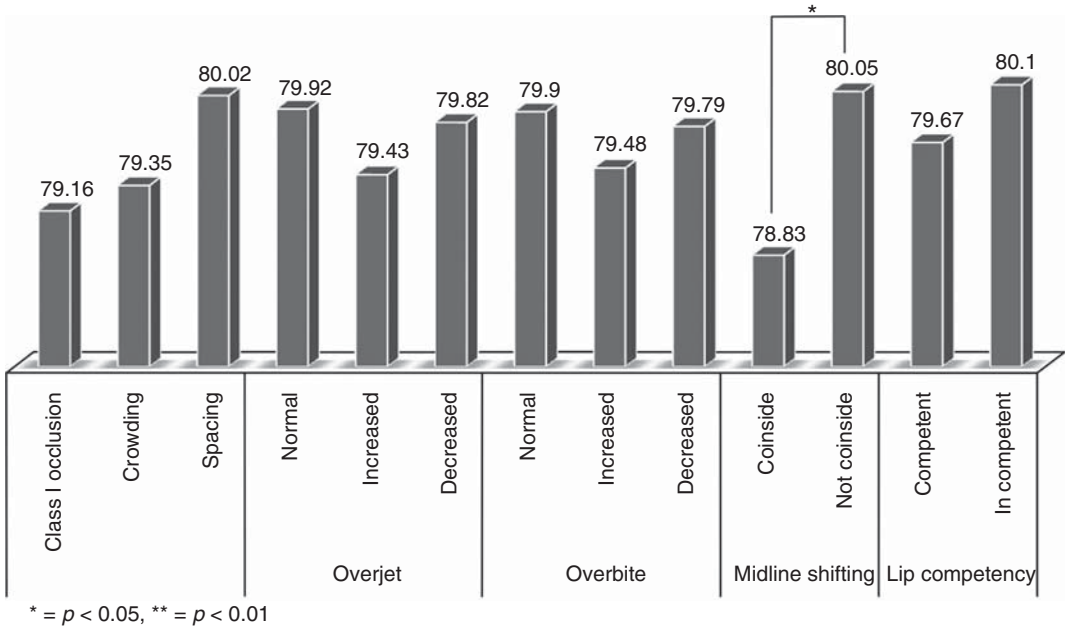

Figure 1. Anterior ratio of tooth size discrepancy among Bangladeshi subjects.

More specifically, subjects with decreased overjet and decreased overbite had significantly larger overall ratios.

Figure 3 [7,9–17] summarizes the mean values of anterior tooth size ratios in the South and Southeast Asian populations and from the present study. For the anterior ratio, the present study had a mean value of 79.77% in 260 samples, which was quite similar with those of Pakistani and Nepalese populations. On the other hand, values from Indian, Malaysian and Thai populations showed variations.

Figure 4 [18–21] summarizes the mean values of anterior tooth size ratios in East Asian populations and from the present study. For the anterior ratio, one study of a Chinese population (China 1) had a mean value of 81.52%, which was the highest value among all studies. Interestingly, another study of a Chinese population (China 2) showed different results. The results of other populations showed variations.

Figure 5 [2,22–30] summarizes the mean values of anterior tooth size ratios in the Middle Eastern populations and from the present study. For the anterior ratio, the present study had larger values than did other populations. Interestingly, results from other studies also showed inconsistencies.

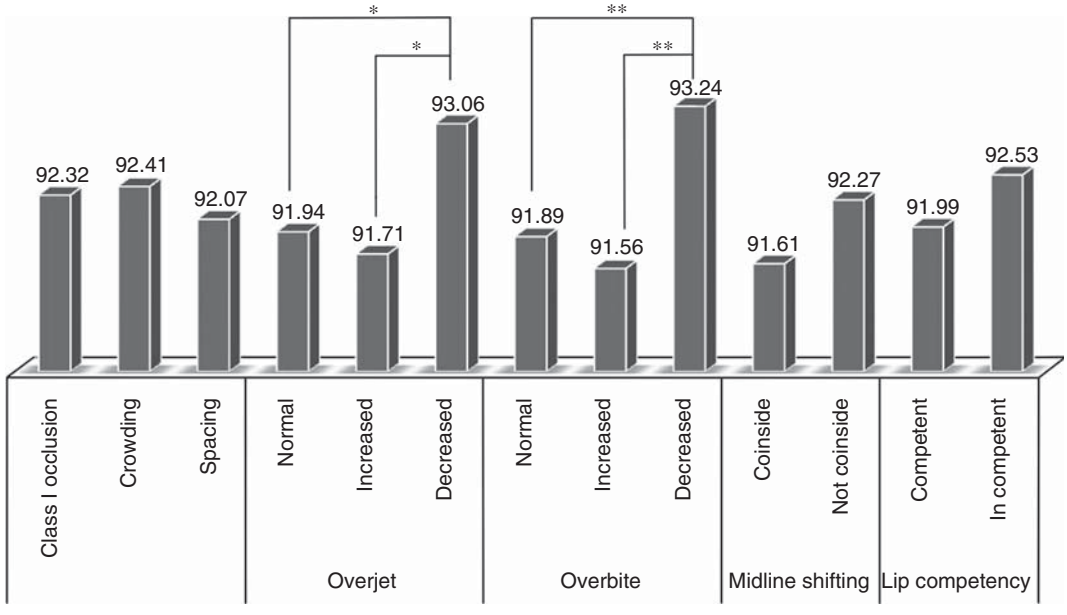

Figure 2. Overall ratio of tooth size discrepancy among Bangladeshi subjects.

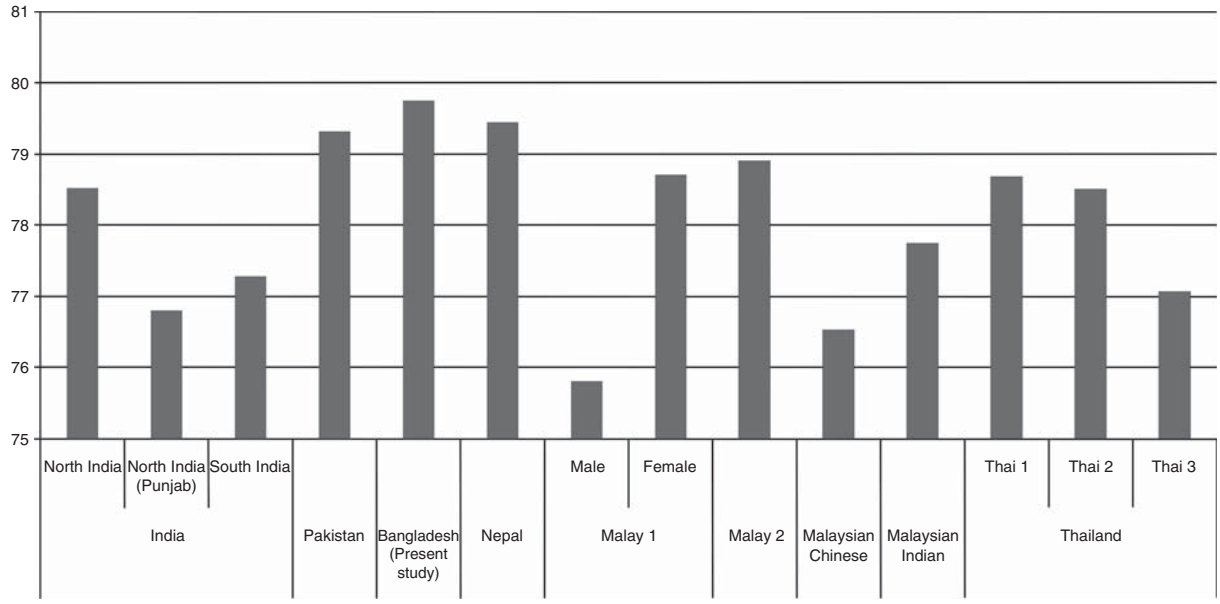

Figure 3. Anterior ratios of tooth size discrepancy in Bangladesh and in different populations in South and Southeast Asia. Rekha et al. [7] (North India), Sudhir et al. [9] (North India Punjab), Geeta et al. [10] (South India), Iffat et al. [11] (Pakistan), Jaiswal et al. [12] (Nepal), Othman et al. [13] (Malay 1), Rahman et al. [14] (Malay 2), Ho et al. [15] (Thai 1), Dechkunakorn et al. [16] (Thai 2) and Somchai [17] (Thai 3).

Figure 6 [4,5,8,31–36] summarizes the mean values of anterior tooth size ratios in the North and South American populations and from the present study. For the anterior ratio, a study of the Hispanic population (America 5) had a mean value of 81.5%, which was the second highest finding of the international studies investigated. Other American studies (American 1–4) showed quite consistent results, with the exception of one study (America 5). The results from studies of Brazilian, Peruvian and Dominican populations showed variations.

Figure 7 [37–42] summarizes the mean values of anterior tooth size ratios in European populations and from the present study. For the anterior ratio, the results of the British, German, Swedish and Spanish populations showed similar results, although the Polish and Lithuanian populations showed variations.

Figure 8 [43] summarizes the mean values of anterior tooth size ratios in an African population and from the present study. For the anterior ratio, the results of the Nigerian population showed variations compared to the present study.

Figure 9 [7,9–17] summarizes the mean values of overall tooth size ratios in the South and Southeast Asian populations. For the overall ratio, the present

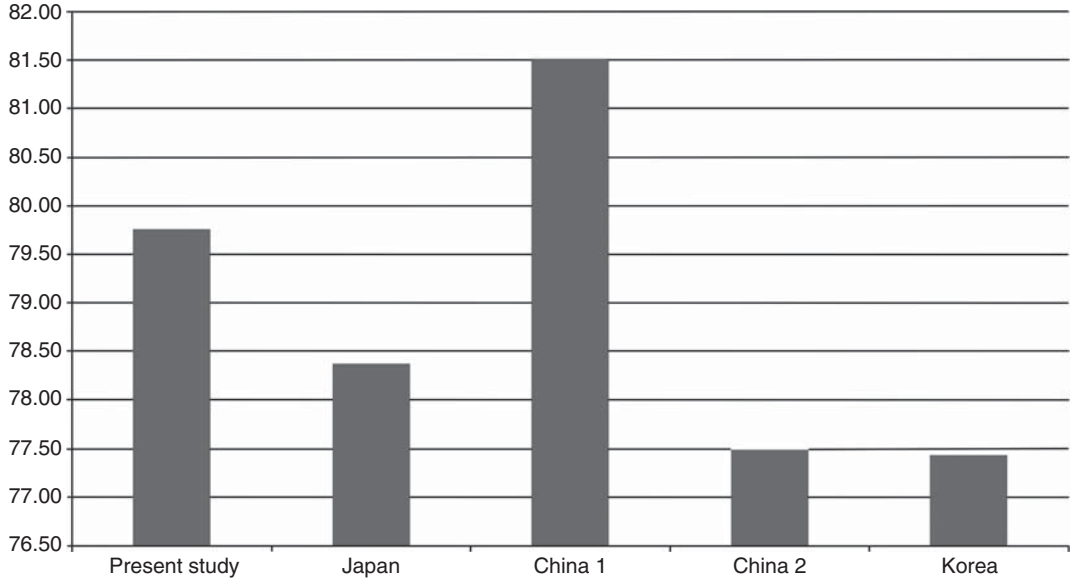

Figure 4. Anterior ratios of tooth size discrepancy in Bangladesh and in different populations in East Asia. Endo et al. [18] (Japan), Nie and Lin [19] (China 1), Ta et al. [20] (China 2) and Shin-jae et al. [21] (Korea).

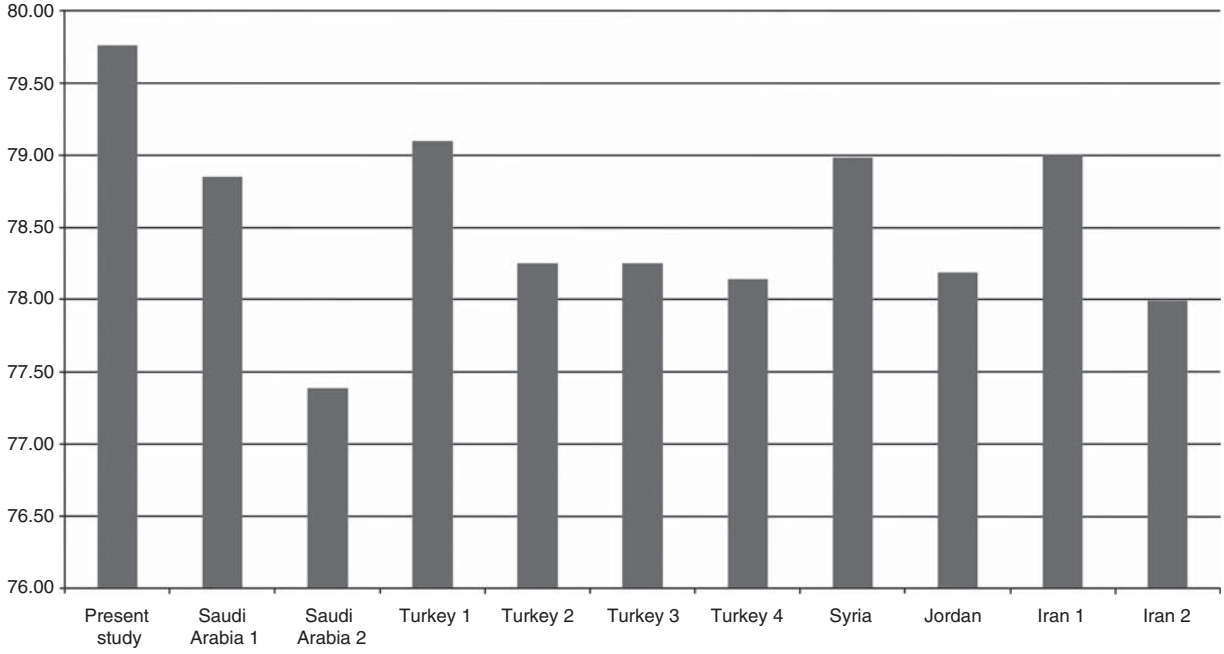

Figure 5. Anterior ratios of tooth size discrepancy in Bangladesh and in different populations in the Middle East. Alkofide and Hashim [22] (Saudi 1), Al-Tamimi and Hashim [2] (Saudi 2), Baidas and Hashim [23] (Turkey 1), Uysal and Sari [24] (Turkey 2), Uysal et al. [25] (Turkey 3), Akyalcin et al. [26] (Turkey 4), Nourallah et al. [27] (Syria), Al-Omari et al. [28] (Jordan), Mirzakouchaki et al. [29] (Iran 1) and Fattahi et al. [30] (Iran 2).

study had a mean value of 92.12%, which was quite similar to that of a Nepalese population. On the other hand, results from Indian, Pakistani, Malaysian and Thai populations showed variations.

Figure 10 [18–21] summarizes the mean values of overall tooth size ratios in East Asian populations and from the present study. For the overall ratio also, a study of a Chinese population (China 1) had a mean value of 93.27%, which was the second highest of the international studies considered. Interestingly, another study of a Chinese population (China 2) showed different results. Findings from other populations showed variations.

Figure 11 [2,22–30] summarizes the mean values of overall tooth size ratios in Middle Eastern populations and from the present study. For the overall ratio, the results of the present study were quite similar to those

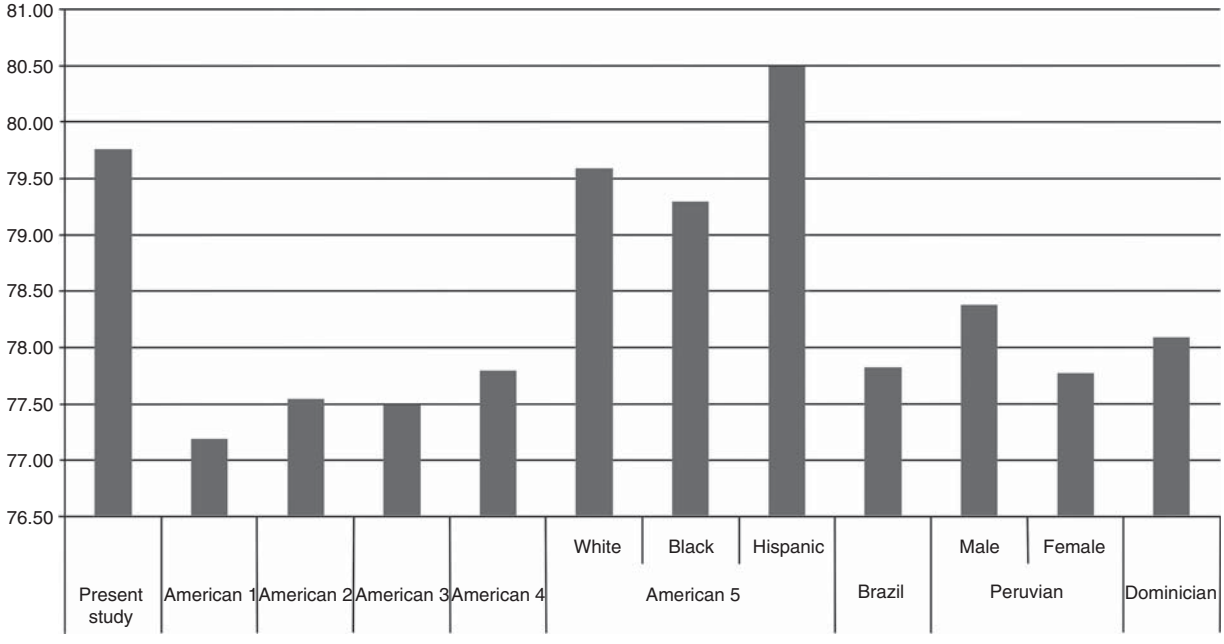

Figure 6. Anterior ratios of tooth size discrepancy in Bangladesh and in different populations in North and South America. Bolton [4,5] (American 1), Stifter [31] (American 2), Crosby and Alexander [32] (American 3), Freeman et al. [33] (American 4), Smith et al. [8] (American 5), Freire et al. [34] (Brazilian), Bernabé et al. [35] (Peruvian) and Santoro et al. [36] (Dominican).

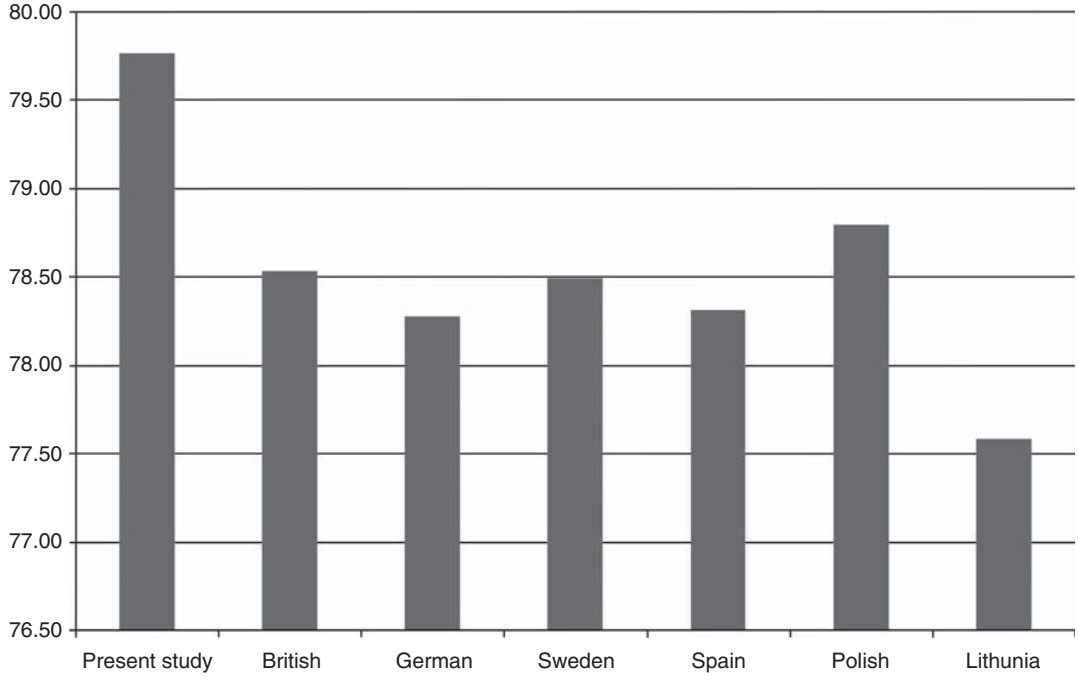

Figure 7. Anterior ratios of tooth size discrepancy in Bangladesh and in different populations in Europe. Othman and Harradine [37] (British), Manke and Miethke [38] (German), Lundström [39] (Swedish), Paredes et al. [40] (Spanish), Barbara et al. [41] (Polish) and Ale et al. [42] (Lithuania).

from three other studies (Turkey 1, Syria and Iran 2), but from the results of other studies.

Figure 12 [4,5,8,31–36] summarizes the mean values of overall tooth size ratios of the North and South American populations and from the present study. For the overall ratio, a study of Black and Hispanic populations (America 5) had mean values of 93.4% and 93.1%, which were the highest and third highest values, respectively, of the international studies considered. Other American studies (American 1–4, Brazilian, Peruvian and Dominican) showed quite consistent results, with the exception of one study (America 5).

Figure 13 [37,39–42] summarizes the mean values of overall tooth size ratios in European populations and from the present study. For the overall ratio, results from European populations were similar to those of the present study, with the exception of findings from a Lithuanian population.

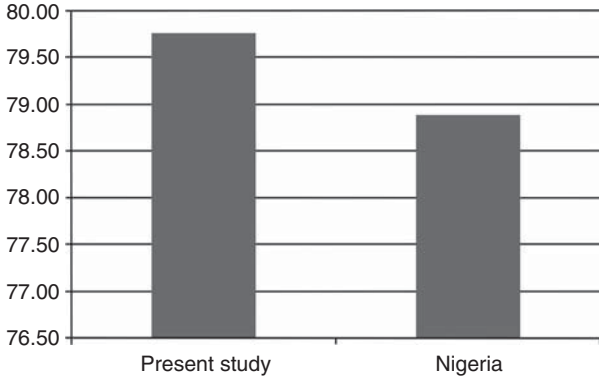

Figure 8. Anterior ratios of tooth size discrepancy in Bangladeshi and African populations. Ajayi [43] (Nigeria).

Figure 14 [43] summarizes the mean values of overall tooth size ratios in an African population and from the present study. The results from the Nigerian population were quite similar to the findings from the present study.

Discussions

The importance of tooth size discrepancy in orthodontic diagnosis has been widely reported in the literature and accepted by the orthodontic community, especially as the relationship between the maxillary and mandibular arches is associated with clinical outcomes. Orthodontists should be aware of tooth size discrepancies before beginning orthodontic treatment. The mesiodistal tooth size of the maxillary and mandibular arches must relate to each other to obtain optimal occlusion at the completion of orthodontic treatment [2]. If a patient has significant tooth size discrepancy, orthodontic alignment into optimal occlusion may not be possible.

The present study showed no significant sexual dimorphism for tooth size discrepancies [7,10,26,32,44]. However, other studies have reported on significant sexual dimorphism for tooth size discrepancies [8,9,30]. We also compared tooth size ratios in the following groups: those with normal occlusion, crowding or spacing; those with normal, increased or decreased overjet; those with normal, increased or decreased overbite; those with or without dental mid-line discrepancy;

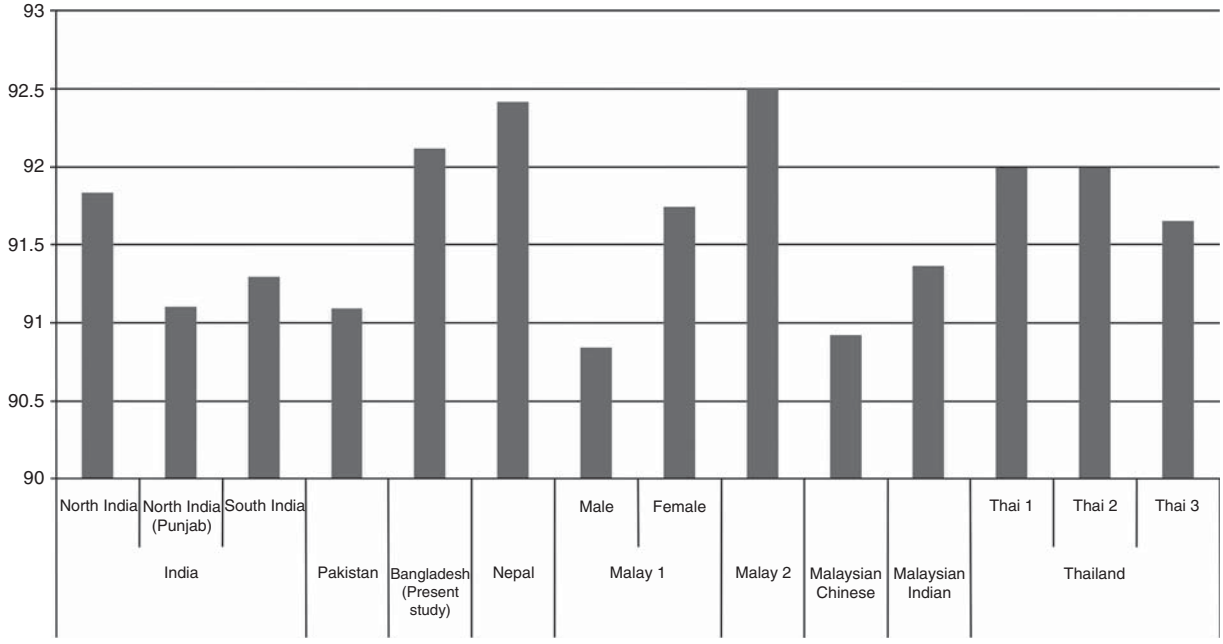

Figure 9. Overall ratios of tooth size discrepancy in Bangladesh and in different populations in South and Southeast Asia. Rekha et al. [7] (North India), Sudhir et al. [9] (North India Punjab), Geeta et al. [10] (South India), Iffat et al. [11] (Pakistan), Jaiswal et al. [12] (Nepal), Othman et al. [13] (Malay 1), Rahman et al. [14] (Malay 2), Ho et al. [15] (Thai 1), Dechkunakorn et al. [16] (Thai 2), and Somchai [17] (Thai 3).

and those with or without lip competence. There were statistically significant differences in the anterior ratios of tooth size discrepancies only in groups with or without dental mid-line discrepancy. There were statistically significant differences in the overall ratios of tooth size discrepancies in groups with normal, increased or decreased overjet and in groups with normal, increased or decreased overbite. Larger anterior ratios were observed in subjects with dental mid-line discrepancy, while larger overall ratios were observed in those with decreased overjet or decreased overbite. All of these values were statistically significant. As such, increases in tooth size ratios in the Bangladeshi population among subjects with dental mid-line discrepancy (anterior ratio) and in those with decreased overjet or decreased overbite (overall ratio) may be predictors of tooth size discrepancies.

The findings from the Bangladeshi sample displayed variability, despite the adequate sample size and the very good condition of the teeth. This variation may be attributed to compensation of tooth size

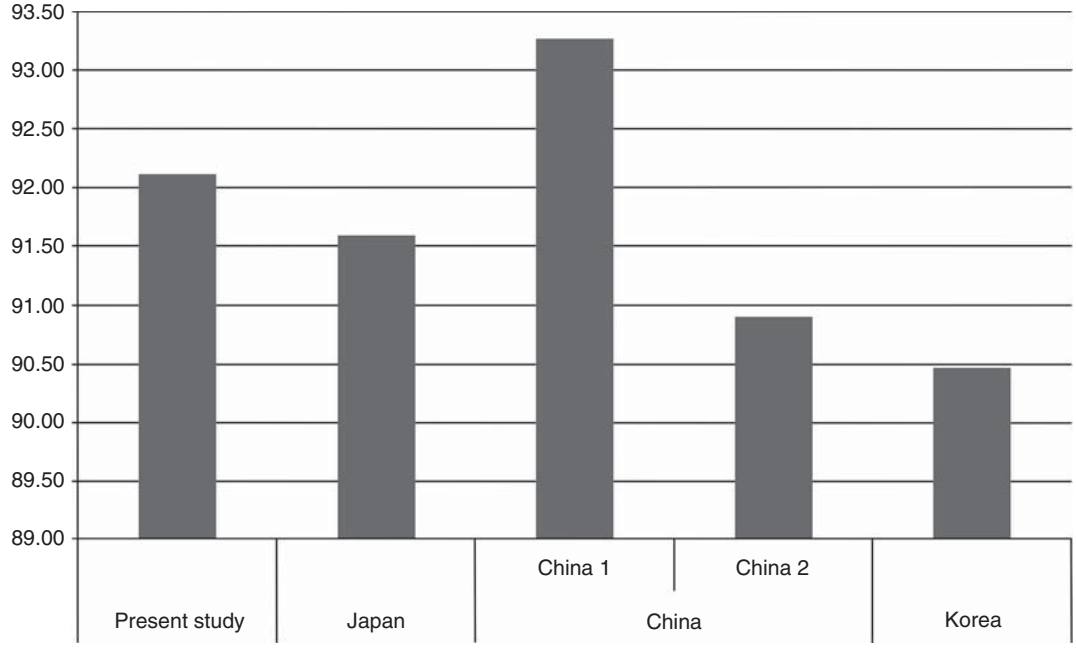

Figure 10. Overall ratios of tooth size discrepancy in Bangladesh and in different populations in East Asia. Endo et al. [18] (Japan), Nie and Lin [19] (China 1), Ta et al. [20] (China 2), and Shin-jae et al. [21] (Korea).

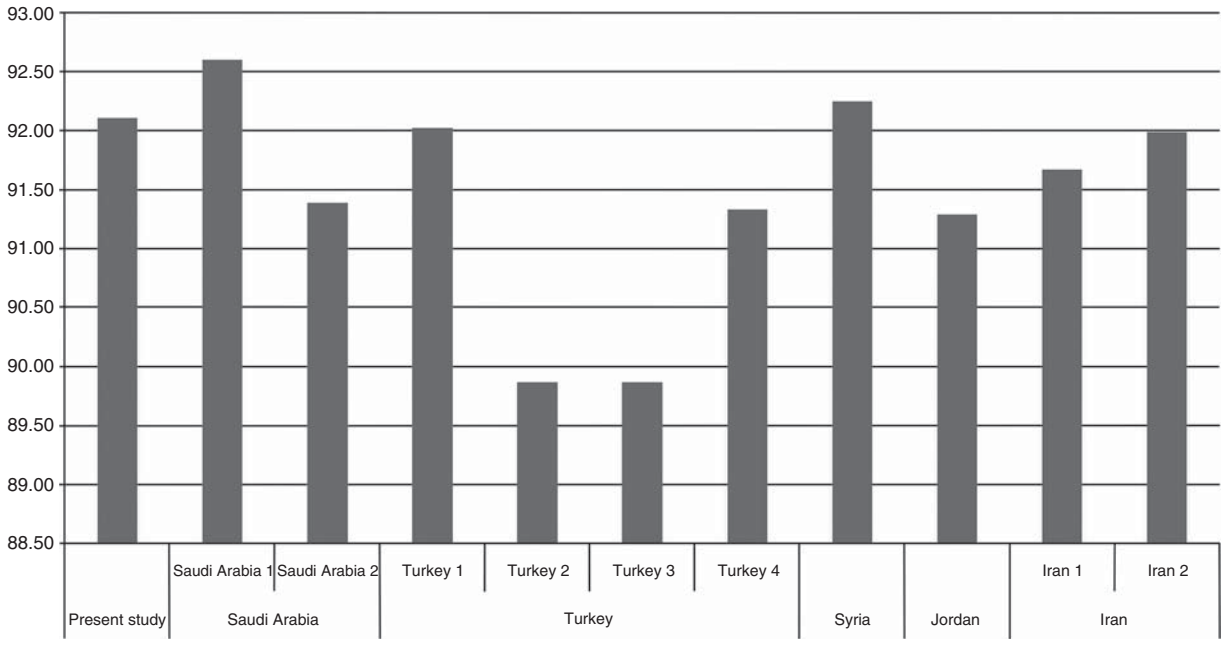

Figure 11. Overall ratios of tooth size discrepancy in Bangladesh and in different populations in the Middle East. Alkofide and Hashim [22] (Saudi 1), Al-Tamimi and Hashim [2] (Saudi 2), Baidas and Hashim [23] (Turkey 1), Uysal and Sari [24] (Turkey 2), Uysal et al. [25] (Turkey 3), Akyalcin et al. [26] (Turkey 4), Nourallah et al. [27] (Syria), Al-Omari et al. [28] (Jordan), Mirzakouchaki et al. [29] (Iran 1), and Fattahi et al. [30] (Iran 2).

ratios to create a harmonious occlusion or a natural reflection of the population that constituted our sample. The original Bolton [4,5] norms were calculated using 55 models with excellent occlusion, of which 44 were orthodontically-treated. Bolton's estimates of variation were under-estimated because his sample was based on subjects with perfect Class I occlusion. Our study utilized 260 models (Table I) and was in agreement with other findings [9,26,32,44], with no statistically significant differences for occlusal status (normal occlusion, crowding and spacing groups).

Conversely, Nie and Lin [19] found significant differences in the anterior and overall ratios between the occlusal status groups in a Chinese population, with the following ratios in decreasing order: Class III, followed by Class I and Class II. Uysal et al. [25] compared inter-arch tooth size discrepancies in subjects with normal occlusion and with different

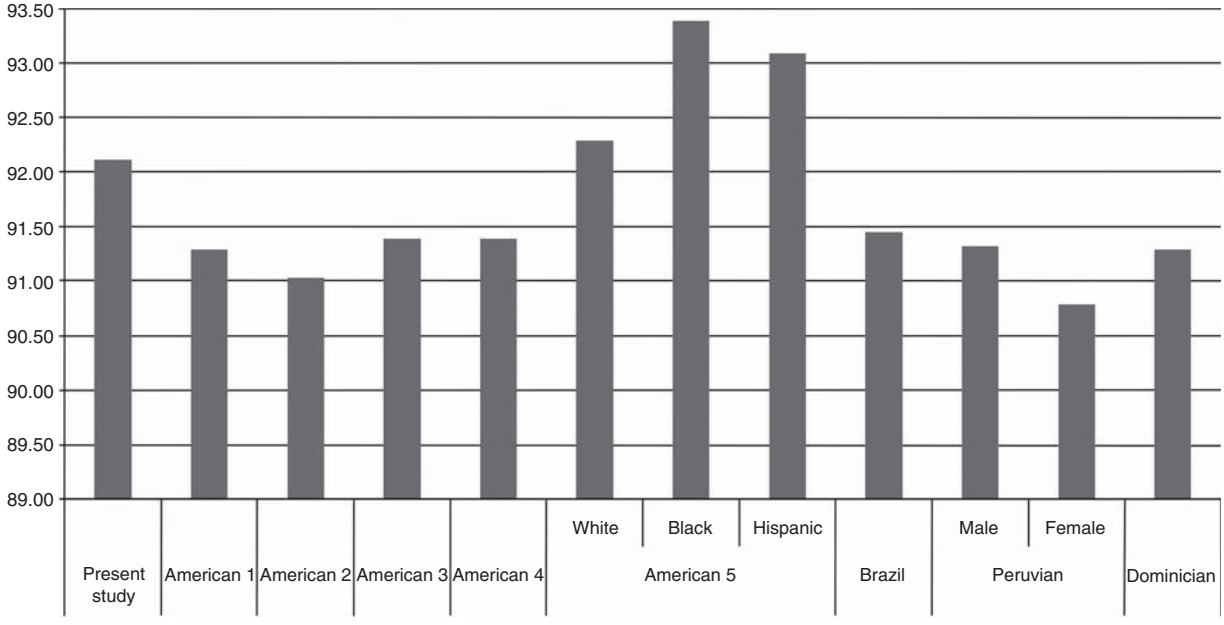

Figure 12. Overall ratios of tooth size discrepancy in Bangladesh and in different populations in North and South America. Bolton [4,5] (American 1), Stifter [31] (American 2), Crosby and Alexander [32] (American 3), Freeman et al. [33] (American 4), Smith et al. [8] (American 5), Freire et al. [34] (Brazil), Bernabé et al. [35] (Peruvian), and Santoro et al. [36] (Dominican).

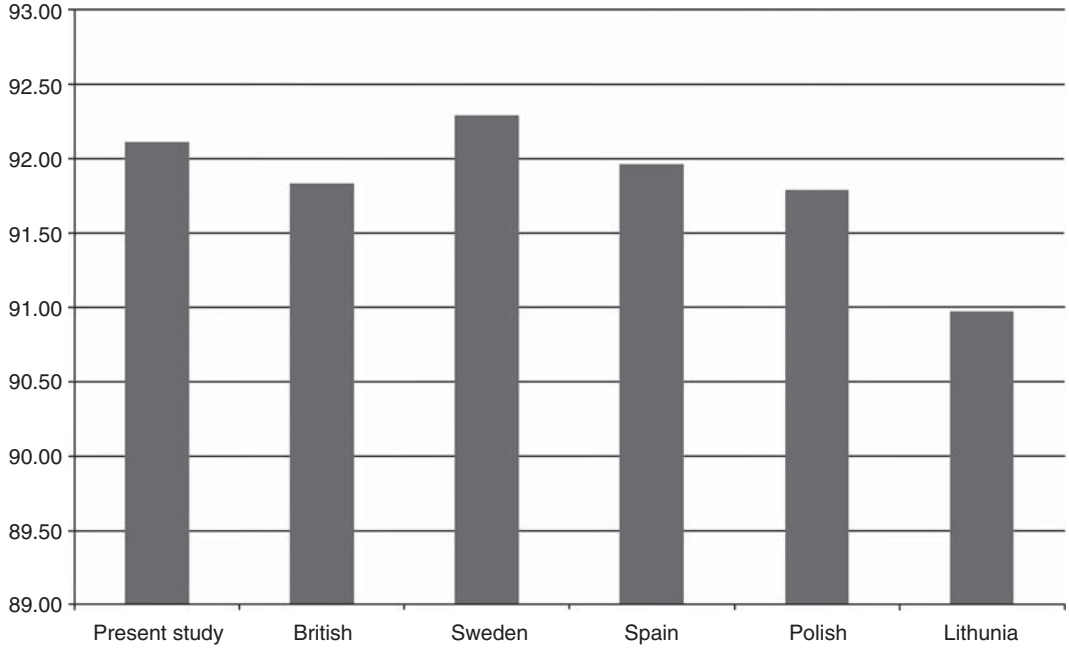

Figure 13. Overall ratios of tooth size discrepancy in Bangladesh and in different populations in Europe. Othman and Harradine [37] (British), Lundström [39] (Sweden), Paredes et al. [40] (Spanish), Barbara et al. [41] (Polish), and Ale et al. [42] (Lithuania).

types of malocclusion and reported Gender dimorphism among subjects with normal occlusion. The malocclusion groups showed significantly higher overall ratios than did the normal occlusion group. However, no statistically significant difference was found between the groups. Ta et al. [20] reported that, although the anterior ratios showed no significant differences among Class I, Class II and Class III malocclusion groups in a Hong Kong population, the overall ratios were significantly greater in Class III than in Class II malocclusion groups. Fattahi et al. [30] showed that the anterior ratio of the Class III group was significantly greater than those of Class II division 1 and Class II division 2 groups in an Iranian population and that the overall ratio of the Class III group was significantly greater than those of the other groups. However, some studies have demonstrated no significant differences in tooth size ratios among different Angle malocclusion groups in different populations. Othman et al. [13] found that 47.5% of the sample had anterior tooth width ratios more than 2 standard deviations away from Bolton's mean. A dental student population at the University of Malaya displayed a higher percentage [13] of outliers than did Bolton's sample.

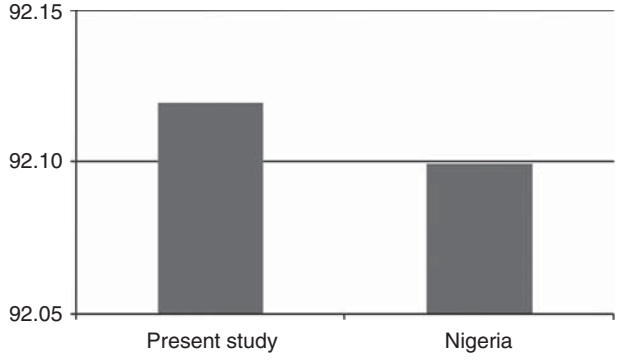

Figure 14. Overall ratios of tooth size discrepancy in Bangladeshi and African populations. Ajayi [43] (Nigeria).

Iffat et al. [11] reported that skeletal Class I and Class III patients displayed mean tooth size ratios within close range of Bolton's norms, whereas skeletal Class II patients showed significantly higher mean anterior tooth ratios. The mean total tooth ratios were within close range of Bolton's norms. Stifter [31] and Geeta et al. [10] replicated Bolton's study in class I dentitions and reported similar results to those of Bolton's [4] study. Smith et al. [8] reported that Bolton's ratios were only applicable to white females and not to white males, blacks or Hispanics. Moreover, the overall ratio was significantly larger in males than in females. In the present study, we found significant differences with the Bolton anterior and overall tooth size discrepancies, as did Endo et al. [18]. According to Akyalcın et al. [26], the prevalence of Bolton anterior and overall tooth size discrepancies was very high compared to their own study sample. Findings from a study by Rekha et al. [7] suggested that a large number of orthodontic patients in a North Indian population possessed Bolton tooth size discrepancies. Such findings may influence treatment goals and results. While Bolton tooth size analysis should be used for every orthodontic patient before initiation of treatment, it may be necessary to determine specific standards, especially regarding the anterior Bolton ratio, for different populations [18,20,24], as well as for different types of malocclusion [20],

because the original Bolton relationships may be limited to the white population in the US.

Conclusions

The following are the key results of this investigation:

(1) Gender differences in the anterior and overall ratios were not significant.
(2) There were statistically significant differences for the anterior ratios of tooth size discrepancy in groups with or without dental mid-line discrepancy.
(3) There were statistically significant differences for the overall ratios of tooth size discrepancy among groups with normal, increased or decreased overjet and also among groups with normal, increased or decreased overbite.
(4) The following may be predictors of tooth size discrepancy: subjects with dental mid-line discrepancy (for the anterior ratio) and those with decreased overjet or decreased overbite (overall ratio).
(5) A graphical presentation of the anterior ratios from the present study and using global data showed variations between populations.
(6) A graphical presentation of the overall ratios from the present study and using global data showed variations, albeit with some similarities.

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