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# Standardizing Interarch Tooth-Size Harmony in a Syrian Population

Abduhl W. Nourallah;<sup>a</sup> Christian H. Splieth;<sup>b</sup> Christian Schwahn;<sup>c</sup> Mohammad Khurdajj<sup>d</sup>

## ABSTRACT

The Bolton analysis is considered to be a good indicator for evaluating the degree of intermaxillary tooth-size harmony, but the possibility of ethnic variation of these values should be examined. Thus, the aim of this study was to calculate both the anterior and overall ratios of mandibular and maxillary tooth sizes for a Syrian sample of harmonious permanent dentitions and to compare these ratios with the data from the Bolton and the Michigan studies. In plaster models of 55 Syrian patients (11–22 years) with neutral occlusion (Angle Class I), harmonious overjet and overbite, no reduction of mesiodistal tooth width or missing teeth, the mesiodistal widths of each tooth from the incisors to the first permanent molars were measured in both arches. In the statistical data analysis, the anterior and overall ratios were calculated according to Bolton. The results for the anterior ratio ( $78.99 \pm 2.18$ ) and the overall ratio ( $92.26 \pm 2.06$ ) showed no statistically significant differences by sex ( $P > .48$ ). These values and the degree of variation were similar to the original data by Bolton. Both studies differed considerably from the values of the anterior ratio found in the Michigan University study, which also shows a higher degree of variability. Nevertheless, the overall ratios of all three studies were very similar. Therefore, the interarch tooth-size analysis and values for a harmonious dentition developed by Bolton can also be transferred to an Arabian or at least a Syrian population.

**KEY WORDS:** Tooth-size analysis, Bolton analysis, Interarch ratio.

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## INTRODUCTION [Return to TOC](#)

In contrast to the progress that has been made in recent decades in the field of orthodontic treatment, especially in fixed appliances, diagnostic aspects have not undergone such extensive development. Essential diagnostic elements such as tooth-size harmony and cephalometric analysis have not been the focus of research, and this has led to few studies being published in this field.

The proportional relationship between the sizes of upper and lower teeth is accepted as an important index by which the orthodontist can determine the possible functional and esthetic limits of the treatment, especially regarding the finishing phase.<sup>1</sup> The early pioneers of orthodontics realized the importance of the harmonious relationship between the teeth in the same arch and between arches,<sup>2</sup> and recent studies have demonstrated interarch tooth-size discrepancy for various groups of malocclusion.<sup>3–5</sup>

More than a century ago, Black<sup>6</sup> developed tables for average tooth sizes. In the research that followed, different approaches were developed for interarch tooth-size analysis and harmonious values.<sup>7–12</sup> Most of these previous studies were performed on casts of Caucasians or regardless of the ethnicity or sex of the subjects.

Subsequent investigations such as the Michigan University study,<sup>13</sup> the study by Sanin and Savara<sup>14</sup>, or a Chinese study<sup>5</sup> differentiated these analyses by sex. Smith et al,<sup>15</sup> who examined the validity of Bolton ratios for different ethnic groups, recently concluded that Bolton's ratios apply only to white women and should not be applied indiscriminately to white men, blacks, or Hispanics. Thus, the generalized use of the Bolton analysis and the proposed values for a harmonious dentition are under discussion and might not be valid for other populations.

The aim of this study, which is part of the national plan for standardizing international norms in the field of medicine and dentistry in Syria, was to calculate both the anterior and overall ratios for a sample of harmonious Syrian dentitions and to compare these ratios with the original data from Bolton<sup>2</sup> and the Michigan studies<sup>13</sup> that differentiated the analysis by sex.

## MATERIALS AND METHODS [Return to TOC](#)

Plaster models of 55 patients (35 male subjects, 20 female subjects, ages 11–22 years) were randomly chosen from patients at the Department of Pediatric Dentistry, Damascus University, according to the following inclusion criteria:

- Neutral occlusion of the permanent dentition (Angle Class I molar and canine relationship),

- Harmonious overjet and overbite ( $2 \pm 0.5$  mm),
- Caries/filling-free teeth and no other reduction of mesiodistal tooth width,
- No extractions.

In 48 patients, orthodontic treatment had already been completed.

The mesiodistal widths of each tooth from incisors to the first permanent molars were measured in both arches in two separate measurements with vernier calipers (0.02-mm accuracy) according to the method described by Seiple<sup>16</sup> and Moorrees and Reed.<sup>8</sup> The mean value of the two measurements was used in further calculations.

In the statistical data analysis (PC/SPSS 10.7), the anterior ratio ( $\Sigma$  width of six lower anterior incisors/ $\Sigma$  width of six upper anterior incisors  $\times$  100) and overall ratio ( $\Sigma$  width of lower 12 teeth/ $\Sigma$  width of upper 12 teeth  $\times$  100) were calculated according to Bolton.<sup>2</sup> The individual data were summarized as ranges and mean values of these ratios. The data were checked for normal distribution. Variation was analyzed as coefficients of variation, standard deviations, and standard errors of the mean values.<sup>17</sup> These data were compared with results from Bolton<sup>2</sup> and the Michigan University studies.<sup>13</sup>

## RESULTS [Return to TOC](#)

In the Syrian sample, the ratios of the upper and lower incisors were normally distributed, and they ranged from 75.4 to 83.00 with a mean value of 78.99 and a low standard deviation of 2.18 ([Table 1](#)). The overall ratio ranged from 88.15 to 95.90 with a normal distribution and a mean value of  $92.26 \pm 2.06$ , also indicating low variability.

The mean values for the anterior and overall ratios for male and female subjects were very similar and did not differ significantly ( $P > .48$ , [Table 2](#)). Thus, the norm values for the Syrian population would be  $78.99 \pm 2.18$  for the anterior ratio and  $92.26 \pm 2.06$  for the overall ratio.

The comparison with the original data from Bolton showed minimally higher ranges and mean values for the anterior and overall ratio ([Table 3](#)). The degree of variation (standard deviation, standard error, coefficients of variation) was nearly equal in both populations.

The sex-specific analysis performed in the Michigan University study<sup>13</sup> also demonstrated no relevant differences between male and female subjects ([Table 4](#)). The mean values of the anterior ratio in the Michigan University study were low compared with the results of the Syrian sample and Bolton's data, whereas the overall ratios in all three studies were very similar.

The standard deviations in the Michigan University study were relatively high compared with Bolton's or the Syrian data.

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The narrow range of values in the Syrian sample demonstrates low variability. This might be attributed to the strict selection of harmonious casts and to the high accuracy of the vernier calipers (0.02 mm) used in this study. The low degree of variation between the highest and lowest values for the proportions of tooth size between lower and upper teeth allows the definition of values for a harmonious dentition. This confirms the findings of Freeman et al,<sup>3</sup> who showed that a large percentage of the orthodontic patients had discrepancies in upper and lower tooth size greater than two standard deviations from Bolton's values. Other studies in the United States and China<sup>4,5</sup> also detected considerable tooth-size discrepancies in various groups of malocclusion. Therefore, these studies suggest the inclusion of Bolton's tooth-size analysis before orthodontic treatment planning.

The data from the Syrian sample—representing an Arabian population—are similar to Bolton's original data<sup>2</sup> from an American population. This is quite surprising because the Michigan University study<sup>13</sup> found lower anterior ratios for another American sample, and Smith et al<sup>15</sup> detected variation for different ethnic groups within the United States. On the other hand, the absolute magnitude of the ethnic differences in the mean overall ratio (whites 92.3%, Hispanics 93.1%, blacks 93.4%) exists despite their relatively low statistical significance.<sup>15</sup> The mean overall ratio in American whites<sup>15</sup> and the Syrian sample were identical, indicating the generalized application of the Bolton analysis from Caucasian samples to an Arabian population.

In summary, this study indicates that the analysis and the original data from Bolton can also be used on an Arabian or at least a Syrian population. It also confirms the results of the Michigan University study<sup>13</sup> and a Chinese study<sup>5</sup> that no relevant sexual dimorphism exists and that these harmonious values are valid for both male and female subjects.

## CONCLUSIONS [Return to TOC](#)

This study, which applied Bolton's tooth-size analysis to a sample of harmonious Syrian models, found values similar to the original data of an American population. Therefore, the analysis of and ideal values for a harmonious dentition developed by Bolton can also be used on an Arabian or at least a Syrian population.

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**TABLE 1.** Range, Mean Values, and Measurements of Variability for the Anterior and Overall Ratio of Upper and Lower Teeth According to the Bolton Analysis

	Range	Mean Value	Standard Deviation	Standard Error of Mean Value	Coefficient of Variation (%)
Anterior ratio	75.21–83.00	78.99	2.18	0.31	2.76
Overall ratio	88.15–95.90	92.26	2.06	0.30	2.23

**TABLE 2.** Arch Length in Millimeters for Maxillary/Mandibular Front (3–3) and Dentition (6–6), and Anterior and Overall Ratio in the Syrian Sample by Sex

	Range		Mean Value		Standard Deviation	
	Male	Female	Male	Female	Male	Female
Arch length (mm)						
Max 3–3	41.0–51.2	41.4–49.4	47.2	46.0	2.4	2.1
Mand 3–3	33.8–41.1	33.7–39.0	37.2	36.4	1.8	1.6
Arch length (mm)						
Max 6–6	83.4–103.4	84.45–99.4	95.4	93.9	4.5	3.8
Mand 6–6	79.9–97.4	80.2–90.9	88.2	86.3	4.2	3.0
Anterior ratio	75.2–83.0	75.5–82.6	78.9	79.2	2.29	2.02
Overall ratio	88.5–95.9	88.2–94.9	92.4	91.9	2.06	2.08

**TABLE 3.** Comparison of the Anterior and Overall Ratio in the Syrian Sample, the Original Data from Bolton,<sup>2</sup> and a Sex-Specific Analysis from the Michigan University Study<sup>13</sup>

	Range		Mean Value		Standard Deviation		Standard Error of Mean Value		Coefficient of Variation (%)	
	Bolton	Syria	Bolton	Syria	Bolton	Syria	Bolton	Syria	Bolton	Syria
Anterior ratio	74.5–80.4	75.2–83.0	77.2	79.0	1.65	2.18	0.22	0.31	2.14	2.76
Overall ratio	87.5–94.8	88.15–95.9	91.3	92.3	1.91	2.06	0.26	0.30	2.09	2.23

**TABLE 4.** Comparison of the Anterior and Overall Ratio in the Syrian Sample, the Original Data from Bolton,<sup>2</sup> and a Sex-Specific Analysis from the Michigan University Study<sup>13</sup>

	Bolton	Syria	Michigan University Study	
			Males	Females
Anterior ratio	77.2 ( $\pm 1.79$ )	78.99 ( $\pm 2.18$ )	73.5 ( $\pm 3.5$ )	73.4 ( $\pm 3.6$ )
Overall ratio	91.3 ( $\pm 1.9$ )	92.26 ( $\pm 2.06$ )	91.0 ( $\pm 2.8$ )	90.6 ( $\pm 2.0$ )

<sup>a</sup>Consultant, Department of Orthodontics and Pediatric Dentistry, Tichreen University, Lattakia, Syria

<sup>b</sup>Department Head, Pediatric and Preventive Dentistry, Christian Albrechts University, Kiel, Germany

<sup>c</sup>Leading Statistician, Center for Oral Medicine, Ernst Moritz Arndt University, Greifswald, Germany

<sup>d</sup>Former Head, Department of Pediatric Dentistry, Damascus University, Damascus, Syria

Corresponding author: Christian H. Splieth, University of Kiel, Arnold-Heller-Strasse 16, D 24105 Kiel, Germany (E-mail: [splieth@konspar.uni-kiel.de](mailto:splieth@konspar.uni-kiel.de))