

Determination of Bolton's Ratio in Different Malocclusions of the Western Region of Saudi Arabian Population: A Retrospective Cross-Sectional Study

Ammar Qasim^{1*}, Yousef Althomali², Nayef Felemban², Raghu Devanna², Abdulrahman Kariri³, Puneet Gupta⁴

¹BDS, General Dentist, Medical Director, Afani Medical Complex, Taif, Saudi Arabia

²Associate Professor of Orthodontics, Orthodontic Division, Department of Preventive Dentistry, Faculty of Dentistry, Taif University, Taif, Saudi Arabia

³BDS, General Dentist, Medical Director, Halub Specialized Complex, Taif, Saudi Arabia

⁴Reader, Department of public health dentistry, Government College of Dentistry, Indore, Madhya Pradesh, India

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*Corresponding author: Ammar Qasim

BDS, General Dentist, Medical Director, Afani Medical Complex, Taif, Saudi Arabia

Abstract

Background: Bolton's ratio is a useful tool in orthodontic studies which helps determine the ratio of dental proportions. It is considered the 7th key to normal occlusion. Variations in different malocclusions can aid in diagnosis and planning the treatment. This study determines Bolton's overall and anterior ratios for male individuals with different classes of malocclusion in the western region of Saudi Arabia. **Methods:** Ninety-six study model records were obtained from male patients attending the Orthodontic division of Preventive Dentistry, Faculty of Dentistry at Taif University, Saudi Arabia. The participants' average age was 19.6 years. The study models were divided into three categories: Angle's Class 1 (n=40), Angle's Class 2 (n=36), and Angle's Class 3 (n=20). To prevent bias, one of the authors measured the study casts using the ORTHOASSISTANT software program at two different time intervals. Intergroup differences were analyzed using one-way ANOVA. Results were considered statistically significant if the p-value of ≤ 0.05 . **Results:** No statistically significant difference was observed in the overall ratio between the three types of malocclusions. However, class 2 and 3 malocclusions demonstrated significant differences in the anterior ratio. Both overall and anterior ratios in this population were higher than normal Bolton's ratios. **Conclusions:** Bolton's overall ratio did not differ significantly between various malocclusions, but Bolton's anterior ratio did show significant differences between Class 2 and Class 3 malocclusion groups. This highlights the importance of orthodontists' appropriate diagnosis and treatment planning in such cases.

Keywords: Saudi Arabia, Malocclusion, Orthodontists, Preventive Dentistry, Malocclusion, Angle Class I, Malocclusion, Angle Class III.

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INTRODUCTION

Malocclusion is a dental condition in which the teeth are misaligned or does not fit together properly when the jaw is closed. This disorder may cause problems such as trouble chewing or speaking, tooth decay, gum disease, and jaw pain. Malocclusion can result from various causes, such as heredity, missing teeth, or unnatural jaw or tooth growth. Orthodontic therapy, like braces or aligners, or surgery may be required in some circumstances to treat a malocclusion. Addressing malocclusion early to prevent further dental problems and promote oral health is essential.

In his investigation of tooth-size ratios in patients with excellent occlusions, Wayne A. Bolton showed that for individuals to have a well-functioning occlusion with optimal posterior interdigitation, normal overbite, and normal overjet, an overall and anterior ratio of 91.3% and 77.2%, respectively, is required [1]. These ratios have since become widely used as a reference in orthodontics to assess the size and proportion of teeth, as discrepancies in tooth size can lead to crowding, spacing issues, and other problems with the alignment of teeth and the overall bite. By understanding the ideal ratios for tooth size,

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orthodontists can provide effective treatment to correct any issues and achieve a balanced, functional bite.

¹Determination of Bolton's Ratio

The Bolton's ratio is a dental metric that evaluates the size of teeth relative to each other and the overall jaw size. To obtain the ideal ratio, the total combined width of the upper front teeth should be around 91.3% to 91.6% of the total combined width of the lower front teeth. The tooth size ratio can be determined by dividing the sum of the mesiodistal width of all 12 mandibular teeth by the sum of the mesiodistal width of all 12 maxillary teeth, starting from the right first molar to the left first molar. Moreover, the anterior ratio is determined by dividing the total mesiodistal width of the six mandibular anterior teeth by the sum of the mesiodistal width of the six maxillary anterior teeth. These computations offer valuable insights into the proportional relationship of tooth sizes between the mandibular and maxillary arches.

Good occlusion in orthodontic treatment is a crucial factor, and it is essential to establish coordination between the maxillary mesiodistal widths and the mandibular teeth [2]. Therefore, identifying potential tooth-size discrepancies is crucial during the early stage of orthodontic examination for effective management through restorative solutions, proximal stripping, or extraction to achieve the necessary width balance between the teeth in both arches [3].

There are few reports on malocclusion within the Saudi Arabian population. A survey of 520 participants between 7 and 12 years old selected using a simple randomization method reported the need for orthodontic treatment in Hail city, Saudi Arabia. Malocclusion variables were recorded for each participant, and the Index of Orthodontic Treatment Need (IOTN) score was calculated. The results determined class 1 malocclusion to be most prevalent, followed by classes 2 and 3. Only 4.4% of participants with grade 1 and 2 malocclusion required orthodontic treatment. Anterior open, crossbite, and scissor bites were significantly related to grades 3 and 4 on the IOTN index [4]. In a scoping review, Al Hammad *et al.*, analyzed orthodontic malocclusion in Saudi Arabia. They found that Class 1 malocclusion was the most common type, with straight facial profiles being the most prevalent. Overbite and overjet norms and abnormalities varied, while crossbite and scissor bite had variable findings. Crowding and spacing were common, with severe or extreme treatment needs being the most prevalent category. Malocclusion showed heightened prevalence and effect on the Saudi population⁵. The World Health Organization (WHO) views malocclusion as a significant oral health problem, with a prevalence ranging from 39% to 93% in children and adolescents.

Numerous studies have investigated the ratio of tooth sizes in different racial, malocclusion, and gender groups [6-20]. However, the findings of these studies have been controversial, with some reporting significant differences between groups while others reporting non-significant differences. For instance, a study by Smith *et al.*, showed significant differences in the ratio of tooth sizes among black, Hispanic, and white populations [18]. Specifically, males had significantly more overall and anterior ratios than females. In contrast, Fernandes *et al.*, showed no insignificant gender and ethnic differences, except for the anterior ratio in Japanese patients [10]. Furthermore, studies examining the ratio in the malocclusion classes have also yielded mixed results. While some studies report statistically significant results toward larger anterior ratios in Class 3 malocclusion, others have found no significant differences [21- 24]. It is worth noting that the inconsistencies in these findings may be due to variations in the methodologies used in the studies, sample sizes, and population differences.

This study aimed to determine Bolton's anterior and overall ratios for a western region of Saudi Arabian male sample with different classes of malocclusion. The study was conducted to find differences in the Saudi population's western region compared to Bolton's original values.

Objectives of The Study:

- Determining Bolton overall ratios for a western region of Saudi Arabian male sample of different classes of malocclusion.
- Determining Bolton anterior ratios for a western region of Saudi Arabian male sample of different classes of malocclusion.

METHODS

This study involved 96 study model records of male patients obtained from the Orthodontic division of Preventive Dentistry, Faculty of Dentistry Taif University, Taif, Saudi Arabia. The study was carried out between June 2022 to December 2022. The good quality of the study models was thoroughly checked by ensuring all the details needed for the study were represented by the samples chosen. The following features checked the good quality of the samples: no mesiodistal and occlusal tooth abrasion, no proximal caries or proximal fillings, no crown and bridge restorations, and no supernumerary teeth or dental malformations.

The Inclusion Criteria Were as Follows:

- Study models were of good quality, with all the permanent teeth fully erupted except the third molars.
- No tooth abrasion and proximal caries.
- No restorations.

- No dental anomalies and supernumerary teeth.
- Only permanent dentition casts were used for the study.
- Records of dental study models from 2016-17 until 2021-22 were used for the study.

The Exclusion Criteria for the Study Were as Follows:

- Dental study models with fractured teeth.
- Dental study models from before 2017 and after 2022.

The age range of the participants was 12 to 25, with an average of 19.6 years. The study models were divided into three malocclusion groups, as shown below.

- Angle’s Class 1 [Male- 40]
- Angle’s Class 2 [Male- 36]
- Angle’s Class 3 [Male -20]

The study casts and instruments used measurements are depicted in the Figure 1. To measure the tooth size and calculate Bolton’s anterior and overall ratios, the study cast measurements were performed using the software program ORTHOASSISTANT at two different time intervals to avoid bias. The steps followed in the software are shown in Figure 2.

Figure Legends



Figure 1: The study casts photos of samples and materials used for measurements

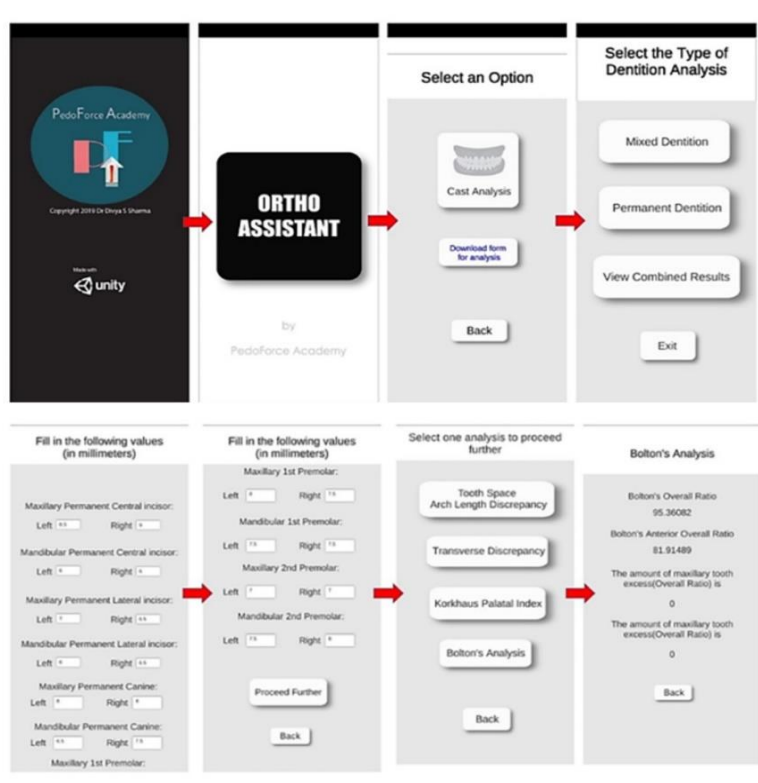


Figure 2: ORTHOASSISTANT App: Steps 1 to 8

Table 1: Bolton's overall and anterior ratios

Malocclusion Type [n= Samples] / Ratio	Class I [40n]	Class II [36n]	Class III [20n]	P Value*
Bolton's Overall Ratio	91.11± 3.35	92.75 ± 2.86	94.37 ± 1.12	0.6
Bolton's Anterior Ratio	77.02± 4.07	81.06± 3.41	84.22± 2.86	0.01

*P value was set at less than ≤ 0.05 .

Statistical Analysis

Using one-way ANOVA, the intergroup differences were analyzed. P-value ≤ 0.05 was considered statistically significant.

Ethics Approval

The research ethics committee of Taif University accredited by the National Committee for bioethics with no. HAO-02-T-105 considered the ethical proposal with no. 44-097 and granted ethical approval on 20-11-2022.

RESULTS

The overall ratio between all three types of malocclusions in this study for all samples was of no statistically significant value. No differences were observed in the overall ratio. However, the anterior ratio showed statistically significant differences with a p-value of less than 0.01 between class 2 and 3 malocclusions. This population study's overall and anterior ratios were higher than Bolton's.

DISCUSSION

The proper arrangement of the maxillary and mandibular teeth is crucial for functional and aesthetic purposes. Evaluating the relationship between the mesiodistal widths of these teeth is generally done using Bolton's ratios. These ratios were developed by Bolton in 1958 and included an overall index and an anterior index [1]. However, it should be noted that the applicability of Bolton's ratios may be limited, as they were originally derived from a specific group of subjects with excellent occlusion. Therefore, several studies have examined Bolton's ratios and have reported varying values depending on factors such as ethnicity, gender, and malocclusion. In the Saudi population, studies have been conducted to assess tooth size discrepancies and Bolton discrepancy's prevalence, but they have relied on Bolton's ratios derived from American patients.

Omar and colleagues conducted a study to evaluate the dental arch dimensions and arch forms and the occurrence of tooth size discrepancies in a cohort of 149 Saudi orthodontic patients. The study also aimed to determine the impact of gender on these parameters. The findings indicated that males had greater dental arch measurements compared to females. Moreover, the most common arch forms observed were narrow, tapered, and narrow ovoid. The prevalence of tooth size discrepancies was higher in the anterior teeth ratio than

in the overall ratio. However, no significant difference was found between males and females concerning tooth size discrepancies [25].

Wędrychowska-Szulc *et al.*, studied Bolton ratios in various malocclusions while comparing them to Bolton's standards. The sample size included 600 pre-treatment study casts obtained from 3088 patients. The findings showed significant differences in the overall mean ratio and mean anterior ratio between the study group and patients with Class 1 and 3 malocclusions compared to the original Bolton standard. Significant differences were observed in both males and females across all malocclusion groups, with the highest mean values for anterior ratio in males with Class 1 and Class 3 malocclusions [20]. In a different study, Togoo *et al.*, evaluated tooth sizes and identified gender differences in three ethnic groups from the southern region of Saudi Arabia. Their sample included 90 individuals (45 males and 45 females) with a mean age of 26.9 years. Except for the third molar, significant differences were observed in tooth size between the groups. Females and males had similar tooth sizes, except for the right first permanent premolars, which were larger in females. The study provided new and more comprehensive norms for tooth diameters in Saudi populations, with evidence of some trends toward sexual dimorphism [26]. Contrastingly, Alshahrani *et al.*, assessed tooth size discrepancies among individuals with different malocclusion classes and normal occlusion in the Southern Saudi population. Their findings indicated no significant differences between genders or among malocclusion and control subgroups. However, the malocclusion and control groups did not conform to Bolton's standards, suggesting tooth size discrepancies in the Southern Saudi population. They suggested that further research will determine the clinical implications of their results [27]. Such conflicting results call for more comprehensive studies of the Bolton ratios within the Saudi population.

The present study results indicate that while the overall incidence of malocclusions did not exhibit a significant difference, there was a notable distinction between class 2 and class 3 malocclusions regarding anterior ratio. Detecting such differences early can aid orthodontists in planning appropriate interventions, such as composite build-ups or mesiodistal stripping when required, and better-predicting outcomes of finishing orthodontic treatment. To address anterior Bolton discrepancies and achieve an optimal relationship of incisors, it may be necessary to modify

the inclinations of anterior teeth. The study found no statistically significant differences in the overall ratio of the three types of malocclusions. However, the anterior ratio significantly differed between class 2 and class 3 malocclusions, with a P value of less than 0.01. Notably, the overall and anterior ratios in the studied population were higher than the normal Bolton's ratios.

Limitations of the Study

The study lacks a sexual dimorphism assessment, as the samples retrieved were of male subjects. Hence, the study lacks a clear-cut conclusion on interpreting results on a female sample of this population region. There is a scope for future studies to involve the female sample and to improvise the study with 3D scanners for diagnosing malocclusions and treatment planning.

CONCLUSION

This study highlights the significance of appropriate alignment of the maxillary and mandibular teeth for functional and aesthetic purposes. While Bolton's ratios are commonly used to assess this relationship, they have limitations. Several studies have investigated Bolton's ratios and have reported varying values among different ethnic groups, populations, genders, and malocclusions. Multiple studies have examined the prevalence of Bolton discrepancy in the Saudi population. However, these studies have utilized Bolton's ratios based on American patients, which may not accurately represent the Saudi population. Therefore, further research is required to establish precise norms for tooth size ratios in the Saudi population. The results indicated that the anterior ratio demonstrated significant differences between class 2 and class 3 malocclusions, but no significant differences were observed in overall ratios.

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Conflicts of Interest

Authors declare no conflict of interest.

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