

# Prevalence of Bolton Discrepancy in Tripoli: Does the Tooth Size Discrepancy Play an Important Role in Malocclusion

Fathi Almadane<sup>1\*</sup> , Nadia Eddib<sup>2</sup> , Rana Almadane<sup>2</sup> 

<sup>1</sup>Department of Orthodontics, Faculty of Dentistry, University of Tripoli, Tripoli, Libya.

<sup>2</sup>Kalte Elfrgan Hospital, Tripoli, Libya

Corresponding Email. [areenfalmadane@gmail.com](mailto:areenfalmadane@gmail.com)

## Abstract

Discrepancies in tooth size should be known at the initial diagnosis and treatment planning stages if perfect results in orthodontic finishing are to be achieved. A high percentage of finishing phase difficulties arise because of tooth size imbalances. Tooth size discrepancies are considered an important variable, especially in the anterior segment. This study is designed to determine the prevalence of tooth size discrepancy (TSD) in a representative orthodontics population among gender differences and among different class of malocclusion according to angle classifications. As well as to evaluate the ability of simple visual inspection to the upper and lower laterals as well as upper and lower premolars teeth size as suggested by Proffit<sup>1</sup> to detect such a discrepancy. the sample Constance of 350 pre-treatment study casts with fully erupted and complete permanent dentitions from first molar to first molar, the random sample was classified into 100 study casts males and 250 study cast females. The sample was classified into 100 case Class I Angle, 150 Case class II Angle and 100 cases was Class III Angle malocclusions. The mesiodistal diameters of the teeth were measured at contact points using digital callipers and the Bolton's analysis was carried out on them. Simple visual estimation of Bolton discrepancy was also performed by Proffit's<sup>1</sup> Visual estimation of TSD. As the sample comprised 350 pre-treatment study casts with fully erupted and complete permanent dentitions from first molar to first molar. The males show more anterior ratio Bolton discrepancy 55% than females 46%, 48.5% of the patients had anterior tooth width ratios. Regarding to the different Angle classes of malocclusions, class III malocclusion shows higher overall Bolton ratio TSDs by 65%, followed by class I malocclusion 58% and 48% was in class II malocclusion. In the other hand, the anterior Bolton TSDs ratio was occurred in class III Angle malocclusion by 65 % while class II Angle malocclusion was 47% and class I Angle malocclusion was 33%. Bolton's analysis should be routinely performed in all orthodontic patients and the findings should be included in orthodontic treatment planning. 1.5-2 mm of the required tooth size correction is an appropriate threshold for clinical significance, when aware of possible discrepancies, the orthodontist will be able to anticipate prosthetic work such as composite buildups or mesiodistal reduction when required, sometimes changes in dental inclinations may be used as an orthodontic treatment strategy to resolve anterior Bolton discrepancies and achieve an ideal relationship of incisors. Proffit<sup>1</sup> Visual estimation of TSDs was done on the same casts and it was predictable and can be done routinely for each case. But Careful measurement is more frequently required in clinical practice than visual estimation would suggest.

**Keywords.** Tooth Size Discrepancy; Bolton Analysis; Bolton Ratio; Tooth Size Analysis.

Received: 24/03/25

Accepted: 21/05/25

Published: 31/05/25

**Copyright** © Khalij-Libya Journal (KJDMR) 2025. Open Access. Some rights reserved. This work is available under the CC BY-NC-SA 3.0 IGO license.

## Introduction

The orthodontic finishing phase is recognized for the many details necessary to accomplish an excellent result. A high percentage of finishing phase difficulties arise because of tooth size imbalances that could have been discovered and considered during the initial diagnosis and treatment planning. Discrepancies in tooth size should be known at the initial diagnosis and treatment planning stages if perfect results in orthodontic finishing are to be achieved. Tooth size discrepancies are considered an important variable, especially in the anterior segment.

A tooth-size discrepancy (TSD) is defined as a disproportion among the sizes of individual teeth [1]. The mesio-distal widths of teeth were first formally investigated by G.V. Black [2] in 1902. He measured a large number of human teeth and set up tables of mean dimensions, which are still used as references today. To achieve a good occlusion with the correct overbite and overjet, the maxillary and mandibular teeth must be proportional in size.

Many authors [3-6] studied tooth width in relation to occlusion following Black's investigation. The best-known study of tooth-size disharmony in relation to the treatment of malocclusion was by Bolton [7] in 1958. Bolton developed two ratios for estimating TSD by measuring the summed mesio-distal (MD) widths of the mandibular the maxillary anterior teeth. Bolton [7] who evaluated 55 cases with excellent occlusions and developed two ratios for estimating TSD by measuring the summed mesiodistal widths of the mandibular to the maxillary anterior teeth (anterior ratio  $77.2 \pm 1.65\%$ ) and the total width of all lower to

upper teeth from first molar to first molar (overall or total arch ratio  $91.3 \pm 1.91\%$ ). He concluded that it would be difficult for proper occlusal interdigitation or coordination of arches in the finishing stage of orthodontic treatment without a proper mesiodistal tooth size ratio between the maxillary and the mandibular teeth. Proffit [1] stated that TSDs less than 1.5 mm are rarely significant. He also suggested that a quick check for anterior TSD can be done by comparing the size of upper and lower lateral incisors. For posterior TSD, he recommends that a quick visual check be done by comparing the size of upper and lower second premolars, which should be of approximately equal size.

The dental literature has many studies comparing tooth size discrepancies and malocclusion in different ethnic groups. However, there is a lack of sex and Angle classification specificity in these studies, and additional data are necessary to understand this association. Most studies have been carried out on a mixture of treated and untreated subjects with good or excellent occlusion. However, especially for the comparison of intermaxillary tooth size relationships among different malocclusions, few studies are available, and the results have been controversial. The genetic effects are considered important for the determination of tooth dimensions, and the first reports were of clinical observations within families. Research on twins helped in understanding the genetic contribution of tooth size because a greater tooth size correlation was found in monozygotic twins [9-10].

Many studies have been carried out to determine the prevalence of TSD in various populations [11-15]. This is because orthodontists have realized the importance of this subject. McLaughlin, Trevisi, and Bennett [16] have suggested it be referred to as the seventh key of normal occlusion. However, the prevalence of TSD in the Tripoli (Libya) orthodontic population remains uncertain. The present study aimed to investigate the prevalence of TSDs in the orthodontic population in Tripoli, Libya, and to assess the usefulness of simple visual estimation of Proffit's TSDs for clinical use.

## Methods

The sample was selected randomly from records of the orthodontic patients who attended Almadane dental clinic in Caser Ben Gashier and the Libyan Academic Dental Centre in Tripoli/ Libya. It consisted of 350 pre-treatment study casts with fully erupted and complete permanent dentitions from first molar to first molar. The mesiodistal diameters of the teeth were measured at contact points using digital callipers, and Bolton's analysis was carried out on them. Simple visual estimation of Proffit's TSD discrepancy was also performed. The sample classified into 100 study casts was of males, and 250 were of females. The samples included a random selection of malocclusions: 100 cases were Class I Angle, 150 cases were Class II Angle, and 100 cases were Class III Angle malocclusions. All patients were aged between 16 and 26 years. Patients for this study were living in Tripoli, Libya, or the surrounding areas. The following inclusion criteria were used in the selection of the study models:

- All the permanent teeth were fully erupted and present, from the right first permanent molar to the left first permanent molar.
- Cases with any congenital abnormalities were excluded.
- No extraction or interproximal stripping was performed.
- Good quality study models.
- Gross restorations, build-ups, crowns, onlays, class II amalgams, or composite restorations that affect the tooth mesiodistal diameter are also excluded from the sample.

Each sample was measured twice by the two operators, and the average value was recorded. Only 10-15 models were measured each day to prevent any effects of fatigue. Measurement was made directly on the study models by using the electronic digital callipers with fine tips to improve access into the interproximal distance. The width of each tooth was measured from its mesial contact point to its distal contact point at its greatest height of contour, from the first molar to the first molar with the callipers held perpendicular to the long axis of each tooth. All the measurements of each tooth from the first molar to the first molar were then transferred to the data sheets. The total and anterior ratios were determined by Bolton's formula

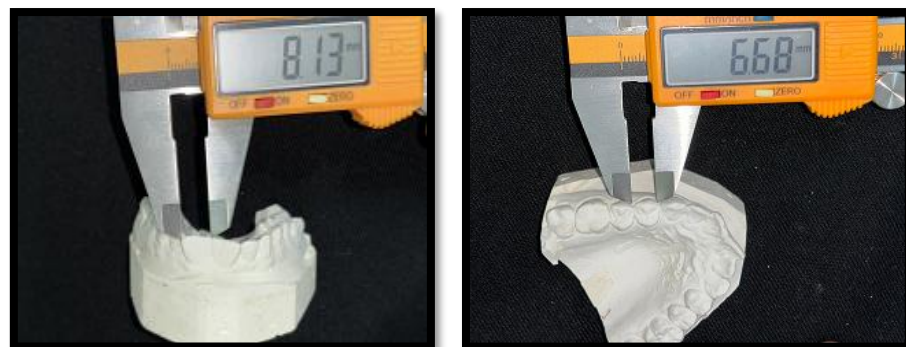
$$\text{Overall ratio} = \frac{\text{sum mand.12}}{\text{sum max.12}} \times 100 = 91.3 \pm 1.91\%$$

$$\text{Overall ratio} = \frac{\text{sum mand.6}}{\text{sum max.6}} \times 100 = 77.2 \pm 1.65\%$$

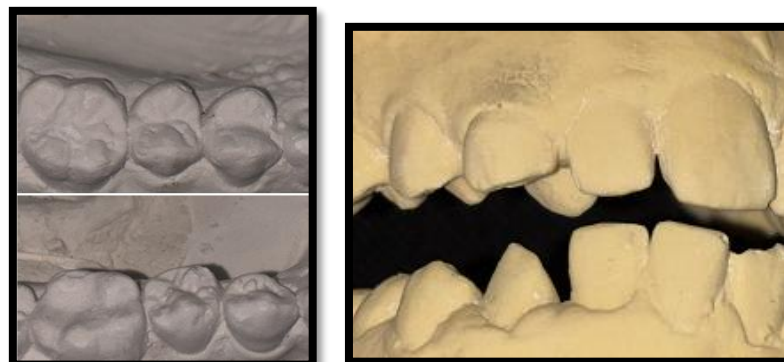
The overall sum of maxillary and mandibular teeth (6 to 6) and the sum of the anterior maxillary and mandibular teeth (3 to 3) were calculated using Microsoft excel program. , simple visual estimation of TSD was also carried out in accordance with Proffit's<sup>1</sup> suggestions in a blind manner away from the measurements.



**Figure 1. Digital calliper for measuring tooth width, Diagnostic models.**



**Figure 2. Example of mesio-distal width measurement of anterior and posterior teeth**



**Figure 3. Example of Profits Visual estimation of TSD between upper and lower lateral incisors, and between upper and lower 2<sup>nd</sup> premolars.**

## RESULTS

As the sample comprised 350 pre-treatment study casts with fully erupted and complete permanent dentitions from the first molar to the first molar. The males show a more anterior ratio Bolton discrepancy of 55% compared to 46%, and 48.5% of the patients had anterior tooth width ratios. Regarding to the different Angle classes of malocclusions, class III malocclusion shows higher overall Bolton ratio TSDs by 65%, followed by class I malocclusion, 58%, and 48% in class II malocclusion. On the other hand, the anterior Bolton TSDs ratio occurred in class III Angle malocclusion by 65 %, while class II Angle malocclusion was 47%, and class I Angle malocclusion was 33%. Proffit<sup>8</sup> Visual estimation of TSDs was done on the same casts, and it was predictable and can be done routinely for each case. But careful measurement is more frequently required in clinical practice than visual estimation would suggest.

**Table 1. Tooth Size Discrepancy Between Genders**

| Anterior ratio | Females | %   | Males | %   | Total | %     |
|----------------|---------|-----|-------|-----|-------|-------|
| Normal         | 135     | 54% | 45    | 45% | 180   | 51%   |
| TSDs           | 115     | 46% | 55    | 55% | 170   | 48.5% |
| Total          | 250     |     | 100   |     | 350   |       |

**Table 2. Anterior ratio Bolton Tooth Size Discrepancy When Angle Class II Was Compared with Either Angle Class I or Angle Class III.**

| Anterior ratio | Angle Class I n. | %   | Angle Class II n. | %    | Angle Class III n. | %    | Total n. | %     |
|----------------|------------------|-----|-------------------|------|--------------------|------|----------|-------|
| Normal         | 67               | 67% | 79                | 52 % | 35                 | 35 % | 211      | 60.2% |
| TSDs           | 33               | 33% | 71                | 47%  | 65                 | 65%  | 139      | 39.7% |
| Total          | 100              |     | 150               |      | 100                |      | 350      |       |

**Table 3. Overall total ratio Bolton Tooth Size Discrepancy When Angle Class II Was Compared with Either Angle Class I or Angle Class III.**

| Overall Bolton ratio | Angle Class I n. | %    | Angle Class II n. | %    | Angle Class III n. | %    | Total n. | %    |
|----------------------|------------------|------|-------------------|------|--------------------|------|----------|------|
| Normal               | 42               | 42 % | 78                | 52 % | 35                 | 35 % | 155      | 44 % |
| TSDs                 | 58               | 58 % | 72                | 48%  | 65                 | 65 % | 195      | 55 % |
| Total                | 100              |      | 150               |      | 100                |      | 350      |      |

## DISCUSSION

Various factors exist regarding tooth size variation, specifically environment and genetics, which include gender. Knowledge of tooth size discrepancies during diagnosis can allow the clinician to prepare for possible difficulties that may arise during the finishing phase. This includes coordinating treatment with a restorative dentist to possibly increase the dimension of tooth width. In this study, we demonstrated that 170 individuals (48.5%) of a total sample of 350 presented with anterior tooth size discrepancies greater than  $\pm 1$  SD using the Bolton analysis parameter. This percentage (48.5%) was considerably higher than that found by Richardson and Malhotra [17] (33.7%) and Bolton [18] (29%). There have been few studies relating these discrepancies to the Angle classification of malocclusion. This study was agreed with Lavelle [19] speculated that Class III individuals had disproportionally smaller maxillary teeth than Class I and Class II subjects did when maxillary and mandibular dentition sizes were compared, the results of the present study is consistent with the results of Crosby and Alexander [20] who also found no statistically significant differences when comparing Class I and Class II subjects. But disagree with them in the overall Bolton TSDs ratio, where the class III angle malocclusion shows 65% TSDs. Therefore, the Bolton discrepancy in the Class III sample must be attributed to the accumulation of minor discrepancies of individual teeth.

## CONCLUSION

Bolton's analysis should be routinely performed in all orthodontic patients and the findings should be included in orthodontic treatment planning. 1.5-2 mm of the required tooth size correction is an appropriate threshold for clinical significance, when aware of possible discrepancies, the orthodontist will be able to anticipate prosthetic work such as composite buildups or mesiodistal reduction when required, sometimes changes in dental inclinations may be used as an orthodontic treatment strategy to resolve anterior Bolton discrepancies and achieve an ideal relationship of incisors.

## References

1. Proffit WR. Contemporary orthodontics. 3rd ed. St. Louis: Mosby; 2000. p. 170.
2. Black GV. Descriptive anatomy of human teeth. 4th ed. Philadelphia: S.S. White; 1902.
3. Ballard ML. Asymmetry in tooth size: a factor in the etiology, diagnosis and treatment of malocclusion. Angle Orthod. 1944;14:67-71.
4. Neff CW. Tailored occlusion with the anterior coefficient. Am J Orthod. 1949;35:309-14.
5. Steadman SR. The relation of upper anterior teeth to lower anterior teeth as present on plaster models of a group of acceptable occlusions. Angle Orthod. 1952;22:91-7.
6. Lundstrom A. Intermaxillary tooth width ratio and tooth alignment and occlusion. Acta Odontol Scand. 1954;12:265-92.
7. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod. 1958;28:113-30.
8. Osborne RH, Horowitz SL, DeGeorge FV. Genetic variation in tooth dimensions: a twin study of permanent anterior teeth. Am J Hum Genet. 1959;30:350-6.
9. Horowitz SL, Osborne RH, DeGeorge FV. Hereditary factors in tooth dimensions: a study of anterior teeth of twins. Angle Orthod. 1958;28:87-93.
10. Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop. 1989;95:457-61.
11. Freeman JE, Maskeroni AJ, Lorton L. Frequency of Bolton tooth size discrepancies among orthodontic patients. Am J Orthod Dentofacial Orthop. 1996;110:24-7.



12. Santoro M, Ayoub ME, Pardi VA, Cangialosi TJ. Mesiodistal crown dimensions and tooth size discrepancy of the permanent dentition of Dominican Americans. *Angle Orthod.* 2000;70:303-7.
13. Bernabé E, Major PW, Flores-Mir C. Tooth-width ratio discrepancies in a sample of Peruvian adolescents. *Am J Orthod Dentofacial Orthop.* 2004;125:361-5.
14. Othman SA, Harradine NW. Tooth size discrepancies in an orthodontic population. *Angle Orthod.* 2007;77:668-74.
15. McLaughlin RP, Bennett JC, Trevisi HJ. *Systemized orthodontic treatment mechanics*. 2nd ed. St. Louis: Mosby; 2007. p. 285.
16. Richardson ER, Malhotra SK. Mesiodistal crown dimension of the permanent dentition of American Negroes. *Am J Orthod.* 1975;68:157-64.
17. Bolton WA. The clinical application of tooth-size analysis. *Am J Orthod.* 1962;48:504-29.
18. Lavelle CL. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. *Am J Orthod.* 1972;61:29-37.