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Relationship between Bolton Discrepancy, Arch Form and Basal Arch Length in Orthodontic Patients: A Cross Sectional Study in a Pakistani Sample

Um-e-Ayman[a], Yusra Shaukat[b], Mehwish Shaheed[c], Afeef Umar Zia[d], Kausar Ilyas[e]

Abstract

Introduction: Bolton tooth size discrepancy (TSD) is the disparity among the sizes of maxillary and mandibular individual teeth. TSD can lead to problems at finishing stage of Orthodontic treatment in terms of achievement of ideal occlusion. This study helped to explore the likely relationship between various arch forms and clinically significant tooth-size discrepancy and to compare the average basal arch length with that of the patients with significant Bolton tooth-size discrepancy in Pakistani population. This knowledge would be beneficial in Orthodontic treatment planning.

Material and Methods: A retrospective cross sectional study was carried out on archive records of Margalla Institute of Health Sciences. A total of 291 records with significant Bolton Discrepancy (TSD >2%) were screened. Sample size was calculated using Raosoft© Sample Size Calculator that came out to be 166. However 256 dental casts (144 males & 112 females) met our selection criteria and thus all were included. Basal arch length (BAL) and arch forms were also determined for each case. BAL was categorized into three groups; excessive, average and decreased. Arch forms were defined as squarish, tapering and ovoid.

Results: Statistically insignificant difference was found in the gender based comparison. However, there were statistically significant differences between the mandibular average arch length and increased arch length for Bolton's Overall Ratio (BOR) ($p = 0.01$). The prevalence of both (Bolton's Anterior Ratio) BAR and BOR was significant in tapered arch form ($p < 0.05$)

Conclusions: Bolton TSD is more prevalent in tapered arch form. Further studies are encouraged to find any racial/ ethnic differences. Average arch length and increased arch length groups have statistically significant BOR difference.

Key words: Arch length discrepancy, Bolton Discrepancy, Tapered arch form

Introduction

Bolton tooth size discrepancy (TSD) is the disparity among the sizes of maxillary and mandibular individual teeth.[1] Tooth size discrepancy is not an uncommon finding among Orthodontic patients, with the prevalence of TSD being 5-30% varying in different populations.[1]

An appropriate mandibulo-maxillary dental relationship is mandatory for achieving ideal occlusion.

Many authors [2-5] have attempted to study the normal mesio-distal tooth width in different ethnic groups for normal occlusion, but so far, the most widely accepted tooth size analysis was given by Wyne A. Bolton in 1958.[6] Bolton evaluated 55 cases with near to ideal occlusions by relating the summed widths of lower teeth to the summed widths of upper

[a] Corresponding Author: BDS, PGR, Ortho, MIHS, Rawalpindi. Email: rao.ayman@gmail.com
[b]BDS, PGR, Ortho, MIHS, Rawalpindi.
[c]BDS, Morth, Assistant Professor, MIHS, Rawalpindi.
[d]BDS, FCPS, MOrth, RCS Ed, FDS RCSED, FDTFED, HOD Orthodontics Department, MIHS, Rawalpindi.
[e]BDS, FCPS, CHPE, Associate Prof. MIHS, Rawalpindi

teeth and developed 2 ratios (anterior and overall) for estimating TSD. It is an important clinical evaluation method in treatment planning.

Stability has always been considered an important aspect of successful orthodontic treatment. Several authors have found that stability of results greatly depends on the conservation of patient's original arch form, especially inter-cuspid and intermolar distances.[7-10] Several classifications have been proposed for the categorization of arch forms, including the widely used classification of Chuck, who in 1932 classified arch forms as tapered, square and ovoid.[11] Arch form shows racial predisposition, with Jordanians have catenary arch form being most prevalent,[12] whereas, Saudi population has ovoid arch form as being the most prevalent.[13] However, the most prevalent arch form in Pakistani population is tapered, followed by ovoid and square variety.[14]

The relationship between malocclusion, gender and ethnicity with Bolton tooth size discrepancy have all been investigated thoroughly.[15,16] However, there's very scanty literature on the relation of arch form and basal arch length with Bolton tooth size discrepancy in orthodontic patients.[17] Khursheed M A et al,[17] found that BOR is dependent on arch length and thus has a statistically significant difference for average and increased arch length. However, sample size in their study was small n=53, which might have compromised reliability of their results, hence further studies are encouraged. This study aims to evaluate the co-relation (if any) between the arch form, basal arch length and Bolton tooth size discrepancy in Pakistani population. The objectives of the study were thus to enquire the likely relationship between various arch forms and clinically significant tooth-size discrepancy in Pakistani orthodontic patients and to compare the average basal arch length with that of the patients with significant Bolton tooth-size discrepancy.

Material & Methods

Written informed consent was obtained before acquiring the included participants' records. A retrospective cross sectional study was conducted on archive records of Margalla Institute of Health Sciences, MIHS dated from January, 2017 to January, 2023 after approval from Ethical Review Committee. A total of 291 records with significant Overall Bolton Tooth Size Discrepancy (BTSD >2%) were screened. Sample size was calculated using Raosoft© Sample Size Calculator that came out to be 166. However 256 records met our selection criteria and thus all were included.

Good-quality pre-treatment study casts of patients reporting to the Orthodontics Department of Margalla Institute of Health Sciences with fully erupted 1st molar to 1st molar in both arches for both genders, without caries, extensive restorations or severe crowding in any of the arches were included in the study.

Orthodontic casts having deciduous tooth/teeth, presence of any missing (except third molars) or supernumerary teeth etc., interproximal caries, restorations, tooth wear or previous history of orthodontic treatment were all excluded from the research.

Tooth size measurements (Mesio-Distal Dimensions MDD) were carried out on dental casts from 1st molar to 1st molar of opposite side in each arch through a digital vernier calliper at 0.01 mm reading accuracy (Fig 1) and were analysed for Bolton anterior ratio (BAR) and Bolton overall ratio (BOR).

$$BOR = \frac{\text{sum of the MDD from 36 to 46} \times 100}{\text{sum of the MDD from 16 to 26}}$$

$$BAR = \frac{\text{sum of the MDD from 33 to 43} \times 100}{\text{sum of the MDD from 13 to 23}}$$

This grouping had been done based on the data values of Mean ± 2 SD, > 2 SD and < 2 SD grouped in average, increased and decreased group, respectively

Tapered, ovoid and square arch form templates (3 M Unitek) were used to classify each case, based on the arch form that provide best fit to the eight clinical bracket points ranging from the mandibular right first premolar to left first premolar (Fig 2).

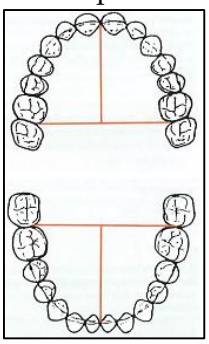

Fig.1 Arch length in both arches

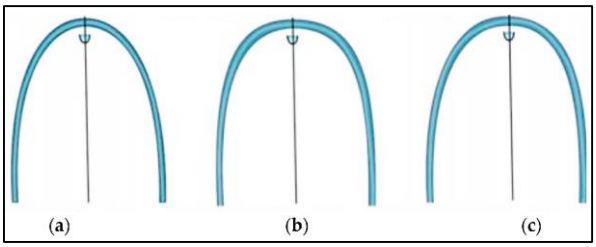

Fig.2 Tapered (a), square (b) and ovoid (c) arch form templates (3 M Unitek)

20 casts were re-assessed after two weeks of the initial measurement to calculate measurement error.

Collected data was than analysed through SPSS 20.0 with a probability level of 0.05 measured to be statistically significant. Student t-test was employed to assess Gender based and Arch form based difference in BAR and BOR while analysis of variance (ANOVA) was employed to assess arch length based difference between the BAR and BOR.

Results

Demographics for Gender based distribution and dental arches (arch length and arch form) have been shown in Table 1.

Statistically insignificant difference was found in the gender based comparison of all the measurements for the tooth size discrepancy.

BAR and BOR for both arches for different arch lengths have been explained in Table 2

Statistically significant differences have been found between the mandibular excessive arch length and average arch length in relation to BOR (p = 0.01). BAR and BOR for different arch forms have been explained in Table 3 Statistically significant differences was assessed between the tapered arch form in relation to BOR as well as BAR (p = 0.01).

		No. of subjects	Total
Gender	Male Female	198 158	256
Arch length	Excessive Average Decreased	52 98 106	256
Arch form	Ovoid Tapered Square	43 178 35	256

Table 1. Demographics: Gender and dental arches based

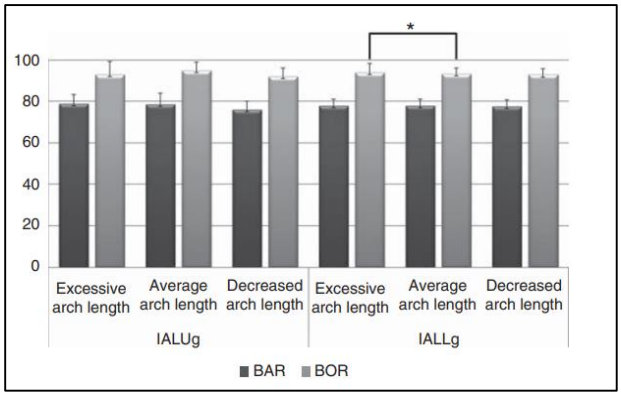

Table 2: Bolton Assessment in different arch length groups assessed through ANOVA at p<0.05

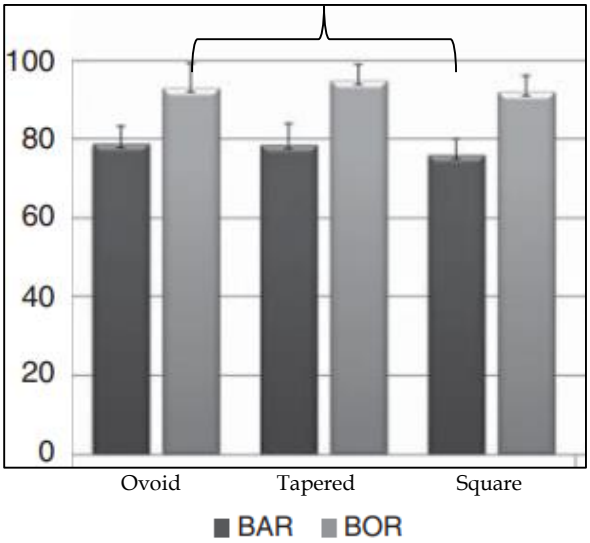

Table 3: Bolton Assessment in different arch form groups. * p < 0.05

Discussion

Bolton's tooth size discrepancy is a crucial factor in Orthodontics that influences treatment planning and outcomes. The difference in tooth sizes should be known to the Orthodontist.[17] Obtaining the optimum occlusion in substantial tooth size discrepancy cases is impossible. Understanding and addressing this discrepancy contribute to achieving a harmonious and functional occlusion for patients undergoing orthodontic treatment.

Even though there are various kinds of measurement tools available, digital vernier callipers were used for all of the measurements in this study. All the readings were taken directly from the study cast as the conventional plaster study models are regarded as a significant part of orthodontic records, and since their analysis are precise, dependable and repeatable.[18-20]

It's important to note that there can be natural variations in tooth size between genders, as well as among different ethnic and racial groups. These variations are not specifically related to Bolton's discrepancy but may be considered when evaluating overall dental characteristics. In our study, the female Bolton's ratios were greater than in males for BAR and BOR, however, no statistically significant difference was found. This finding was consistent with the previous studies.[21-23] A systematic review conducted by Machado et al[24] also confirms this relationship. Furthermore, our study revealed that both BOR and BAR are significantly more prevalent in tapered arch form. This finding is related to the study of Tajik I et al[14], which states that the order of prevalence of arch forms in a Pakistani population is tapered, followed by ovoid and square forms.

Orthodontic treatment planning involves addressing not only the tooth size discrepancy but also the associated arch length concerns. In cases where there is a deficiency in arch length due to smaller teeth, orthodontic treatment may involve measures to create additional space. This can include extraction of teeth, interproximal reduction (IPR), or expansion of the dental arch. Depending on the specific nature of the Bolton discrepancy and its impact on arch length, the orthodontist may choose to extract teeth to address excess space or expand the arch to address insufficient space. Al-Ansari et al[25] conducted a study on an Indian population demonstrating the affect of arch length and width on Bolton's ratio. Their study showed a significant relationship between arch length and Bolton's discrepancy which was similar to the results of our study.

Similar to any research, there are potential inherent limitations. The inability to obtain the desired sample size was one of the study's limitations. Despite this limitation, this study had the largest sample size compared to any other study of its type. The findings' broad application is further constrained by the study's geographic constraints and sampling of a single hospital.

Achieving proper arch length and tooth size balance is crucial for a harmonious and aesthetically pleasing smile. An imbalance can affect the overall facial aesthetics and patient satisfaction with the orthodontic treatment outcome.

Conclusion

Carefully evaluating the tooth size ratio for various arch length and arch form varieties during orthodontic treatment is necessary. There has to be more research on different populations about arch length and arch perimeter groups in connection to tooth size ratio. The following conclusions can be taken from our findings.

(1) The comparison of the sexes revealed no appreciable differences.
(2) Both BAR and BOR was more prevalent in tapered arch form.
(3) There was no discernible variation between arch width groups for BOR and BAR.
(4) In respect to BOR, statistically significant variations between the average arch

length and the mandibular excessive arch length was found.

Ethical Approval

The study was approved by the Institutional Ethical Review committee of Margalla Institute of Health Sciences, Rawalpindi (MIHS).

Disclaimer

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Conflict of Interest

No conflict of interest

Authors' Contribution

UA: Principal author/corresponding author
YS: Assisted in sample collection and article writing
MS: Supervisor
AUZ: Reviewer
KI: Reviewer

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