Comparison between Bolton analysis and Chu's simplified method for calculating anterior tooth size discrepancy

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Abstract

Objective: *The objective of present study is to compare the accuracy of Chu's simplified method for calculating anterior tooth size discrepancy with that of Bolton's method.*

Material and methods: *The study was performed on 58 dental casts of untreated orthodontic patients, which were to undergo fixed orthodontic treatment in department of Orthodontics, Rehman College of Dentistry, Peshawar, Pakistan*

Results: *Chu's method for determining anterior tooth size discrepancy show over-estimation as compared to Bolton's method, with an average difference of 2.33 ±1.3mm. Difference was highly significant statistically (p<0.001).*

Conclusion: *Chu's method cannot be an accurate clinical substitute of Bolton's method.*

Introduction:

Tooth size discrepancy (TSD) is defined as lack of proportion between the sizes of upper and lower teeth[1]. To accomplish perfect occlusal, inter digitations with ideal overjet and overbite, the sizes of the upper and the lower teeth must be proportionate.[2,3] Calculation of tooth size discrepancy have helped orthodontists to prepare complex case planning by emitting diagnostic setup with mathematical calculations. Many problems arise due to overseeing the need of calculating tooth size discrepancy at initial diagnosis and treatment planning stage. If upper anterior teeth are relatively bigger with respect to lower teeth, it will represent as increased overjet, deep overbite or anterior crowding. In case of mandibular excess, it will be represented as edge to edge bite, spaces in upper anterior segment, lower incisor crowding or improper occlusion of posterior teeth.[4-6]

Bolton in 1958 introduced a method to calculate relative tooth size discrepancy between upper and lower arches. In his study he determined mathematical ratios that can be established by adding mesiodistal width of upper and lower teeth from first molar to first molar for overall ratio and canine to canine for anterior ratio.[7]

In recent years alternative tooth size discrepancy calculations methods have been advocated due to the inherent weaknesses of Bolton analysis such as low reliability, and complex calculations. These new methods include Johnson/Bailey analysis and Chu's method which tried to reduce the complexity and increase the reproducibility of tooth size discrepancy. [8] While Johnson/Bailey analysis is designed for both anterior and overall tooth size discrepancy. Chu's method focuses solely on anterior tooth size discrepancy.[9] However Bolton's analysis is still considered the gold standard for calculations of tooth size discrepancy.

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Chu's method for determining anterior tooth size discrepancy uses a simplified process that does not need complex tables and calculation. Chu showed that there is correlation between the widths of the central incisors, lateral incisors, and canines. Dentists can quickly determine the optimal width of a missing or anomalous tooth using the correlations.[10]

Before using any new tooth size discrepancy calculations method it is imperative that it meets the current gold standards i:e Bolton's analysis.[11] To the best of our knowledge, Chu's simplified method for anterior tooth size discrepancy has not been compared with Bolton's method. Hence the aim of the study is to compare Bolton's and Chu's method for calculating anterior tooth size discrepancy. If significant difference between aforementioned methods doesn't exists, then anterior tooth size discrepancy can be found out at chair side, without going into complex mathematical calculations.

Materials and method:

Ethical approval was obtained from ethical committee Rehman College of dentistry. This study was performed on dental casts of untreated orthodontic patients that will undergo fixed orthodontic treatment. 58 dental Casts were randomly selected from records of department of Orthodontics, Rehman College of Dentistry, Peshawar, Pakistan. The inclusion criteria were complete permanent dentition from permanent canine to canine in both the arches. Dental casts with morphological defects such as peg laterals, fractured crowns and severe attrition were excluded.

The mesiodistal width of six maxillary and mandibular anterior teeth was used to calculate the anterior tooth size discrepancy using two different methods. The anterior tooth size discrepancy ratio was calculated according to the formula used in Bolton's analysis:

$$\frac{Sum\ of\ 6\ lower\ teeth}{Sum\ of\ 6\ upper\ teeth} x100 = Anterior\ Ratio$$

Based on the resultant ratio tooth size discrepancy in millimeters was calculated.

For Chu's analysis, we used the mesiodistal width of mandibular central incisor as the standard. The ideal mesiodistal width of the rest of the anterior teeth were calculated according to Chu's method which is shown in figure 1.
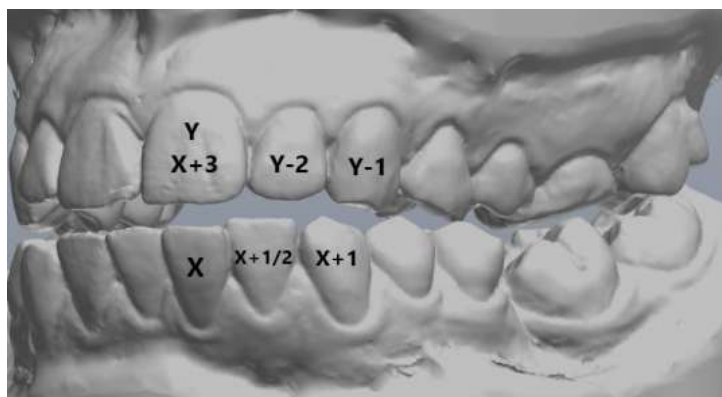
Fig 1. Mathematical association among proportionally esthetic upper and lower anterior teeth.

After calculating anterior tooth size discrepancy with each method, we compared the discrepancies for any significant differences

All the measurements are done with one set of ruler and divider and are performed by single examiner. For inter and intra examiner reliability mesiodistal widths of anterior teeth of ten dental casts were calculated again after a month of initial calculations by the same examiner (SS) and another colleague (JS).

All the statistical analyses were performed with SPSS version 25.0(IBM Inc). Shapiro-wilk normality tests showed that data was normal. Comparisons between the Bolton's and Chu's method were performed with paired T test. P value of 0.05 or less were considered significant. Reliability was tested with Pearson correlation coefficient. R value of 0.90 or higher was considered as excellent agreement between the observations.

RESULTS:

A total of 58 dental casts were analyzed using both methods. Sample consisted of 37 males and 21 females. Mean mesiodistal widths of individual anterior teeth are given in table 1.

The central tendency of Bolton's method and Chu's simplified method is given in the box plot Figure 2 and Figure 3 respectively. The Chu's simplified method for calculating tooth size discrepancy ranged from 77 to 82.5mm with a mean of 80.1mm±1.1mm.

Each subject varied positively and negatively with as much as a 1.2% difference between individual patients for anterior ratio. (Table 2)

The maximum difference of tooth size discrepancy between two methods varied 2.33mm. Statistical analysis showed a high significance ($p < 0.001$) when comparing the two different methods. (Table 3)

45% of the cases showed clinically significant tooth size discrepancy (>2mm) when calculated via Chu's method while only 32% of the cases showed clinically significant tooth size discrepancy when calculated via Bolton's method.

Excellent inter and intra reliability was observed (R value > 0.8)

Table 1: Mean Mesiodistal width of individual anterior teeth (mm)

	Maxillary teeth	**MD width (mm)**	**Mandibular teeth**	**MD width (mm)**
Left	Central Incisor	8.7	Central incisor	5.5
	Lateral Incisor	6.9	Lateral incisor	6
	Canine	7.7	Canine	6.8
Right	Central Incisor	8.7	Central incisor	5.5
	Lateral Incisor	7	Lateral incisor	6
	Canine	7.7	Canine	6.8

Table 2: Means and standard deviations of anterior tooth ratios obtained via Bolton's method and Chu's simplified method.

	N	Mean (%)	S.D	Correlation
Bolton's method	58	78.8	2.7	0.4*
Chu's simplified method	58	80	1.1	

*Highly Significant

Table 3: Means and standard deviations of anterior tooth size discrepancy obtained via Bolton's method and Chu's simplified method.

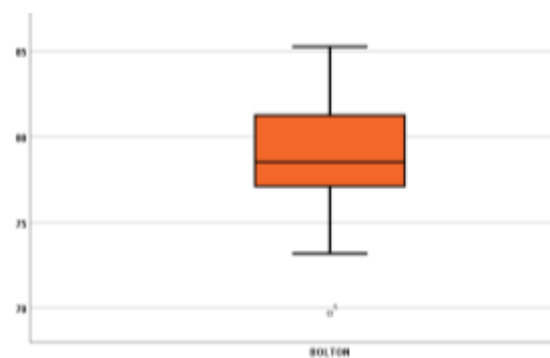|	N	Mean(mm)	S.D	Correlation
Bolton's Method	58	1.4	1.8	0.7*
Chu's Simplified Method	58	-0.9	1.7	

*Highly significant

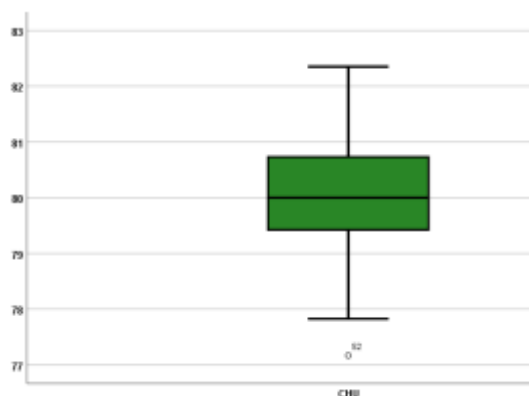

Fig 2 Central Tendency Of Bolton Method

Fig 3 Central Tendency Of Chu's Method

Discussion:

In this study tooth size discrepancy measurements calculated with Chu's simplified method and Bolton's method were compared. Chu's method can be calculated in a very short time and can give almost instant ideal values of the anterior dentition. The simplified method of Chu's is an attractive alternate to the complex calculations required in Bolton's tooth size discrepancy estimation. However, the simplicity of the method should not compromise the accuracy of tooth size discrepancy estimation with either method. [9-10]

In our study, Chu's method for determining anterior tooth size discrepancy showed over estimation of 1.2% as compared to Bolton's method. Results are highly significant and show weak positive correlation between Chu's simplified method and Bolton's method when measuring anterior tooth ratio. However moderate correlation between Chu's and Bolton method was observed when measuring tooth size discrepancy. This shows that in terms of anterior tooth size discrepancy Chu's method cannot be an accurate substitute of Bolton's method.

Chu et al while proposing this simple method of completing tooth size discrepancy noted that it overestimated the anterior tooth size discrepancy calculated with Bolton's analysis. This is in agreement with our findings. However according to them the inherent reliability issues in measuring the mesiodistal width of individual teeth may make their simplified method clinically acceptable. They also noted that achieving a specific Bolton ratio is not always clinically necessary to achieve an esthetic and functionally sound occlusion. [9-10]

The exact amount of clinically acceptable tooth size discrepancy varies from clinician to clinician[12, 13] however it is generally agreed that tooth size discrepancy of more than 2mm has clinical implications. In our study Chu's method showed, on average, about 10% more cases that required clinical management of tooth size discrepancy. This means that Chu's method overestimated the number of patients with clinically significant tooth size discrepancy.

Certain limitations of the study are less number of casts, overall Bolton ratio is not calculated, and ethnicity and regional difference as casts of one population is used.

Conclusion:

1. Chu's method for determining anterior tooth size discrepancy show over estimation as compared to Bolton's method.

2. Chu's method cannot be an accurate substitute of Bolton's method.

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