

## Overall Bolton Ratio in Different Malocclusion Groups attending in Bangabandhu Sheikh Mujib Medical University

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### Abstract

**Background:** Tooth-size discrepancy is the most common cause of malocclusion next to skeletal and soft tissue problem. Bolton ratio analysis is one of the most widely practiced methods of calculating tooth size discrepancy. If any malocclusion occurs due to tooth size discrepancy proper interdization with normal overjet and overbite cannot be achieved by orthodontic treatment.

**Objectives:** This study was carried out to evaluate the overall Bolton ratio in different malocclusion groups attending in Bangabandhu Sheikh Mujib Medical University and its utilization for the proper treatment planning and retention protocol.

**Materials and Methods:** This cross-sectional study was conducted in the Department of Orthodontics, BSMMU, Dhaka during the period of February, 2014 to July, 2015. In this cross sectional study, a total 150 pretreatment study casts of patients attending in the Department of Orthodontics, BSMMU were included as a sample with an age range of 14 to 26 years. Among the total sample, 80 were from Angle's class I malocclusion group, 55 from class II group and 15 from class III group. The mesiodistal width of each tooth from permanent first molar of one side to the first molar of other side in the same arch of both jaw were measured by digital vernier caliper. The collected data were evaluated by the unpaired t-test and one way ANOVA test.

**Results:** There were no significant differences of overall Bolton ratio observed among the malocclusion groups. Overall tooth size discrepancies outside 2 standard deviation were found more than most other studies done previously. No sexual dimorphism was observed.

**Conclusion:** The high percentage of the tooth size discrepancy will increase awareness among the orthodontists to consider the Bolton analysis prior to treatment initiation.

**Key words:** Bolton, Malocclusion, Tooth size discrepancy.

### Introduction

Tooth size abnormality is a common cause of malocclusion. Bolton analysis is one of the most widely practiced methods for detecting tooth size abnormality.<sup>1,2,3</sup> It is very important in diagnosis and treatment planning. The overall Bolton ratio is the percentage determined by summing the widths of the 12 mandibular teeth divided by the sum of the widths of the 12 maxillary teeth and should be 91.3±0.26 percent. Anterior ratio is the percentage obtained by summing the widths of the 6 mandibular anterior teeth divided by the sum of the widths of 6 maxillary anterior teeth and should be 77.2±0.22 percent.<sup>4</sup> If any discrepancy persists in the Bolton ratio, achieving final occlusion with proper interdization, overbite and overjet would be very difficult. Bolton stated that these ratios should be the tools used in orthodontic diagnosis and that will allow orthodontists to gain insights into the functional and aesthetic outcome without the use of diagnostic setup.<sup>4,5</sup> There are many studies comparing tooth size discrepancies and malocclusion. According to these studies reported 20 to 30% of people with significant tooth-size anterior discrepancies and 5-18% for overall discrepancies.<sup>6</sup> For the total arch analysis, Sharma et al observed that correction greater than 2mm was required 36% of patients in the upper arch or 32% in the lower arch.<sup>7</sup> Although Bolton analysis has proven extremely useful in clinical setting

to act as a guide for extreme tooth size discrepancies (TSD), its application has some limitations. First Bolton's estimates of variation were underestimated because the samples were derived from perfect class I occlusions.<sup>8,9</sup> Second, the population and gender composition of Bolton's sample were not specified, which implies potential selection bias.<sup>9</sup> Bolton data has not met the same TSD ratios mean for some of other populations and marked statistical differences were found in studies carried out by other authors as in the Peruvian population<sup>10</sup> Turkish population,<sup>11</sup> Spanish population<sup>12</sup> and Polish population.<sup>13</sup> A study showed that both overall and anterior ratios were greater in Blacks than in Caucasians with those in Asians being intermediate, and that the overall ratio was consistently greater in men than in women regardless of racial origin.<sup>14</sup> Other study found that the overall ratio was significantly larger in men than in women.<sup>9</sup> Another study found significant differences in the Bolton ratio among several occlusal categories.<sup>15</sup> The study was performed in 360 Chinese subjects and the data were analyzed according to Angle classifications class I, II and III as well as according to skeletal type. In contrast their anterior ratio was similar to Bolton's value, suggesting that Blacks differ markedly in the posterior arch segment relationship. So overall Bolton ratio analysis could be paramount for some race or ethnic groups to find out their population specific standards. Although numerous studies have been performed on Bolton ratios, very few studies on Bolton anterior ratio have been done in Bangladesh but study on Bolton overall ratio has not been done.<sup>16,17</sup> The present study will investigate the overall Bolton ratio in different malocclusion groups of Bangladeshi patients attending for orthodontic treatment and to compare between and among them. Objective of the study was to assess the overall Bolton

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ratio in different malocclusion groups attending in Bangabandhu Sheikh Mujib Medical University.

### Materials and Methods

This cross-sectional study was conducted in the Department of Orthodontics, BSMMU, Dhaka during the period of February, 2014 to July, 2015. In this cross sectional study, a total 150 pretreatment study casts of patients attended in the Department of Orthodontics, BSMMU were included as t sample with an age range of 14 to 26 years. Among the total sample, 80 were from Angle's class I malocclusion group. 55 from class II group and 15 from class III group. The mesiodistal width of each tooth from permanent first molar of one side to the first molar of other side in the same arch of both jaws were measured by digital vernier caliper. Inclusion Criteria were Pre-treatment study casts of patients aged between 14 and 26 years, study casts of permanent dentitions having all incisors, canines, premolars and first molars in occlusion, all the available diagnostic records of each cast. Exclusion Criteria were Distorted study models, gross restorations, build-ups, crowns, onlays or class II amalgam restorations, composite restorations that affect the mesiodistal diameter of tooth and congenitally missing, impacted and grossly carious teeth. The collected data were evaluated by the unpaired t-test and one way ANOVA test.

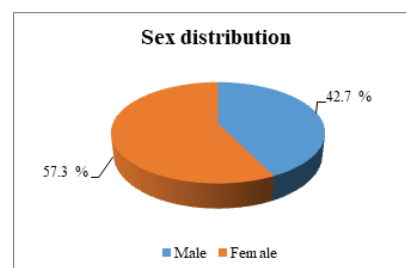
### Results

After an initial screening and with fulfilling the inclusion criteria, the sample size of 150 (64 males, 86 females) were selected to take part in the study. Descriptive statistical analysis was carried out which included calculation of mean values standard deviation and ranges. There were 80 (36 males, 44 females) class I patients, 55 (23 males, 32 females) class II patients and 15 (5 males, 10 females) class III patients among the total sample. There were no statistically significant differences in overall Bolton ratios among the different malocclusion groups. Table 4 summarizes the means, standard deviations and statistical comparisons of Bolton overall ratios observed in each group. It showed that there were no statistically significant differences of overall Bolton ratio among the three classes of malocclusion. Since there were no significant differences between the groups of malocclusion, all the casts were combined and then separated into males and females. Unpaired t-test was performed to check for sexual dimorphism. Again, there were no statistically significant differences in between males and females. But comparatively a high percentage (14.7%) of tooth size discrepancies above 2 standard deviation was found (Table 7). Table-1 shows the age distribution of the patients, among 150 patients, male and female in class I malocclusion group, mean age was 16.75±2.83 and 17.47±3.08 respectively. In malocclusion group class II mean age to male and female patients were 16.78±3.34 and 16.3±2.24 and n malocclusion group class III the mean age of male and female were 20.0±4.60 and

17.40±3.74 years respectively. Pie diagram showing, among the total sample, 42.7% were male and 57.3% were female with a ratio of male and female 1:1.34 indicating female predominance in the study population. Table 2 shows the malocclusion of the study population, maximum 80(53.3%) patients were in class I malocclusion group, I malocclusion group, 55(36.7%) were in class II and 15 (10%) were in class III malocclusion group which indicates predominance of class I patients among the study population. Among the total sample 42.7% were male and 57.3% were female. Among the malocclusion groups, mean age of male and female patients was almost similar (16.38 to 17.47 years) except class III malocclusion group, in which mean age of male and female patients were 20.8 years and 17.4 years respectively. Among the total sample, the mean age was 17.06±3.06 years. Comparatively young patient group were chosen to avoid alteration of mesiodistal width. Table 3 shows the unpaired 't' test on overall Bolton ratio between malocclusion groups with Bolton's standard. The mean difference of overall Bolton ratio was not statistically significant between malocclusion group and Bolton standard ( $p > 0.05$ ). Table 4 shows that ANOVA test of overall Bolton ratio among the different malocclusion groups and unpaired 't' test between two groups were performed. The mean differences of overall Bolton ratio between groups and among were not statistically significant ( $p > 0.05$ ). Table 6 shows the comparison of Bolton ratio between male and female patients. In male patients, the mean overall Bolton ratios were 90.92±4.76, 91.46±2.58 and 92.91±2.65 in malocclusion class I, class II and class III respectively. In female patients, the mean overall Bolton ratios were 91.62±2.44, 90.77±2.85 and 91.49±1.88 in malocclusion class I, class II and class III respectively. There was no significant difference between male and female patients among the different malocclusion groups. Table 7 summarizes the percentage of overall Bolton discrepancy above 2 standards deviation. In individual malocclusion group, the highest discrepancy was observed in class III malocclusion group among male patients which was 40%. In the total sample, 14.7% patients have overall tooth size discrepancies exceeding 2 standards deviation.

**Table I: Age distribution of the patients (n=150)**

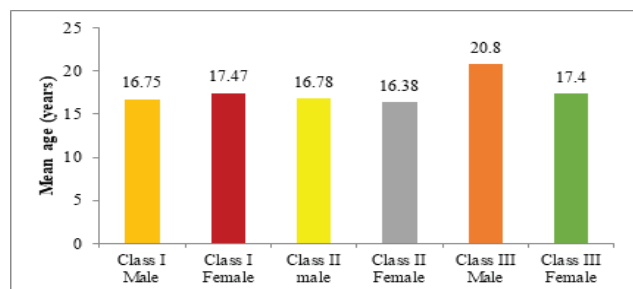
Malocclusion	Sample size		Range (years)		Mean±SD	
	Male	Female	Male	Female	Male	Female
Class I	36	44	14-26	14-24	16.75±2.83	17.47±3.08
Class II	23	32	14-24	14-22	16.78±3.34	16.3±2.24
Class III	5	10	16-26	14-24	20.0±4.60	17.40±3.74
Total	150		14-26		17.06±3.06	



**Figure 1:** Sex distribution among the total sample (n=150).

**Table II:** Distribution of sex among the malocclusion (n=150)

Malocclusion group	Male No. (%)	Female No. (%)	Total No. (%)
Class I	36(56.3)	44(51.2)	80(53.3)
Class II	23(35.9)	32(37.2)	55(36.7)
Class III	5(7.8)	10(11.6)	15(10.0)
Total	64(42.7)	86(57.3)	150(100.0)



**Fig. 2:** Bar diagram showing mean age in different malocclusion groups (n=150)

**Table III:** Comparison of overall Bolton ratio between malocclusion groups with Bolton’s standard by unpaired

		Sample size	Mean	Range	SD	Coefficient of variation (%)	p value
Male	Class I	36	90.92	69.85-98.70	4.76	5.24	0.596
	Class II	23	91.46	86.02-95.88	2.58	2.82	0.763
	Class III	10	92.91	89.92-95.90	2.65	2.85	0.0886
Female	Class I	44	91.63	86.02-96.21	2.44	2.66	0.452
	Class II	32	90.77	84.69-95.73	2.85	3.14	0.303
	Class III	5	91.49	88.73-94.09	1.88	2.05	0.773
Total		150	91.38	69.85-98.70	3.68	4.03	0.878

**Table IV:** Analysis of Variance (ANOVA) and unpaired ‘t’ test between and among the different malocclusion

	Class I Mean±SD (n=80)	Class II Mean±SD (n=55)	Class III Mean±SD (n=15)
Overall ratio	91.50±4.40	91.06±2.74	91.96±2.18
Mean of overall ratio	91.38±3.68 (n=150)		
Statistical analysis			
Group			p value
Class I vs Class II vs Class III			0.644
Class I vs Class II			0.491
Class I vs Class III			0.66
Class II vs Class III			0.402

**Table V:** Statistics comparing overall ratio among Bolton and Stifter studies and the present study (all patients included)

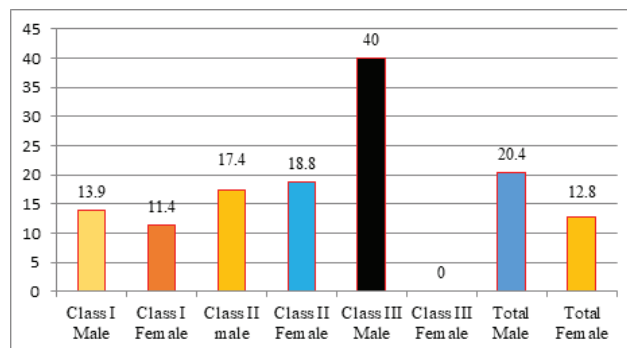
	Bolton Study (n=55)	Stifter Study (n=51)	Present Study (n=150)
Mean	91.3	91	91.4
SD	1.91	1.9	3.68
Range	87.5-95.8	87.2-94.6	69.85-98.70

**Table VI:** Comparison of the Bolton overall ratio between the male and female patients (n=150)

Malocclusion group	Male Mean±SD	Female Mean±SD	p value
Class I	90.92±4.76	91.62±2.44	0.393
Class II	91.46±2.58	90.77±2.85	0.363
Class III	92.91±2.65	91.49±1.88	0.247
Total	91.51±4.81	91.29±2.56	0.717

**Table VII:** The frequency of Bolton overall tooth-size discrepancies exceeding 2 standard deviations.

Malocclusion group	Sample size	Frequency of overall ratio discrepancy		
		No. of patients having discrepancy	Percentage	
Male	Class I	36	5	13.90%
	Class II	23	4	17.40%
	Class III	5	2	40.00%
Female	Class I	44	5	11.40%
	Class II	32	6	18.80%
	Class III	10	0	0.00%
Total	150	22	14.70%	



**Figure III:** Bar diagram showing overall discrepancy distribution in malocclusion groups

**Discussion**

Bolton ratio can be act as an effective tool to address tooth size abnormality for achieving the finishing excellence in orthodontics. In the present study Bolton's overall ratio in the three classes of malocclusion was studied. The results of this study showed no statistically significant differences among the malocclusion groups ( $p > 0.05$ ). This finding was in agreement with previous studies done by other researchers.<sup>15,18,19</sup> But a single study disagreed with this present study in respect that class III malocclusion group had disproportionately smaller maxillary teeth than class I and class II group did when maxillary and mandibular teeth sizes were compared some study also reported similar findings as Lavelle.<sup>13,14,15,20</sup> In the present study, the mean overall ratio for class I malocclusion group was found 91.50 with a standard deviation of 4.40 and for class II and class III, it was 91.06 and 91.96 with a standard deviation of 2.74 and 2.18 respectively. In the class I malocclusion group had the highest standard deviation and ranges which are larger than expected and similar findings were reported by others study.<sup>18</sup> Sulaiman and Afifyet al but in disagreement with other studies Uysal and Sari, Wedrychowska-Szulc et al.<sup>11,13,19</sup> The mean overall ratios of the current study in the total sample and in individual malocclusion groups were identical to the Bolton and Stifter studies but the present findings showed a larger dispersion from high to low within each group (higher standard deviations and ranges) compared with the Bolton and Stifter findings. This variation might be derived from the characteristics of the selected

samples. Bolton's samples (55) were selected from patients having ideal occlusion, 11 of those patients were untreated. In the present study, the sample size was 150 and all the patients were created orthodontically. Since a larger percentage (100 %) of the sample had malocclusion severe enough to have treatment, it is very likely that this contributed the larger percentage of tooth size discrepancies observed in the current study. Although the current study did not demonstrate a difference in the overall Bolton ratios among the malocclusion groups, it pointed out a number of patients (14.7%) in each malocclusion group having ratios greater than 2 standard deviation from the Bolton's standard (Table 7) and it is established that Bolton discrepancies outside 2 standard deviation need clinical intervention like proximal stripping or prosthetic build-ups. In this study, ratios more than 2 standard deviation from Bolton's mean were defined as values indicating significant tooth size discrepancies as other investigators.<sup>10, 11,12,21</sup> A significant discrepancies in the overall ratio above 2 standard deviation was found in 14.7% of patients of the Bangladeshi population which was more frequent than the other populations studied by Paredes et al. (5 %), Bernabe et al. (5 %), Wedrychowska-Szulc et al. (10.2 %), Santoro et al. (11%), Freeman et al. (13.4%) and less frequent than Uysal and Sari (15.4%). The current study demonstrated that there were no gender differences in overall Bolton ratio among the malocclusion groups and this finding is in agreement with other investigators (Crossby and Alexander, Nie and Lin, Nourallah et al. Sulaimani and Afify, and in a disagreement with Lavelle and Bernabe et al. The current study showed a high percentage of patients had overall tooth size discrepancies at pre-treatment analysis among the three malocclusion groups when compared with the established ratios of Bolton. The reason for this is that the samples of Bolton were derived from ideal occlusion, but all of our selected samples had malocclusion. From this point of view, it could be suggested that tooth size discrepancy may be a cause of malocclusion. If these discrepancies are addressed properly at the commencement of treatment achieving finishing excellence would be easier.

#### Limitations of the study

The study groups were selected from the records of the Department of Orthodontics, Bangabandhu Sheikh Mujib Medical University, BSMMU. So, the findings that obtained from a specific regional area may not be representative of the whole nation. The larger sample will allow the findings to be more representative of the whole nation. Bolton anterior ratio was not included in the present study.

#### Conclusion

It can be concluded that the overall Bolton ratio found in the present study did not differ from that of Bolton's value. The higher percentage of tooth-size discrepancies observed in this study should alert our orthodontists to consider Bolton analysis prior to treatment initiation.

#### Recommendations

Based on the findings from this study, recommendation is put forward for future researcher to do additional in-depth research consisting of larger sample group for greater acceptability of the study. Bolton anterior ratio is needed to be included for widening the range of the study. Skeletal classification can be included for selection of the sample for greater acceptance of the study.

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#### Conflict of Interest: None

**Ethical Approval:** The study Institutional Review Board of Bangabandhu Sheikh Mujib Medical University approved.

#### References

1. Pizzol KE, Gonçalves JR, Santos-Pinto AD, Peixoto AP. Bolton analysis: an alternative proposal for simplification of its use. *Dental Press Journal of Orthodontics*. 2011;16:69-77.
2. Cancado RH, GONÇALVES W, Valarelli FP, FREITAS KM, Crêspo JA. Association between Bolton discrepancy and Angle malocclusions. *Brazilian oral research*. 2015 Oct 20;29:1-6.
3. Muqbil I. Analysis of Bolton's tooth size discrepancy for a referred UK population (Doctoral dissertation, University of Birmingham).
4. Bolton WA, 1958, Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthodontist*, vol 28, pp112-130.
5. Bolton WA. 1962, The clinical application of a tooth-size analysis'. *American Journal of Orthodontics*, vol 48, pp 504-529.
6. Othman SA, Harradine NWT. 2006, "Tooth size discrepancies and Bolton's ratios: A literature review. *Journal of Orthodontics*. vol 33, pp 45-51.
7. Sharma R, Kumar S, Singla A 2011. Prevalence of tooth size discrepancy among North Indian orthodontic patients. *Contemporary Clinical Dentistry*, vol 2, no.3 pp 170-175.
8. Freeman JE, Maskeroni AJ, Lorton L, 1996, Frequency of Bolton tooth-size discrepancies among orthodontic patients. *American Journal of Orthodontics and Dentofacial orthopedics'* vol 10, pp 24-27.
9. Smith SS, Buschang PH, Watanabe E 2000, Interarch tooth size relationship of three populations: 'does Bolton's analysis apply? *American Journal of Orthodontics and Dentofacial Orthopedics*, vol 17, pp 169-174.
10. Bernabe E, Major PW, Flores-Mir C. 2004 Tooth-width ratio discrepancies in a sample of Peruvian adolescents'. *American Journal of orthodontics and Dentofacial Orthopedics* vol 125, pp361-365.
11. Uysal T, Sari Z, 2005, "Intermaxillary tooth size discrepancy and mesiodistal crown dimensions for a Turkish population. *American Journal of Orthodontics and Dentofacial Orthopedics*, vol 128, pp 226-230.
12. Paredes V, Gandia JL, Cibrian R, 2006, 'Do Bolton's ratios apply to a Spanish population? *American Journal of Orthodontics and Dentofacial Orthopedics*. vol. 129, pp 428-430.
13. Wedrychowska-Szulc B, Janiszewska-Olszowska J, Stepień P. 2010, 'Overall and anterior Bolton ratio in Class I, II and III orthodontic patients'. *European Journal of Orthodontics*, vol 32, no. 3. pp 313-318.
14. Lavelle CLB, 1972, Maxillary and mandibular tooth size in different

racial groups and in different occlusal categories'. *American Journal of Orthodontics*, vol 61, pp29-37.

15. Nie Q, Lin J, 199, Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. *American Journal of Orthodontics and Dentofacial Orthopedics*, vol 16 pp 539-544.

16. Ali MW, 2008, "A study on Bolton anterior tooth size discrepancies among different malocclusion groups. A dissertation work carried out in the Department of Orthodontics and Dentofacial Orthopedics, Dhaka Dental College and Hospital, Mirpur, Dhaka.

17. Hasan MN, 2010, 'Anterior tooth discrepancies among different malocclusion groups in the Department of Orthodontics. A dissertation work carried out in the Department of Orthodontics, Bangabandhu Sheikh Mujib Medical University, BSMMU, Dhaka.

18. Crosby DR, Alexander CG, 1989. "The occurrence of tooth size discrepancies among different malocclusion groups. *American Journal of Orthodontics and Dentofacial Orthopedics*. Vol 95, pp 457-461.

19. Sulaimani FHA, Afify AR, 2006, 'Bolton analysis in different classes of malocclusion in a Saudi Arabian sample'. *Egyptian Dental Journal*, vol 52, pp 1119-1125.

20. Araujo E, Souki M. 2003, 'Bolton anterior tooth size discrepancies among different malocclusion groups. *Angle Orthodontist*, vol. 73, pp 307-313.

21. Santoro M. Ayoub ME, Pardi VA, Cangialosi TJ, 2000, Mesiodistal crown dimensions and tooth size discrepancy of the permanent dentition of Dominican Americans'. *Angle Orthodontist*, vol 70, pp 303-307.

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