Effect of premolar extraction on Bolton overall ratio in north Indian population

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Abstract

Introduction: Bolton ratio is considered as seventh key of normal occlusion. Many orthodontic patients have to undergo premolar extractions as a part of treatment. **Aims and objectives:** The present study was taken up to investigate the effect of premolar extractions on Bolton's overall ratios in a sample of north Indian population. **Materials and methods:** Mesiodistal tooth widths were measured on pretreatment dental casts of 200 subjects (100 males and 100 females). The Bolton's overall ratios were determined before and after hypothetical premolar extractions and the subjects were divided into small, normal, and large overall ratio groups categorized by the Bolton standard deviation definition. Extractions were performed in the following combinations: (1) all first premolars, (2) all second premolars, (3) maxillary first and mandibular second premolars, and (4) maxillary second and mandibular first premolars. **Results:** The overall ratios decreased in every group after extraction of any combination of premolars. Maximum discrepancy was observed in the extraction of all first premolars and least in second premolars. Statistically significant differences were seen in the extraction pattern amongst males and females. **Conclusions:** In cases which require premolar extractions, it is mandatory to check if any discrepancy exists between different extraction patterns since the ratios may shift from normal to abnormal or *vice versa* as it may affect the interdigitation of teeth.

Keywords: Bolton ratio**,** Crowding, Occlusion, Plaster casts

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Introduction

Black, (1902) first assessed tooth size and measured the mesio-distal widths of a large number of human teeth in order to establish the mean dimensions for each tooth in the dental arch [1]. In 1949, Neff developed the *anterior coefficient*, a ratio of 1.20 to 1.22 by which an ideal overlap of 20% of the lower incisor crown height could be achieved [2]. Lundstrom described the anterior index for an ideal overbite which ranged from 73% to 85% showing a large biologic dispersion in the tooth width

ratio[3]; however the most recognized work is that of Bolton, (1958) who proposed an anterior ratio of 77.2 and overall ratio of 91.3 which are necessary for proper articulation of maxillary and mandibular teeth [4,5]. Bolton, (1962) proposed these ratios as diagnostic tools which allow the clinicians to assess the functional and aesthetic outcome of treatment without the use of a diagnostic wax up [5].

Bennett and McLaughlin, (1993) added a seventh key to occlusion which was correct tooth size [6]. In order to achieve a good occlusion with satisfactory

intercuspation of teeth, correct overjet and overbite, they concluded that the maxillary and mandibular teeth must be proportional in size along with Andrews six keys to occlusion which were established in 1972.

Excellent clinical applicability of Bolton's anterior and overall tooth-size ratios are still used today. But Bolton method has its own limitations out of which the most significant is its applicability in extraction treatment since the ratio between arches of unequal lengths would not remain constant when premolars of approximately equal size are removed from each arch [5].

Hence, the purpose of this study was to investigate the effects of premolar extractions on the Bolton's overall ratios and tooth-size discrepancies in a north Indian population

Materials and Method

A total of two hundred samples consisting of 100 males and 100 females with less than 3mm of crowding were selected. Maxillary and mandibular impressions were made and poured in type III dental stone.

The selection criteria of the samples were (1) No prior orthodontic treatment, (2) All permanent teeth till I[st] molars were fully erupted to occlusion (3) Age 12-25 years (4) Casts with crowding more than 3mm in either of the arches were not considered (5) no proximal restorations (6) no anomalies or mutilated dentitions (7) no attrition of teeth below the contact point.

The maximum mesiodistal width was measured from first molar to first molar on non soaped models using digital read out sliding caliper with the caliper tips kept parallel to occlusal and vestibular surface. All measurements were done by the same investigator. The overall ratios were calculated by using the method of Bolton.

In each malocclusion group, hypothetical tooth extractions were performed on each subject in the following 4 combinations: (1) all first premolars, (2) all second premolars, (3) maxillary first and mandibular second premolars, and (4) maxillary second and mandibular first premolars. The overall ratios were again calculated after the hypothetical extractions in each malocclusion group.

Calculations were made before extractions to determine the distributions of subjects with overall toothsize discrepancies more than 1 SD from the Bolton means $(91.3\% \pm 1.91\%)$. All the subjects were subdivided into 3 groups in each category: (1) small overall ratio $(<87.48\%)$, (2) normal overall ratio $(89.31\%$ to $93.21\%)$, and (3) large overall ratio $(>93.21\%)$.

Overall ratios were again calculated after hypothetical extraction with Bolton's means $(88\% \pm 1\%)$. All the subjects were again subdivided into 3 groups: (1) small overall ratio $(<87\%)$, (2) normal overall ratio $(88\%$ to $90\%)$, and (3) large overall ratio $(>90\%)$

Statistical analysis- Statistical analysis was performed using SPSS software (version 10, SPSS Inc, Chicago, Ill). We used Dahlberg's method [7] to assess intraoperator and interoperator measurement errors. Operator 1(A.G.) and operator 2 (S.K.) repeated the measurement of 20 casts after 15 days.

T test was used to test the main effects of extraction combinations of premolars in the sample groups in both males and females. One way ANOVA test $(P<0.05)$ was used to compare the overall ratios before and after extractions to check whether the groups were similar or not.

Results

The results of **Dahlberg's method** showed the coefficient of reliability varied from 98.71 for intraoperator measurements and 95.67 for interoperator measurements.

Mean and Standard deviation (SD) values of Bolton's Ratio in different extraction patterns in males and females is shown in Table 1. In males: the extraction combination of U5L5 (88.39%) and U5L4 (88.96%) were in the normal range of Bolton. In females: the extraction combination of U5L5 (88.38%) and U4L5 (88.90%) were in the normal range of Bolton.

Table-1: Mean and SD values of Bolton's Ratio in different extraction patterns in males and females (M= Males, F= Females, U= upper, L= lower).

Extraction Pattern	Number of Subjects	Mean of Bolton's Ratio	Standard Deviation (SD)	Standard Error Mean
M_U4L4	100	89.6742	2.30201	.23020
M_U5L5	100	88.3913	2.07362	.20736
M_U4L5	100	89.0787	2.12018	.21202
M_U5L4	100	88.9618	2.21371	.22137
F_U4L4	100	89.5785	2.77998	.27800
F_U5L5	100	88.3067	2.68061	.26806
F_U4L5	100	88.9009	2.74492	.27449
F_U5L4	100	89.0225	2.73490	.27349

Table 2 summarizes the results of T-tests used for testing the significance of various extraction methods to the standard value. The corresponding P-value suggests that which type of extraction significantly provide the normal range of Bolton (88.0% ±1%). On detailed observation with a T test value kept as 88, highly significant T values are obtained for: Males- U5L5 (significance- 0.062), Females- U5L5 (significance- 0.255). Mild significance is also noted for females U4L5 with a significance value of 0.001.

The suggested normal range of Bolton for difference of means is -1 to +1. From Table/Fig 2, one can easily observe that the 95% confidence intervals of the difference of means for extraction U5L5 (both for Male and Female) lies in this range. Therefore, we can conclude that the U5L5 is the only extraction method which is more effective to achieve Bolton mean.

Table-2: T-tests to show the statistical significance of various extraction patterns to the Bolton standard ratio (88%).

	Test Value = 88					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
M_U4L4	7.273	99	.000	1.67420	1.2174	2.1310
M_U5L5	1.887	99	.062	.39130	-.0202	.8028
M_U4L5	5.088	99	.000	1.07870	.6580	1.4994
M_U5L4	4.345	99	.000	.96180	.5226	1.4010
F_U4L4	5.678	99	.000	1.57850	1.0269	2.1301
F_U5L5	1.144	99	.255	.30670	-.2252	.8386
F_U4L5	3.282	99	.001	.90090	.3562	1.4456
F_U5L4	3.739	99	.000	1.02250	.4798	1.5652

The four extraction combinations were compared in Table/Fig 3 by one way ANOVA to test the hypothesis that the four extraction patterns are equal.

$$i.e., \mu1= \mu2= \mu3= \mu4$$

On comparison it was observed that the significance level is .000 which rejects our hypothesis and shows that the four extraction patterns are different.

Table 3: -One way ANOVA test at P<0.05 (Highly Significant).

Obs	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	163.165	3	54.388	8.934	.000
Within Groups	4845.963	796	6.088		
Total	**5009.128**	**799**			

Discussion

Tooth size arch length discrepancy or Bolton's ratio which is also considered as seventh key to normal occlusion[6] is an important factor while planning for ideal arch alignment. The scientific literature shows that still there is insufficient information on the effect of premolar extraction on Bolton's tooth size arch length discrepancy and its applicability in North Indian population as Bolton's discrepancy has racial as well as ethnic variations [8-12]. Thus the present study was conducted to check the effect of premolar extraction on Bolton's tooth size discrepancy in North Indian population.

The age group of the subjects in the study was between 12 to 25 years, as early adulthood dentition has less mutilation with no attrition. Thus the effect of these factors on mesiodistal tooth width would be negligible. This was in accordance to the studies of Doris *et al* [13] and N. Puri *et al* [14] who concluded that early permanent dentitions provide the best sample for tooth size measurements.

Hunter and Priest [15][16] concluded that an accurate surface details of hard and soft tissue can be obtained when impression were made with alginate and poured in plaster. They also stated that measurements made on soaped models were slightly larger in overall dimensions when compared to those made on non soaped models. They also found that the digital sliding callipers to be more accurate, while the dividers gave a consistently higher mean reading. They concluded that this was due to the taper designs of the dividers. That is why in accordance with Moorrees and Reed [16] the maximum mesiodistal width was measured using digital read out sliding calliper (digital Vernier calliper-Aerospace, China) with the calliper tips kept parallel to occlusal and vestibular surface. All the teeth were measured in their mesiodistal dimension which was taken as the distance between anatomic contact points. Thus, in the current study all measurements were taken on non soaped dental casts made from alginate impressions and measured with digital sliding callipers.

In our study, there is a significant difference between pre-treatment and post treatment Bolton's value indicating that the premolar extraction will have a definite affect on the final occlusion. 2-way ANOVA showed no significant differences in the overall ratios between the malocclusion groups, but significant differences before and after extractions. Pre-treatment normal values can shift to either a maxillary or mandibular excess post extraction. Our results show that the overall ratios decreased after extraction of any combination of premolars in each malocclusion group was confirmed by Tong *et al* [17]. However Huesdens [18] study indicated that extraction therapy affected minimally the occlusion. Only severe pre-treatment Bolton's values will be affected and not the mild ones.

The decrease in overall ratio in any extraction combinations might be because the ratios of the mesiodistal widths of the maxillary first or second premolars to those of 12 maxillary teeth were smaller than those of the mandibular first or second premolars to 12 mandibular teeth. In other words, in spite of first or second premolar extractions, the rates of the sum of the mesiodistal widths of remaining 10 teeth to the sum of those of 12 teeth are smaller in the mandible than in the maxilla.

The maximum discrepancy was seen in the extraction group of upper and lower first premolars. This extraction combination resulted in an abnormal tooth size discrepancy indicating the necessity of certain other means at the end of the treatment to achieve a correct intercuspation. These results were in accordance with Saatci [19], Tong *et al* [17] who unanimously supported this fact. Kayalioglue [20] in his study also gave a ratio that while going for the extraction in this group, if the overall ratio is 89.28%, then only can normal functional and aesthetic outcomes be achieved.

The extraction group of second premolars resulted in a more normal occlusion. Second premolars are considered to be more close to nature and they give

more stability to a dentition. Lama [21] quoted Begg's philosophy as strong evidence in support of simulation of Mother Nature. Also since second premolars are the teeth that are most commonly congenitally missing, their removal is in accordance with nature. Moreover, as canines are the only tooth left for tearing the food after first premolar extraction, so they should be spared and second premolars preferred from even a functional point of view. This extraction group also reduced the discrepancies that had existed before treatment. Saatci [19] in his study showed that on extraction of premolars of equal mesiodistal dimensions from upper and lower dental arches, more severe and frequent tooth-size discrepancies were created when compared with the removal of greater mandibular premolars. Bolton [5] also supported the removal of mandibular second premolars as it often creates the potential for a better occlusion than the removal of the first premolars, Tong *et al* [17] and Endo T [22] also observed normal overall Bolton's ratio after extraction in the groups extracting upper second premolar and lower first premolar. However, the study presented shows that in our population groups extracting upper first premolar and lower second premolar; and upper second premolar and lower first premolar also achieve normal ratio. On statistical evaluation however both the groups show a very weak significance. The T test values show a mean of 88.98 and 88.99 respectively and a mean difference of 0.98 and 0.99 respectively. Thus, these groups are not very reliable to achieve ideal occlusion after extraction in such patterns.

A tooth-size discrepancy can affect orthodontic treatment outcome and its stability. The mean overall ratios in every malocclusion group were more than 89% after extraction combinations of upper and lower first premolar, demonstrating that, if the sum of the mesiodistal widths of the remaining 10 teeth in the maxilla were considered normal, that in the mandible would be greater than the mean. From a clinical perspective, this finding suggests that along with extraction, selective interproximal enamel reduction might be required in the mandibular teeth for proper occlusal interdigitation.

None of the previous studies [17,19,20] showed any difference in the extraction patterns amongst various extraction groups in males and females. There was no gender difference. However, our study shows a difference in the extraction pattern that should be employed in males and females. In males along with

upper and lower second premolars, upper second and lower first premolar also achieve a normal occlusion (T test mean value of 88.96). However, in females after upper and lower second premolars, upper first and lower second premolar combination (T test mean of 88.90) should be the choice of extraction to lead to a satisfactory occlusion.

This difference in ratios due to sex is attributed to the fact that males have significantly larger teeth as compared to females in north Indian population. Studies by Jain *et al* [23] have shown that there is a statistically significant difference in mesiodistal tooth width between males and females where the males showed higher mean values than females. This may be the reason for the difference in the extraction pattern amongst males and females providing us a different pattern to achieve normal occlusion.

The study was further extended to propose norms for mesiodistal tooth dimension of males and females. The mean values obtained were in accordance with the normative data in previous studies and thus we agree that the males had larger teeth than females, and the canines in both jaws displayed a statistically significant sexual dimorphism in mesiodistal tooth size. This was in agreement with the results of Mack [24]; Bishara *et al* [25]. Selmer-Oslen [26] found the greatest sex differences were in the canines and premolars. The maxillary first premolars were larger than the second premolars, while the mandibular second premolars were larger than the first premolars.

Conclusions

In determining the effect of premolar extraction on Bolton's tooth size discrepancy in a sample of 200 North Indian population subjects, the following conclusions were drawn:

1. Statistically significant difference in Bolton's overall ratio amongst pretreatment and post treatment Bolton's value.

2. The Bolton overall ratio decreased after extraction of premolars.

3. In some of the patients high overall ratios could change to normal overall ratios and normal overall ratios could change to small overall ratios.

4. Maximum discrepancy was created in the extraction of all first premolars.

5. Least discrepancy was seen in the group involving the extraction of second premolars.

6. Statistically significant difference was seen in the extraction pattern amongst males and females.

The orthodontic cases which require premolar extractions, it is recommended to consider the effect of various premolar extraction patterns on the Bolton's overall ratio, as it may affect the post orthodontic posterior occlusion.

Funding: Nil, Conflict of interest: None.
Permission of IRB: Yes

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How to cite this article?