

# COMPARISON OF OVERALL AND POSTERIOR BOLTON RATIOS OF SKELETAL CLASS II MALOCCLUSION BEFORE AND AFTER DIFFERENT COMBINATIONS OF FOUR PREMOLAR EXTRACTIONS IN A PAKISTANI POPULATION

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## ABSTRACT

**Objectives:** To find whether different premolar extraction patterns change the overall Bolton ratio from 91.30%, and the posterior Bolton ratio from 105.27% among the Pakistani population in a skeletal class II malocclusion.

**Materials and Methods:** This Quasi Experimental study was conducted at at the Orthodontics Department of Khyber College of Dentistry, Peshawar on 30 dental models of skeletal class II patients. A Digital Vernier Caliper was used to measure the mesiodistal widths of the teeth mesial to the second molar. Overall and posterior Bolton ratios were calculated before and after hypothetical extractions of the premolars. One-sample-t test was used to see if there was any significant difference between the overall and posterior Bolton ratios of the Bolton study and our study. Paired-samples-t test was used to find the change in Bolton ratios before and after extractions. P value of  $\leq 0.05$  was considered significant.

**Results:** The mean overall and posterior Bolton ratios were  $91.57 \pm 1.21\%$  and  $103.36 \pm 2.82\%$ , respectively. Following premolars' extractions in the pattern: all first premolars, upper first with lower second premolars, upper second with lower first premolars and all second premoalrs, the overall ratio decreased significantly ( $p < 0.05$ ) to  $90.29 \pm 1.54\%$ ,  $90.55 \pm 1.61\%$ ,  $89.47 \pm 1.62\%$  and  $89.72 \pm 1.59\%$ , respectively, whereas the posterior ratio for all first premolars and upper first with lower second premolar extractions increased significantly to  $105.27 \pm 3.18\%$  and  $105.88 \pm 3.71\%$  ( $p < 0.05$ ).

**Conclusion:** Premolar extractions in skeletal class II malocclusion cause a significant decrease in the overall Bolton ratio. The all first premolars and upper first with lower second premolar extractions pattern cause a significant increase in the posterior Bolton ratio.

**Key words:** Corrective orthodontics, dental models, malocclusion, premolars, tooth extraction

## INTRODUCTION

One of the prime aims of orthodontic therapy is the achievement of an ideal occlusion, which includes good interdigitation of the teeth, and

achievement of an ideal overjet and overbite<sup>1,2</sup>. Simultaneously achieving all of these goals of orthodontic treatment is dependent on several factors, including that that an individual should have normal mesiodistal tooth sizes in the maxilla and the mandible<sup>3</sup>. The ratio of the mandibular tooth sizes to the maxillary tooth sizes is called the Bolton ratio<sup>3</sup>. A normal tooth size ratio is achieved when the ratio of the twelve mandibular teeth to the twelve maxillary

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teeth, from the permanent left first molar to the permanent right first molar, is 91.3%<sup>4</sup>. An imbalance in this ratio may cause disturbances in the occlusion and less than ideal overjet, overbite and molar or canine relationship<sup>2,3</sup>.

The original Bolton ratio was calculated for the Caucasian population<sup>4</sup>. Since then, it has been extensively studied by other races around the world. It has been shown that the Bolton ratio differs among the variety of races<sup>5-8</sup>. A class II malocclusion has a prevalence of 26% in the Pakistani population<sup>9</sup>. Extractions of the premolars for orthodontic purposes are a norm<sup>10</sup>. They can lead to better stability<sup>11</sup>. But whether or not extractions of the premolars disrupts the Bolton ratio, leading to compromised inter-arch relationships, is disputed.

An extensive Egyptian study by Ellaithy and Goma showed those patients who had a class II malocclusion and ideal pre-treatment Bolton Ratios, all extractions patterns of the premolars lead to a clinically significant discrepancy following extractions<sup>12</sup>. There is a lack of evidence as to whether extractions of the premolars in class II malocclusion leads to a change in the Bolton ratios among the Pakistani population.

The aim of our study is to find out whether different extraction patterns of the premolars (upper first: lower first [14, 24, 34, 44], upper first: lower second [14, 24, 35, 45], upper second: lower first [15, 25, 34, 44], upper second: lower second premolars [15, 25, 35, 45]) change the overall Bolton ratio from 91.30%<sup>4</sup> and the posterior Bolton ratio from 105.27%<sup>4</sup> among the Pakistani population in a class II malocclusion.

The null hypothesis is that there is no difference in the Bolton ratios before and after different extractions patterns of the premolars in class II malocclusion.

## MATERIALS AND METHODS

This Quasi-experimental study was conducted in Orthodontics Department of Khyber College of Dentistry, Peshawar from August to October 2023 after obtaining ethical approval from the RRB (53/ADR/KCD). Using OpenEpi, taking the change in overall Bolton Ratio (%) as a parameter, the changes in ratio of 92.07±2.32% before extractions and 89.87±2.45 after extraction in class II malocclusion, the sample size was 34, 17 in each group. To assume

data normality, 30 were taken in each group, keeping 95% confidence interval (CI) and 80 power<sup>12</sup>.

Those patients were consecutively selected who had a class II skeletal base (<ANB: greater than 4°) with no missing teeth. Their study models were taken and those that had a pre-existing Bolton discrepancy, tooth anomalies, chipped/worn/grossly carious teeth, interproximal restorations, or crowns were not included in the study. Study models with voids, bubbles, cracks or chipped off teeth were also excluded.

Digital Vernier Caliper (POWERFIX® Profi+, Model No: HG00962A, least count 0.01) was used to measure tooth widths mesial to the second molars. The caliper beaks were inserted perpendicular to the tooth's long axis from the facial aspect. Teeth were measured from the mesial contact point to the distal contact point at the greatest interproximal distance. Overall and posterior ratios were calculated.

Overall ratio= Sum of mesiodistal widths of lower teeth from left to right molar/ Sum of mesiodistal widths of upper teeth from left to right molar

Posterior ratio= Sum of mesiodistal widths of lower teeth from left molar to first premolar and right molar to first premolar/ Sum of mesiodistal widths of upper teeth from left molar to first premolar and right molar to first premolar

Bolton ratios were re-calculated following hypothetical extractions of all first premolars (14, 24, 34, 44), upper first and lower second premolars (14, 24, 35, 45), upper second and lower first premolars (15, 25, 34, 44) and all second premolars (15, 25, 35, 45) by subtracting the values of the extracted teeth from the recorded measurements.

The overall and posterior excess were calculated in millimeters using the formula given by Bolton<sup>4</sup>. They were re-calculated after subtracting the values of the extracted premolars. Measurements were recorded by two researchers, who had an intraclass correlation coefficient (ICC) score of 0.986. Their intra-rater reliability (via ICC) was 0.987 and 0.990. hence, there was excellent intra-rater and inter-rater reliability.

SPSS version 25 was used for data analysis. Kolmogorov-Smirnov test was used to check data normality. Gender is presented as frequency and percentage. Age, Bolton ratios, overall and posterior

excess are presented as mean and standard deviation (SD) with Standard error (SE).

One sample t test was used to see if there was any difference between the overall and posterior Bolton ratios of the Bolton study<sup>4</sup> and our study. Paired-samples t test was used to find the change in Bolton ratios before and after extraction following the different extraction patterns. P value < .05 was considered significant.

**RESULT**

There were 22 (73.3%) females and 8 (26.6%) males, with mean age of 18±4.45 years (males: 18.13±4.36 years, females: 17.95±4.64 years). The data was normally distributed with the p value > .05 for all variables except upper left lateral incisor and lower right first premolar.

Table 1 shows the mean overall Bolton ratio before and after the different premolar extractions. The mean overall Bolton ratio (91.57±1.21%) was similar to the one given by Bolton (91.30±1.91%) (p= .237)<sup>4</sup>. The difference between the mean value before extraction and after all extraction patterns was statistically significant (p <.05) (Table 2).

There was a strong, positive, and significant correlations between the Bolton ratios before and after extraction (Table 3).

Table 4 shows the mean posterior Bolton ratio before and after extractions. The mean posterior Bolton ratio (103.36±2.82%) was significantly different from the one calculated from the Bolton study (105.27%) (p= .001)<sup>4</sup>. The difference between the mean value before extraction and after 14, 24, 34, 44 and 14, 24, 35, 45 extraction patterns was statistically significant (p <.05) (Table 5).

Hence, the null hypothesis is proved wrong and there is a difference in the overall Bolton ratios before and after different patterns of premolar extractions, and in the posterior Bolton ratios before extraction and after all first premolar extractions and upper first with lower second premolar extractions in class II malocclusion. The null hypothesis is proved correct that there is no difference in the posterior Bolton ratios before extraction and after all second premolar extractions and upper second with lower first premolar extraction in class II malocclusion.

**DISCUSSION**

Premolar extractions have been shown to cause the interdigitation of the teeth to become less than ideal as it changes the Bolton ratio<sup>4</sup>. A change in the ratio that equates to a 1.5-2-mm is considered clinically significant and measures to address this excess tooth material must be taken<sup>13-15</sup>.

**Table 1: Mean values of overall Bolton ratio (% and mm) before and after the four extraction patterns (n=30)**

	Before extraction	After extraction			
	mean	14, 24, 34, 44	14, 24, 35, 45	15, 25, 34, 44	15, 25, 35, 45
<b>Ratio (%)</b>	91.57±1.21	90.29±1.54	90.55±1.61	89.47±1.62	89.72±1.59
<b>Excess (mm)</b>	1.06±0.58	0.89±1.36	0.67±1.43	1.64±1.46	1.42±1.44

**Table 2: Paired-samples-t test for the overall Bolton ratio vs the four extraction patterns' Bolton ratio (n=30)**

Before vs After Extraction	Mean difference in Bolton ratio (%)	SD (%)	SE	95% CI limits		Test statistic	P value
				Lower	Upper		
14, 24, 34, 44	1.27	0.85	0.16	0.95	1.59	8.200	.000
14, 24, 35, 45	1.02	0.99	0.18	0.64	1.39	5.613	.000
15, 25, 34, 44	2.10	1.01	0.19	1.72	2.48	11.384	.000
15, 25, 35, 45	1.85	0.97	0.18	1.48	2.21	10.405	.000

**Table 3: Correlation between Bolton ratios before extraction and after extractions.**

Bolton Ratio	Extraction Pattern			
	14, 24, 34, 44	14, 24, 35, 45	15, 25, 34, 44	15, 25, 35, 45
<b>Overall Bolton</b>	.835*	.791*	.784*	.794*
<b>Posterior Bolton</b>	.850*	.785*	.772*	.780*

\*= significant at alpha 0.05

We took patients who had a Bolton ratio within the normal range (91.3±1.91%). The mean Bolton ratio in our study (91.57±1.21%) is very close to the ideal ratio (91.3±1.91%)<sup>4</sup>. This is also similar to the value (91.71%) calculate by a meta-analysis for class II malocclusion<sup>16</sup> and the ratio calculated for the [For Blinding] (91.0%)<sup>17</sup> on whom our study was conducted.

Following premolars’ extractions in the pattern, our values decreased significantly (p <.05). The decrease is still within normal, as the lower limit for Bolton’s ratio is 89.39%, although Bolton insisted that a change within 1 SD from 91.3% would need clinical measures to correct it. Ellaithy and Gomaa<sup>12</sup> found very similar changes of 90.48±2.68%, 89.87±2.45%, 90.61±2.68%, and 89.74±2.45%, following all first, upper first with lower second, upper second with lower first and all second premolars extraction patterns, respectively, from an initial of 92.07±2.32%, which were statistically significant (p <.05), but within the normal range.

Considering the mean difference in the initial overall Bolton ratio and following all first premolar extractions, comparing with a North Indian study by Kumar et al.<sup>18</sup> in both studies, there was a significant difference between the initial and final means (our study: 1.27±0.85% and Kumar’s study: 1.53±1.32%). Similar results were found for the upper first with lower second premolar extraction pattern (1.02±0.99% and 1.63±1.25%), upper second with lower first premolar extraction pattern (2.1±1.01% and 2.12±1.29%) and all second premo-

lar extraction pattern (1.85±0.97% and 2.07±1.28 %).

Converting into millimeters, extractions of the upper second premolars cause a larger increase in maxillary tooth material compared to the other two extraction patterns. The greatest change occurs for the 15, 25, 34, 44 extraction pattern (1.64±1.46mm), which becomes clinically significant. Mongillo et al<sup>19</sup>. found that in class I malocclusion, 16% patients showed residual spacing in the mandible when all first premolars were extracted, whereas Holton found that 9% patients finished with a discrepancy greater than 2-mm when upper first with lower second premolar extraction pattern was followed. Contrary to this, in our study, 27% cases exhibited a discrepancy greater than 2-mm in the 14, 24, 34, 44 pattern, and 27% cases exhibited a discrepancy greater than 2-mm in the 14, 24, 35, 45 pattern. In the 15, 25, 34, 44 extraction pattern, 37% of patients showed an increase greater than 2-mm.

The mean posterior Bolton ratio was 103.36±2.82% in our study, which is significantly different from the calculated value from Bolton’s thesis (105.27%)<sup>4</sup>. This difference of approximately 2-mm indicates that, on average, our population has less mandibular tooth material, or more maxillary tooth material, than the Caucasian population studied by Bolton in his thesis. In other words, the Pakistani population has smaller lower premolars and molars, or larger upper premolars and molars than the Caucasian population. Mongillo et al<sup>19</sup> and Holton et al<sup>20</sup>. both found the posterior Bolton to be 105.77±1.99%.

Following the extractions, the posterior Bolton

**Table 4: Mean values of posterior Bolton ratio (% and mm) before and after the four premolar extractions (n=30)**

	Before extraction	After extraction			
		14, 24, 34, 44	14, 24, 35, 45	15, 25, 34, 44	15, 25, 35, 45
<b>Ratio (%)</b>	103.36±2.82	105.27±3.18	105.88±3.71	103±2.91	103.58±3.15
<b>Excess (mm)</b>	1.15±1.06	0.54±0.88	0.49±1.12	0.73±0.99	0.68±0.97

**Table 5: Paired-samples-t test for the overall posterior Bolton ratio vs the four extraction patterns’ posterior Bolton ratio (n=30)**

Extraction pattern	Mean difference in Bolton ratio (%)	SD (%)	SE	95% CI limits		Test statistic	P value
				Lower	Upper		
<b>14, 24, 34, 44</b>	-1.91	1.68	0.30	-.025	-.013	-6.245	0.001*
<b>14, 24, 35, 45</b>	-2.52	2.30	0.42	-.034	-.017	-5.997	0.001*
<b>15, 25, 34, 44</b>	0.36	1.94	0.35	-.004	.011	1.024	0.314
<b>15, 25, 35, 45</b>	-0.23	2.00	0.36	-.010	.005	-.614	0.544

Negative value indicates an increase.

\*= significant value at alpha 0.05

ratio significantly increased in the 14, 24, 34, 44 and 14, 24, 35, 45 extraction patterns in our study, indicating an increase in the mandibular tooth material or decrease in the maxillary tooth material. The ratio remained almost constant in the other two extraction patterns. Mongillo et al<sup>19</sup> also found this ratio to increase with 14, 24, 34, 44 extraction in class I malocclusion by  $1.52 \pm 1.15\%$ , which is similar to the increase in our study of  $1.91 \pm 1.68\%$ . Holton et al<sup>20</sup> found the ratio to increase in a 14, 24, 35, 45 extraction pattern in class I malocclusion by  $0.750 \pm 1.49\%$ , which is much less than the increase in our study by  $2.52 \pm 2.30\%$ .

Hence, upper second premolar extractions may lead to a tooth size discrepancy characterized by spacing in the lower arch, indicating a reduction in the mandibular tooth material following extraction. Measures must be taken to address this discrepancy, otherwise, excellent interdigation of the teeth may not be possible.

The limitations of our study were that a small sample was used, with no consideration given to the difference in morphology between the sexes, which is an area of debate

## CONCLUSION

The mean overall Bolton ratio in a Pakistani population is  $91.57 \pm 1.21\%$ . Following the four premolars' extraction patterns (14, 24, 34, 44; 14, 24, 35, 45; 15, 25, 34, 44 and 15, 25, 35, 45), the ratio drops to  $90.29 \pm 1.54\%$ ,  $90.55 \pm 1.61\%$ ,  $89.47 \pm 1.62\%$  and  $89.72 \pm 1.59\%$ , respectively.

The mean posterior Bolton ratio is  $103.36 \pm 2.82\%$ . Following the four premolars' extractions, the ratio increases to  $105.27 \pm 3.18\%$ ,  $105.88 \pm 3.71\%$  and  $103.58 \pm 3.15\%$  in the all first premolars extraction, upper first with lower second premolar extraction, and all second premolars extraction patterns. It slightly drops to  $103 \pm 2.91\%$  in the upper second with lower first premolar extraction pattern.

There is a strong positive and significant correlations between the overall Bolton ratios before extraction and after premolar extractions, and posterior Bolton ratio before extraction and after premolar extractions.

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