Changes in Traditional Bolton's Ratio With Various Extraction Combinations - An *In vitro* Study

PREMALATHA KANNIYAPPAN[1], B. SARAVANAN[2] and E. THULASIRAM[3]

Department of Orthodontics, Tagore Dental College & Hospital, Chennai 600 015
*Corresponding author E-mail: drpremalatha@tagoredch.in

ABSTRACT

To obtain a good occlusion with the correct overjet and overbite. there should be an harmony between the combined mesiodistal widths of maxillary and mandibular teeth. Extraction of premolars is routinely carried out in orthodontic treatment which changes the ratio of inter arch tooth size relationship. Till date Bolton's analysis remains the golden standard for predicting interarch tooth-size discrepancy. 1) To investigate whether the extraction of four premolars as a requirement of orthodontic therapy is a factor in creating tooth size discrepancy. 2) To determine whether any tooth extraction combination creates more severe discrepancies. 3) To investigate the reasons behind such discrepancies if determined due to any extraction combinations. 48 pretreatment models (30 Class I and 18 Class II) with an ideal Bolton's tooth size ratio of 91.3% ± 1 SD were taken and Bolton's analysis -the overall ratio, anterior ratio and Bolton's discrepancy was calculated. Hypothetical tooth extractions were performed with the following combinations. 1) All first premolars, 2) All second premolars, 3) Maxillary first and Mandibular second premolars, 4) Maxillary second and Mandibular first premolars and subjected to Bolton's analysis Mesiodistal dimensions of all premolars were measured and the data is evaluated to find any variation between right and left sides or between the arches. The Maxillary first and Mandibular second premolars extraction group produced the highest discrepancy followed by all first premolars extraction group. The all-second premolars extraction group produced the least discrepancy.

Key words: Bolton's analysis, Mesio distal width, Anterior tooth ratio, Overall tooth ratio,Tooth size arch length discrepancy, Extraction combinations.

INTRODUCTION

One of the goals in comprehensive orthodontic treatment is to obtain a best possible functional and esthetic result for the patient at the end of treatment. There are many factors that influence the attainability of this goal, one of which is the relationship of the total mesiodistal width of the maxillary teeth to that of the mandibular teeth.

Over the years many investigators have attempted to quantify this relationship. The mesiodistal widths of teeth were first formulated by

Black in 1902[1]. In 1923 Gilpatric[2] calculated that the total mesiodistal tooth diameters in the maxillary arch exceeded that in the mandibular arch by 8 to 12 mm .In 1949, Neff [3] developed the "anterior coefficient," he concluded, "that everything else being normal an orthodontic or non-orthodontic arch will settle to the degree of overbite indicated by the anterior coefficient."

In 1954 Lundström[4] showed a large biologic dispersion in the tooth width ratio and said it was great enough to have an impact on the final tooth position, teeth alignment and overbite and

overjet relationships. Ballard[5] (1956) in a study of 400 orthodontic cases, revealed an excess of at least 2 mm of mesiodistal tooth width in the mandibular anterior segment when compared to the maxillary anterior teeth in over 50% cases.
In 1958 Bolton[6] evaluated 55 cases with "excellent" occlusion, 44 had been treated orthodontically without extractions and 11 were untreated. He stated that a correct maxillary and mandibular mesiodistal tooth size relationship is important to the achievement of proper occlusal interdigitation. He computed the specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from both canine-canine and first molar-first molar so as to obtain optimum occlusion. The following ratios were established by:

a)   Overall ratio = 91.3% , the standard deviation was 1.91%

b)   Anterior ratio = 77.2% , the standard deviation was 1.65%

Bolton[7] in 1962 presented another article dealing with the clinical application of his tooth-size analysis. He reported that the overall ratio should not be used as a specific guide to the predicted occlusion after the removal of four premolars. He explained that a ratio set-up between arcs of unequal length (such as dental arches) would not remain constant when segments (premolars) of approximately equal size were removed from each arch. Bolton further stated that after the extraction of four premolars, patients in whom no tooth-size discrepancy existed would have an overall ratio that fell in a range from 87% to 89%.

The aim of this study
This study was done in order
1.   To investigate whether the extraction of four premolars as a requirement of orthodontic therapy is a factor in creating tooth size discrepancy.
2.   To determine whether any tooth extraction combination creates more severe discrepancies.
3.   To investigate the reasons behind such discrepancies if determined due to any extraction combinations

MATERIALS AND METHODS

This study was conducted from 48 pretreatment models with malocclusions that did not have appreciable Bolton's tooth size discrepancies. Their overall ratio fell within 91.3% ± 1 SD. Models were taken from a total sample of 310 study casts. Out of 48 pretreatment models, 30 models had Angle's Class I molar and canine relations and 18 had Class II molar and canine relations.

Criteria for Selection
1.   All permanent teeth till first molars are sufficiently erupted.
2.   Patients with severe interproximal caries, lesions or restorations are not used.
3.   All had Bolton's overall ratio of 91.3% ± 1 SD.
4.   No attempt was made to select patients on the basis of age, sex or classification of malocclusion and therefore arch depth, axial inclination, overbite or overjet are not taken into consideration.

Using a Digital vernier caliper with an accuracy of 0.01 mm the following measurements are taken:

From the pretreatment models the mesiodistal dimension of the teeth were taken. The widest points on the mesio distal direction on each tooth are measured. All measurements are in millimeters (Figure 1).

The same investigator performed all measurements. For method error evaluation, 10 casts were selected at random, two weeks after the original measurements. The teeth were remeasured on these casts. The first and second measurements were compared.   No significant differences between the two sets of measurements ($P > 0.05$) were found when Wilcoxon's non-parametric test was done.

These measurements were recorded and subjected to Bolton's analysis: the overall ratio, anterior ratio and Bolton's discrepancy was calculated.

Hypothetical tooth extractions were performed on each cast by simply substituting zero for that tooth. Following combinations of extractions were performed.
1.   All first premolars
2.   All second premolars
3.   Upper first and lower second premolars
4.   Upper second and lower first premolars

These measurements were again used to calculate Bolton's discrepancy after premolars extraction for every extraction combination one by one.

The values obtained were subjected to statistical test and evaluation.

RESULTS

In all 48 cases hypothetical premolar extractions were performed by simply substituting zero for that tooth. Bolton's method was used to find the discrepancy for all combinations. They all produced statistically significant discrepancy in the overall 10 ratio with a P value of 0.000.

Table 1 shows the Bolton values after four combination of premolars extractions, expressed as mean, SD with P value and standard error mean are shown. (The negative value indicates tooth material deficiency and positive value indicates tooth material excess)

All first premolars extraction produced mean deficiency of maxillary overall tooth material of 1.72 mm with a SD of 0.74 and mean mandibular excess of 1.51 mm with SD of 0.66.

All second premolars extractions produced a mean deficiency of maxillary tooth material of 0.85 mm with SD of 1.14 and a mean mandibular excess of 0.81 mm with a SD of 1.21

Upper first premolars and lower second premolars extraction produced a mean maxillary deficiency of 1.72 mm with a SD of 1.14 and mandibular excess of 1.56 mm with SD of 0.96

Upper second premolars and lower first premolars extraction produced a mean maxillary deficiency of 1.06 mm with a SD of 1.04 and mandibular excess of 0.99 mm with SD of 0.88

When multiple comparisons were done between the groups, there is a significant difference between all second premolars extraction group and upper first and lower second premolars extraction group with a P value of 0.001 in maxilla and with a P value of 0.004 in mandible.

The upper first premolars and lower second premolars extraction group produced the maximum discrepancy and all second premolars extraction group produced the least discrepancy (Figure 1 and Figure 2).

Table 1 : Bolton values given after four combination of premolars extraction combination, expressed as mean, SD with P value and standard error mean. (The negative value indicates tooth material deficiency and positive value indicates tooth material excess)

| Extraction combinations		Mean	SD	P Value	Std Error Mean
All first premolars n = 30	Maxilla	-1.72	0.74	0.000	0.135
	Mandible	1.51	0.66	0.000	0.120
All second premolars n = 30	Maxilla	-1.06	1.04	0.000	0.190
	Mandible	0.99	0.88	0.000	0.161
Upper first &lower second premolars n = 30	Maxilla	-1.72	1.14	0.000	0.208
	Mandible	1.560	0.960	0.000	0.176
Upper second & lower first premolars n = 30	Maxilla	-0.85	1.14	0.000	0.208
	Mandible	0.81	1.21	0.000	0.221

Effect Of Premolar Extractions
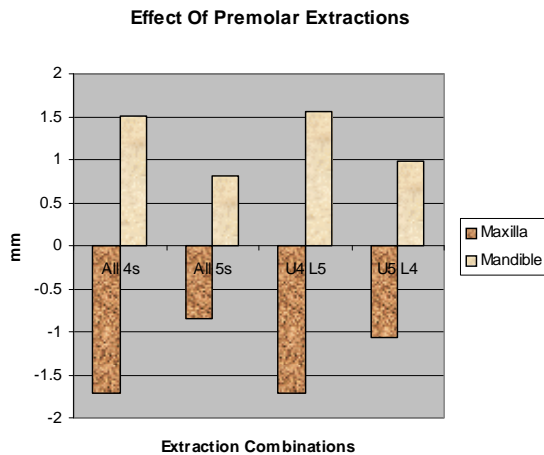
Fig. 1: The effect of various premolars extraction combination on Bolton's tooth size discrepancy in maxilla and mandible
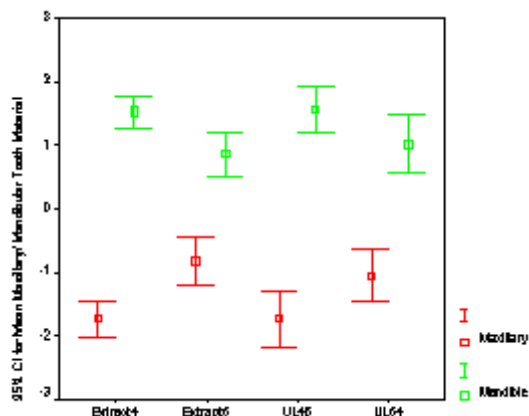

Fig. 2: : The effect of various premolars extraction combination on Bolton's tooth size discrepancy in maxilla and mandible. (The negative value indicates tooth material deficiency and positive value indicates tooth material excess)

DISCUSSION

It is widely accepted that a correct maxillary and mandibular mesiodistal tooth size relationship is important to the achievement of proper occlusal interdigitation in the finishing stages of orthodontic treatment. Though many authors [2-5] had attempted to quantify this relationship, it was Wayne Bolton in 1958 [6] who computed the specific ratios of the mesiodistal widths that must exist between maxillary and mandibular teeth from both canine-canine and first molar-first molar so as to obtain optimum occlusion.

The intended purpose of tooth size discrepancy ratio as a diagnostic aid as said by Bolton is "…To gain insight into the functional and esthetic outcome of a given case without the use of diagnostic set up". Till date this diagnostic setup remains the golden standard for predicting interarch tooth-size discrepancy and is widely used due to the fact that, the measurements are easily and quickly made. In a subsequent paper, Bolton[7] expanded on the clinical application of his tooth size analysis. Bolton's standard deviations from his original sample have been have been used to

determine the need for reduction of tooth tissue by interdental stripping or the addition of tooth tissue by restorative techniques.

Inspite of its prevalent use, the reliability of Bolton's analysis is still debated. Though some authors like Stifter [8], Hashim[9] have agreed that Bolton's ratio is applicable, the validity and accuracy of this analysis has been repeatedly challenged by authors like shellart[10] Redahan [11] have said that Bolton's ratio must be used with caution while using it in a severely crowded dentition[12,13], or with abnormal tooth morphology and thickness [14,15,16,17]. Doubts have been raised about the reliability of applying this analysis to all cases with varied malocclusions[18-23] in various populations[24-28,] One criticism on Bolton's study is that apart from a small sample size, the estimates of variation is underestimated because his sample size is derived from perfect Class I occlusion [18]. Studies have shown that [13,16,29,30,31,32,33] the change in the tooth-size arch length relationship is multifactorial depending on factors like overbite [34,35]overjet [5, 6], inclination of anteriors [36,37], intercanine width [18, 38], intermolar width [30] arch width [39] and curve of spee [40]

Recent studies have raised the need for developing a new formula to forecast tooth –size discrepancies in patients based on not only the size of the whole teeth but also functional arch components derived from normal cusp- fossa interdigitation [41,]by including tooth thickness [42]archdepth [43] etc

The effects of extraction:In his second paper, Bolton[8] discussed the effect of premolar extraction on the overall ratio. Bolton correctly stated that premolar extraction would mathematically reduce the suggested overall mean ratio value of 91.3%. After the extraction of 4 premolars, patients in whom no TSD existed would have an overall mean ratio of 88%.

The results of this study showed that after premolar extraction, the Overall 10 ratio is increased to a much higher level than 88% which was proposed by Bolton in 1962 .The mean ratio is 89.14 % which is closer to the ratio obtained (89.28%) by Kayoliogu [44]

Extraction of premolars produced mandibular tooth material excess and maxillary tooth material deficiency. When various hypothetical extraction combinations were performed, the results (Table 1) indicate that upper first premolars and lower second premolars extraction group produced the highest discrepancy followed by all first premolars extraction group. This result differs from that of Saatci [45] who observed that all first premolars extraction group produced the greatest discrepancy. But when multiple comparisons were done between the groups, it was shown that there was no significant difference between the all first premolars extraction group and upper first premolars and lower second premolars extraction group.

The results also showed that all second premolars extraction group produced the least discrepancy, which agrees with that of the Saatci[36] and Tong et al[46] studies .Hence the Bolton's overall ratio with respect to changing the pattern of extractions has variable results .

CONCLUSION

This study evaluated the effect of premolars extraction on overall Bolton's tooth size discrepancy and arrived at the following conclusions.

a)   The upper first and lower second premolars extraction group produced the highest discrepancy followed by all first premolars extraction group.

b)   The all-second premolars extraction group produced the least discrepancy.

Hence the Bolton's overall ratio with respect to changing the pattern of extractions produces statistically significant discrepancy. So the clinician must be aware of this before and Bolton's tooth size discrepancy should be included as one of the factors before deciding on extaction pattern.

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