Original Article

The Effect of Premolar Extractions on Tooth Size Discrepancies

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Abstract: The purpose of this study is to investigate the effect of premolar extractions on tooth size discrepancy. A total of 213 plaster casts were divided into a Bolton big (BB), a Bolton normal (BN) and a Bolton small (BS) group according to the Bolton normal value plus or minus one standard deviation. The Bolton overall ratio of each group was measured and compared before and after hypothetical premolar extractions. The Bolton overall ratios after premolar extractions were smaller than those before extraction in each group. Some of the patients in the BN group and BB group were moved into the BS group and BN group after premolar extractions. A tooth size discrepancy occurred in some patients with normal overall ratios after premolar extractions, but a tooth size discrepancy might be corrected in some patients with big overall ratios after premolar extraction. (*Angle Orthod* 2004;74:508–511.)

Key Words: Bolton index; Extraction; Premolar

INTRODUCTION

The goals of orthodontic diagnosis and treatment planning are to determine the best possible esthetic and functional results at the end of treatment. Many factors will affect these goals, and one of them is extraction. The extraction decision is the most critical decision made by orthodontists when planning treatments,[1–3] and the extraction of premolars is common. The Bolton overall ratio will change after premolar extraction, and it is influenced by different extraction combinations. Both Bolton,[4] in 1962, and Yang,[5] in 2002 concluded that the overall ratio decreased after extraction of four first premolars. Li[6] also reported that the Bolton overall ratio decreased after extraction with combinations of all first premolars, all second premolars, upper first and lower second premolars, and upper second and lower first premolars. However, Saatci[7] stated that the overall ratio increased after removal of all first premolars and upper first and lower second premolars but decreased after extraction of all second premolars and upper second and lower first premolars.

What is the effect of premolar extraction on the Bolton overall ratio? If orthodontists know that a tooth size discrepancy will occur or be more severe after extraction of premolars, they would be likely to be more cautious in deciding whether to extract or not. If the orthodontist knows that a tooth size discrepancy will be corrected after extraction of premolars, the orthodontist will be more likely to make a decision to extract. Therefore, the purpose of this study is to investigate how the Bolton overall ratio changes after extraction of various combinations of premolars.

MATERIALS AND METHODS

Patients were selected from the records of individuals treated at the clinical practice of the Department of Orthodontics, Shanghai First Peoples' Hospital from 1999 to 2002. To minimize error variance, the selection criteria were (1) all subjects were of Han nationality born and living in Shanghai, China, (2) pretreatment study models of patients were of good quality, (3) all permanent teeth (except third molar) had erupted and were present from left first molar through right first molar, (4) no tooth decay, residual crown, or crown-bridge restorations were present, (5) no severe mesiodistal or occlusal tooth abrasion was present, and (6) no tooth deformity or supernumerary teeth were present. A total of 563 patient records were examined to provide 213 patients acceptable for this study. They were between 11 and 29 years of age, with a mean age of 15.26 years (85 male and 128 female, 83 Class I, 73 Class II, and 57 Class III).

Using a digital slide caliper with an accuracy of 0.01 mm

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TABLE 1. Distribution of Overall Ratio for Angle Classification in Different Groups[a]

Angle Class	Sex	BS Group N	BS Group %	BN Group N	BN Group %	BB Group N	BB Group %	Total N
I	M	16	50.00	15	46.88	1	3.12	32
II	M	5	17.24	19	65.52	5	17.24	29
III	M	7	29.17	13	54.17	4	16.66	24
Total	M	28	32.94	47	55.29	10	11.77	85
I	F	16	31.37	30	58.82	5	9.81	51
II	F	22	50.00	22	50.00	0	0.00	44
III	F	13	39.39	18	54.55	2	6.06	33
Total	F	51	39.84	70	54.69	7	5.47	128
Total		79	37.09	117	54.93	17	7.98	213

[a] BS group: Overall ratio <89.39%; BN group: 89.39% < Overall ratio < 93.21%; BB group: Overall ratio >93.21%.

(Shanghai measure factory, Shanghai, China) and positioning the caliper tips parallel to the occlusal surface of each tooth, one of the authors (Dr Tong) measured the greatest mesiodistal diameter between the anatomic mesial and distal contact points of each tooth from the left first molar to the right first molar all within a one-month period. The Bolton overall ratios were calculated using the formula reported by Bolton:[8]

$$\frac{\text{Sum mandibular 12}}{\text{Sum maxillary 12}} \times 100 = \text{overall ratio (\%)}.$$

To determine measurement error, 10 sets of models of each Angle classification were randomly selected and measured two weeks later, after the first measurement by the same examiner. The paired *t*-test was used to determine measurement error. One-way analysis of variance (ANOVA) was used to determine whether there was any sex difference in the overall ratios. If no sex difference existed, the overall ratios from the male and female samples would be combined. If a sex difference existed between the Bolton overall ratios, they would be calculated separately.

According to the Bolton overall ratio ±1 standard deviation (91.3 ± 1.91%) calculated in 1958, we divided the subjects into three groups:

- Bolton small (BS) group including small overall ratios (smaller than 89.39%, mean − 1 SD);
- Bolton normal (BN) group including normal overall ratios (between 89.39% and 93.21%, mean ± 1 SD);
- Bolton big (BB) group including big overall ratios (larger than 93.21%, mean + 1 SD), (Table 1).

We hypothetically removed four different combinations of four premolars from each case. These combinations were (1) all first premolars, (2) all second premolars, (3) upper first and lower second premolars, and (4) upper second and lower first premolars. The hypothetical extraction was accomplished by substituting zero in place of the corresponding premolars that were removed. The overall ratios were measured again and compared using one-way ANOVA to see whether and how they were changed for every extraction combination before and after extractions. Numbers of patients in each group were calculated again after extractions to see whether the patients moved to other groups and how many patients moved for every extraction combination. Chi-square test was used to verify if the change in numbers was related to the extraction combination. The software used for the statistical analysis was SPSS (Version 11.01), and the level of significance was $P < .05$.

TABLE 2. Changes of Numbers in Bolton Small Group after Premolar Extractions

Sex	Group	4|4 4|4 [a] N	4|4 4|4 [a] %	5|5 5|5 N	5|5 5|5 %	4|4 5|5 N	4|4 5|5 %	5|5 4|4 N	5|5 4|4 %
M	BS	28	100	28	100	28	100	28	100
	BN	0	0	0	0	0	0	0	0
	BB	0	0	0	0	0	0	0	0
	Total	28	100	28	100	28	100	28	100
F	BS	51	100	51	100	51	100	51	100
	BN	0	0	0	0	0	0	0	0
	BB	0	0	0	0	0	0	0	0
	Total	51	100	51	100	51	100	51	100

[a] Means extraction of four first premolars. The rest is deduced by analogy. N indicates number of patients; it is the same in the Table 3 and 4.

TABLE 3. Changes of Numbers in Bolton Normal Group after Premolar Extractions

Sex	Group	4|4 4|4 N	4|4 4|4 %	5|5 5|5 N	5|5 5|5 %	4|4 5|5 N	4|4 5|5 %	5|5 4|4 N	5|5 4|4 %
M	BS	20	42.55	41	87.23	21	44.68	38	80.85
	BN	27	57.45	6	12.77	26	55.32	9	19.15
	BB	0	0.00	0	0.00	0	0.00	0	0.00
	Total	47	100.00	47	100.00	47	100.00	47	100.00
F	BS	31	44.29	45	64.29	25	35.71	50	71.43
	BN	39	55.71	25	35.71	45	64.29	20	28.57
	BB	0	0.00	0	0.00	0	0.00	0	0.00
	Total	70	100.00	70	100.00	70	100.00	70	100.00

RESULTS

No significant difference ($P = .064 > .05$) was found between the two analyses performed by the same investigator at least two weeks apart. A significant sex difference was observed for the overall ratio ($P = .043 < .05$), so we calculated the overall ratio for the males and females separately.

Although the overall ratios in the BS group declined after different extraction combinations, Table 2 shows that all the patients still remained in this group. However, Table 3 shows that 42.55%, 87.23%, 44.68%, and 80.85% of the male patients and 44.29%, 64.29%, 35.71%, and 71.43% of the female patients in the BN group moved into the BS

TABLE 4. Changes of Numbers in Bolton Big Group after Premolar Extractions

		4|4 / 4|4		5|5 / 5|5		4|4 / 5|5		5|5 / 4|4	
Sex	Group	N	%	N	%	N	%	N	%
M	BS	0	0.00	0	0.00	0	0.00	0	0.00
	BN	6	60.00	9	90.00	6	60.00	9	90.00
	BB	4	40.00	1	10.00	4	40.00	1	10.00
	Total	10	100.00	10	100.00	10	100.00	10	100.00
F	BS	0	0.00	0	0.00	0	0.00	0	0.00
	BN	3	42.86	7	100.00	4	57.14	6	85.71
	BB	4	57.14	0	0.00	3	42.86	1	14.29
	Total	7	100.00	7	100.00	7	100.00	7	100.00

TABLE 5. Changes of Numbers and Chi-square Test Results in Bolton Normal and Big Groups

Sex	Group	Number	4|4 / 4|4	5|5 / 5|5	4|4 / 5|5	5|5 / 4|4	P value
M	BN	Remain	27	6	26	9	0.000
		Change	20	41	21	38	
F		Remain	39	25	45	20	0.000
		Change	31	45	25	50	
M	BB	Remain	4	1	4	1	0.187
		Change	6	9	6	9	
F		Remain	4	0	3	1	0.072
		Change	3	7	4	6	

group after removal of all first premolars, all second premolars, upper first and lower second premolars, and upper second and lower first premolars, respectively.

Similarly, Table 4 shows that 60%, 90%, 60%, and 90% of the male patients and 42.86%, 100%, 57.14%, and 85.71% of the female patients in the BB group moved into the BN group after extraction with four different combinations. Changes in numbers were significantly related to the extraction combinations for both male and female in the BN group but not in the BB group (Table 5).

The overall ratios in each group decreased after extraction with different combinations. Figure 1 and Table 6 show

TABLE 6. Overall Ratio Means in each Group before and after Premolar Extractions

Sex	Group	Before	4|4 / 4|4	5|5 / 5|5	4|4 / 5|5	5|5 / 4|4
M	BS	0.8820	0.8686	0.8579	0.8664	0.8601
	BN	0.9100	0.8973	0.8852	0.8982	0.8842
	BB	0.9449	0.9299	0.9201	0.9302	0.9199
F	BS	0.8765	0.8634	0.8537	0.8635	0.8536
	BN	0.9084	0.8945	0.8864	0.8966	0.8843
	BB	0.9392	0.9288	0.9111	0.9249	0.9150

that the overall ratios decreased most in the extraction combinations of both all second premolars and upper second and lower first premolars. For the BS and BN group, significant differences for both male and female patients could be found between before and after four different combinations of extraction. However, for the BB group, significant differences of both male and female patients could be found only before extraction and after the extraction combinations of all second premolars and upper second and lower first premolars.

DISCUSSION

The results of the paired *t*-test for measurement difference demonstrated that there was no time-related trend for measurement error. Thus, the clinically significant differences made in performing the Bolton analysis were not due to any consistent difference in measurement technique.

There was a significant sex difference, as was reported by Smith[9] and Santoro.[10] Therefore, the overall ratios for males and females were calculated separately.

In the current study, we compared the changes in numbers in each group before and after extractions of premolars and found that some of the male and female patients in the BN group moved into the BS group with each combination of extraction. The change was related to the specific extraction combination, and the numbers obviously changed in combinations of four second premolars and upper second

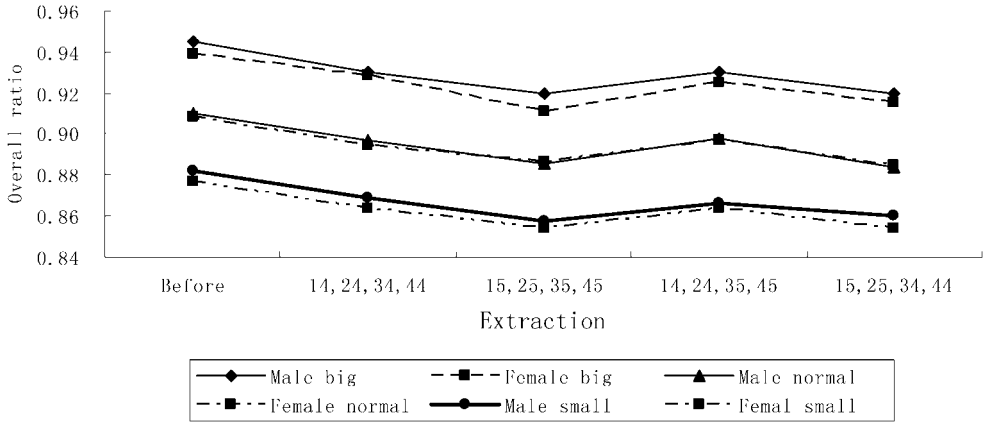

FIGURE 1. Changes of overall ratio means in each group before and after premolar extractions.

and lower first premolars. It shows that some of the patients with normal overall ratios would become those with small ratios after extraction of premolars, especially after removal of four second premolars and upper second and lower first premolars.

Similarly, in the BB group, some of the male and female patients moved into the BN group, and the obvious change in numbers also occurred in the extraction combinations of four second premolars and upper second and lower first premolars. This might suggest that part of the tooth size discrepancy with a big overall ratio would become normal after premolar extractions, especially after removal of four second premolars and upper second and lower first premolars. However, the change in numbers was not related to the extraction combination. It might be that we had so few patients in the BB group that we could not find a changed rule. It needs to be researched further.

We also compared the overall ratios before and after extraction and found that the overall ratios of both males and females in the small and normal groups decreased in any extraction combination. A significant difference was present between the before and after in each extraction combination in these two groups. This suggests that small or normal overall ratios before extraction would decrease after extraction with each combination. Furthermore, the overall ratios markedly decreased in the extraction combination of four second premolars and upper second and lower first premolars. This finding reveals that removal of four second premolars and upper second and lower first premolars had the most effect on the overall ratio. Because it is most likely that upper second premolars will be smaller than upper first premolars, the overall ratio will be smaller with removal of upper second than upper first premolars.

In the BB group, we also found that the overall ratios decreased in each extraction combination. The overall ratios markedly decreased in the extraction combination of four second premolars and upper second and lower first premolars, and significant difference could be found between before and after extraction of these two combinations. It is also suggested that these two extraction combinations could affect the overall ratio. However, no significant difference was found between before and after extraction combination of four first premolars and upper first and lower second premolars. Such a condition may be attributed to the limited number of patients in the large Bolton group. Therefore, further studies should be carried out to produce more reliable data on this topic.

CONCLUSIONS

In the present study, the following conclusions may be drawn when combining changes of numbers and overall ratios:

- The Bolton overall ratio decreased after extraction of premolars;
- In some of the patients, normal overall ratios could change to small overall ratios;
- In some of the patients, high overall ratios could change to normal overall ratios after removal of premolars, especially combinations of four second premolar and upper second and lower first premolars.

REFERENCES

1. Gottlieb EL, Nelson AH, Vogels DS. JCO study of orthodontic diagnosis and treatment procedures. Part 1 overall results. *J Clin Orthod.* 1986;20:612–625.
2. Gottlieb EL, Nelson AH, Vogels DS. JCO study of orthodontic diagnosis and treatment procedures. Part 1 results and trends. *J Clin Orthod.* 1996;30:615–629.
3. Proffit WR. Forty-year review of extraction frequencies at a university orthodontic clinic. *Angle Orthod.* 1994;64:407–414.
4. Bolton WA. The clinical application of a tooth size analysis. *Am J Orthod.* 1962;48:504–529.
5. Yang MZ, Xu TM, Lin JX. Bolton analysis of four first premolar extraction cases with good occlusion [in Chinese]. *Chin J Orthod.* 2002;9:32–34.
6. Li YC, Zhu ZX, Li M, et al. The effect of premolar extractions on Bolton index [in Chinese]. *Chin J Orthod.* 2001;8:59–61.
7. Saatci P, Yukay F. The effect of premolar extractions on tooth-size discrepancy. *Am J Orthod Dentofacial Orthop.* 1997;111: 428–434.
8. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthod.* 1958;28:113–130.
9. Smith SS, Buschang PH, Watanabe E. Interarch tooth size relationships of 3 populations: Does Bolton's analysis apply? *Am J Orthod.* 2000;117:169–174.
10. Santoro M, Ayoub ME, Pardi VA, et al. Mesiodistal crown dimensions and tooth size discrepancy of the permanent dentition of Dominican Americans. *Angle Orthod.* 2000;70:303–307.