

Effects of premolar extractions on Bolton overall ratios and tooth-size discrepancies in a Japanese orthodontic population

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Introduction: The purpose of this study was to investigate the effects of premolar extractions on the Bolton overall ratios and overall tooth-size discrepancies in a Japanese orthodontic population. **Methods:** Mesiodistal tooth widths were measured on 198 pretreatment dental casts of subjects with Class I, Class II, and Class III malocclusions. The overall ratios and tooth-size discrepancies were determined before and after hypothetical premolar extractions. Before and after extractions, the subjects were divided into small, normal, and large overall ratio groups categorized by the Bolton standard deviation definition, and into small, normal, and large correction groups by the actual amount of change calculated for tooth-size correction in millimeters. 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. For statistical evaluations, analysis of variance, Kruskal-Wallis, Friedman, Scheffé, Bonferroni, and Tukey tests were performed. **Results:** The overall ratios decreased in every malocclusion group after extraction of any combination of premolars. The decreases were significantly notable in combinations 2 and 4. Some subjects in the normal overall ratio and maxillary and mandibular correction groups moved into the clinically significant tooth-size discrepancy group after premolar extraction, and the reverse was also true. **Conclusions:** In formulating a treatment plan involving premolar extractions, orthodontists should consider that the overall ratios might decrease, and normal and clinically significant tooth-size discrepancies could change mutually after extractions. (*Am J Orthod Dentofacial Orthop* 2010;137:508-14)

Bolton's tooth-size ratios, including overall and anterior ratios, have been widely accepted as an essential diagnostic tool in orthodontic practice since their publication.^{1,2} The Bolton anterior and overall ratios were defined as the ratios of the mesiodistal widths between the 6 anterior mandibular teeth and the 6 anterior maxillary teeth, and the mesiodistal widths between the 12 mandibular teeth and the 12 maxillary teeth, respectively.^{1,2} Some evidence points to sex and racial or ethnic differences in the tooth-size ratios.^{3,4} Some investigators reported statistically significant associations between tooth-size ratios and

malocclusion types.^{5,6} Others found no significant differences in either anterior or overall ratios in subjects with different malocclusion.⁷⁻⁹

A tooth-size discrepancy between the maxillary and mandibular arches is found by analyzing tooth-size ratios. Some studies found that ratios more than 2 SD from Bolton's mean of 91.3% indicated clinically significant overall tooth-size discrepancies.⁵⁻¹² In orthodontic practice, the actual amount of discrepancy (in millimeters) provides more useful information on the required correction for clinically significant tooth-size discrepancy than does the ratio as a percentage.^{9,13} Some investigators^{9,13,14} selected 1.5 mm as an appropriate threshold for clinical significance of discrepancy, quoting Proffit and Ackerman¹⁵ that tooth-size discrepancies less than 1.5 mm were rarely significant.

In orthodontic treatment, tooth extraction is often necessary to achieve the best possible esthetic and functional outcome for patients, and the extraction of 4 first premolars is most common.¹⁶ The overall ratio and tooth-size discrepancies are directly influenced by premolar extraction. Nonetheless, only a few investigations have been conducted about the applicability of the overall ratio as a criterion, shown by the shortage of literature.^{2,17} Bolton² found that the mean overall ratio was

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The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

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Submitted, February 2008; revised and accepted, April 2008.

0889-5406/\$36.00

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doi:10.1016/j.ajodo.2008.04.026

91.3% (SD, 1.91) in patients without a tooth-size discrepancy, and, after extraction of 4 premolars, the patients had a mean overall ratio of 88% (SD, 1). Tong et al¹⁷ stated that the overall ratios after extraction of all premolar combinations were smaller than those before extraction, and, in some of the patients, normal and large overall ratios changed into small and normal overall ratios, respectively, after extraction of premolars. The change of overall ratio groups was especially noteworthy in combinations of all second premolars and the maxillary second and mandibular first premolars. Saatci and Yukay¹⁸ and Gaidyte and Baubiniene¹⁹ investigated tooth-size discrepancies created by premolar extractions using the Bolton index, which is a positive value of either maxillary or mandibular corrections required to give the Bolton mean overall ratio.

The purpose of this study was to investigate the effects of premolar extractions on the Bolton overall ratios and tooth-size discrepancies in a Japanese orthodontic population.

MATERIAL AND METHODS

A total of 198 Japanese subjects with various malocclusions were selected retrospectively from a list of orthodontic patients who had received treatment in our clinics at the Nippon Dental University Niigata Hospital, Niigata, Japan. They included patients with Class I, Class II, and Class III malocclusions and met the criteria for the dental casts as described below. The occlusion category, according to Angle's classifications, coincided with the skeletal category. Skeletal types were assessed cephalometrically by the mean ANB angles ($3.3^\circ \pm 2.1^\circ$ for males; $2.6^\circ \pm 1.7^\circ$ for females)²⁰: Class I, from 1.2° to 5.4° for males and from 0.9° to 4.3° for females; Class II, $>5.4^\circ$ for males and $>4.3^\circ$ for females; and Class III, $<1.2^\circ$ for males and $<0.9^\circ$ for females. Each malocclusion group consisted of 33 male and 33 female subjects. The selection criteria of the casts were (1) fully erupted permanent dentition with only the third molars unerupted, (2) good-quality pretreatment casts, (3) no tooth agenesis or extractions, (4) no mesiodistal restorations or abrasion, and (5) no tooth anomalies.

Digital calipers were used to measure the mesiodistal widths from first molar to first molar to the nearest 0.01 mm on each cast. The mesiodistal width of each tooth was measured at the greatest distance between the contact points on the proximal surfaces. All measurements were done by 1 investigator (I.K.). The overall ratios were calculated by using the method of Bolton.^{1,2}

Thirty pairs of dental casts were randomly selected a month later, and the mesiodistal tooth widths were again measured by the same investigator. The overall ratios were calculated by the same method. A paired *t* test showed no statistically significant differences between the first and second measurements ($P > 0.05$). Random errors, assessed by calculating the standard deviation of the differences between the first and second measurements, were less than 0.72% for the overall ratios, and less than 0.8 and 0.73 mm for the maxillary and mandibular corrections, respectively; these were unlikely to affect the significant results in this study.¹³

Because 2-way analysis of variance (ANOVA) indicated no significant differences in overall ratios between the sexes or malocclusion types, and no significant interaction between 2 variables, the values for the sexes were combined for all other analyses, as shown in Tables I and II.

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 tooth-size discrepancies more than 2 SD from the Bolton means ($91.3\% \pm 1.91\%$) and more than 1.5 mm of maxillary or mandibular correction required to give the Bolton mean overall ratio, and all the subjects were subdivided into 3 groups in each category: (1) small overall ratio ($<87.48\%$), (2) normal overall ratio (87.48% to 95.12%), and (3) large overall ratio ($>95.12\%$). Both maxillary and mandibular correction groups were (1) small correction (<-1.5 mm), (2) normal correction (-1.5 to $+1.5$ mm), and (3) large correction (>1.5 mm).

Similarly, to determine how many subjects moved into other groups, the number of subjects in each group was calculated again according to the Bolton mean overall ratio (88% ; SD, 1)² and a 1.5-mm threshold after all premolar extraction combinations.

Statistical analysis

Statistical analyses were performed with StatMate software (ATMS, Tokyo, Japan). The means and standard deviations of the overall ratios were calculated before and after the 4 extraction combinations of premolars in each malocclusion group. Two-way ANOVA was performed to test the main effects of extractions and malocclusion types on the overall ratio. One-way ANOVA and Scheffé

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