Effects on the Dental Arch Form Using a Preadjusted Appliance with Premolar Extraction in Class I Crowding

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ABSTRACT
Objective: To determine the dental arch form effects of treatment with a preadjusted appliance (0.022″ slot) performed concomitantly with extraction of premolars in Class I crowding.
Materials and Methods: Twenty-six patients (20.17 ± 12.15 years) with Class I crowding who attained a favorable occlusion after treatment were divided into nonextraction and extraction groups. The three-dimensional coordinates of the FA point of each tooth were determined. The dental arch form was expressed as a quartic polynomial expression with log F value used to represent the dental arch form and calculated using the quadratic and quartic coefficients. Changes in the dental arch form before and after treatment were compared between the groups.
Results: In the extraction group, log F value was significantly higher after treatment, and the upper dental arch became more tapered. The U1-APo was significantly lower after treatment. No change was observed in U1-FH. The anterior teeth demonstrated posterior movement due to sliding mechanics, and torque was controlled. The anterior length of the dental arch became significantly longer after treatment for the maxilla and mandible in both groups. Results demonstrated that the upper dental arch might become tapered after treatment used concomitantly with premolar extraction, as a result of the increase in anterior length while maintaining intercanine width for dealing with crowding of the anterior teeth.
Conclusion: It is necessary to anticipate that the upper dental arch form will become tapered during extraction treatment for Class I crowding and to select an appropriate arch form.

KEY WORDS: Arch form; Quartic polynomial expression; Crowding; Preadjusted appliance; Premolar extraction

INTRODUCTION

Japanese patients with malocclusion typically have crowded anterior teeth as a major complaint,[1] for which premolar extraction is often indicated. Previous studies of the effects of premolar extraction have reported that the dental arch dimensions before treatment were maintained,[2] while morphologic changes were few in the lower dental arch[3] and the area of the upper anterior teeth increased.[4] However, there is no known report on the effects of premolar extraction on positional changes of the anterior teeth and dental arch form with use of a preadjusted appliance.

A preadjusted appliance uses a preformed wire to perform treatment with sliding mechanics; thus, it is considered important to describe its effects on the dental arch form. Accordingly, it is considered vital to study morphologic changes of the dental arch before and after such treatment in a clinical setting. In the present study, we investigated the effects of treatment with a preadjusted appliance performed after extraction of premolars on the positional relationships of the upper and lower anterior teeth, as well as the dental arch form in patients with Class I crowding.

MATERIALS AND METHODS

The subjects were 26 patients with Class I crowding (20.17 ± 12.15 years [mean age ± SD]) who under-

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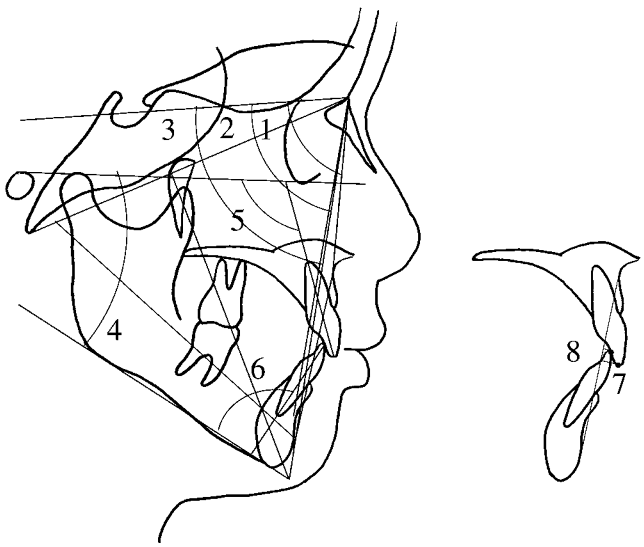

Figure 1. Measurements used for lateral cephalometric analysis. (A) SNA (degrees). (B) SNB (degrees). (C) Facial angle (degrees). (D) Mandibular plane (degrees). (E) U1 to FH (degrees). (F) L1 to mandibular plane (degrees). (G) U1 to APo (mm). (H) L1 to APo (mm).

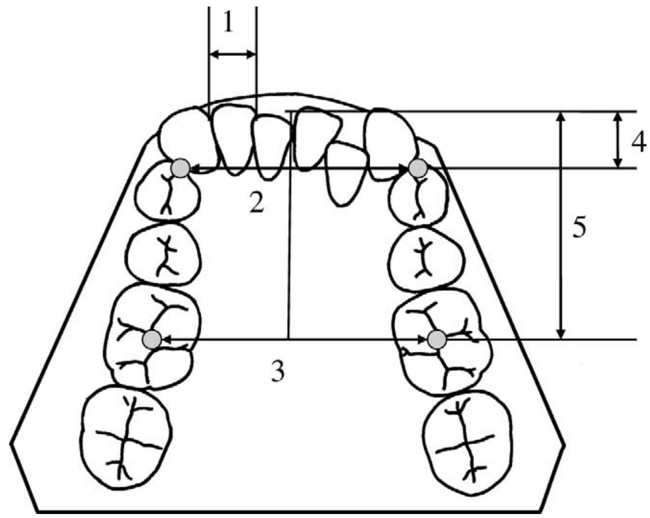

Figure 2. Cast model analysis. (A) Maximum mesiodistal tooth width. (B) Anterior width of the dental arch, distance between the distal proximal surface points of the bilateral canines. (C) Posterior width of the dental arch, central alveolus on the occlusal surface of the bilateral first molars. (D) Anterior length of the dental arch, vertical distance dropped from the mesial contact point of the bilateral central incisors to the line connecting the distal proximal surfaces of the bilateral canines. (E) Posterior length of the dental arch, vertical distance from the mesial contact point of the bilateral central incisors to the line connecting the distal proximal surfaces of the bilateral first molars.

went treatment using a preadjusted appliance (MBT system, 0.022 slot) and attained a favorable occlusion. They were divided into the nonextraction ($n = 10$, 25.66 ± 17.0 years) and extraction ($n = 16$, 16.75 ± 6.3 years) groups. The inclusion criteria were as follows:

—Skeletal structure rated as Skeletal I and demonstrating Angle Class I malocclusion.
—No abnormality in the dental crown morphology.
—No restorative materials or occlusal wear that could have an effect on the measurements.
—No temporomandibular joint derangement.
—Patients who had not undergone lateral expansion or distal movement of the molars.

Cast models and lateral cephalometric radiographs before and after treatment were used as study materials. For measuring the three-dimensional coordinates of the FA point of each tooth, a three-dimensional coordinate measuring device (XYZAX RVA600, Tokyo Seimitsu, Tokyo, Japan) was used. The three-dimensional coordinate values were obtained according to Otani's method,[5] then projected to the reference plane and converted into two-dimensional coordinates. The dental arch configuration was expressed by a quartic polynominal expression, $y = ax^2 + bx^4$, using Mathematica 5.1 (Wolfram Research, Champaign, Ill) to calculate the log F value ($F = a^3/b$) from the coefficients of the quadratic and quartic terms, which represented the dental arch configuration. A dental arch configuration with a smaller log F value indicated a squared type, while that with a larger log F value indicated a tapered type.[5]

For analysis of lateral cephalometric radiographs, SNA, SNB, facial angle, and mandibular plane were measured as well as U1-FH, L1-Mand, U1-APo, and L1-APo (Figure 1).

The maximum width of the crown, anterior and posterior lengths and widths of the dental arch, and arch-length discrepancy between the upper and lower arch were determined using cast models prepared at the time of the first examination (Figure 2). Each item was measured three times by the same examiner using a digital micrometer caliper (minimum scale, 0.01 mm; instrumental error, ± 0.02 mm; Mitutoyo, Tokyo, Japan) and a model measuring instrument (YDM, Tokyo, Japan). To determine the mean of the three measurements, the mean and standard deviation were calculated for each of the subjects in the extraction and nonextraction groups.

Statistical Analysis

The log F values for the extraction and nonextraction groups were compared using a Mann-Whitney U test, while those before and after treatment were compared using a Wilcoxon signed-ranks test. For cephalometric analysis, radiographs obtained before and

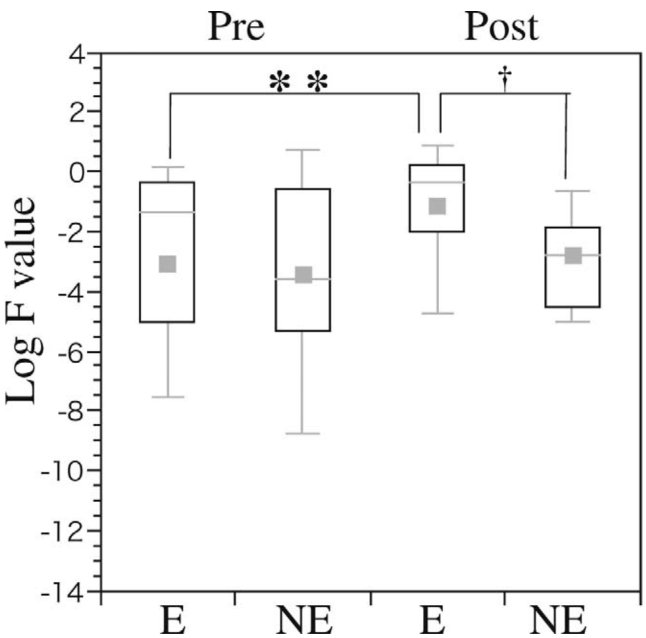

Figure 3. Comparison of upper dental arch form before and after treatment between the extraction and nonextraction groups. E = extraction group, NE = nonextraction group.

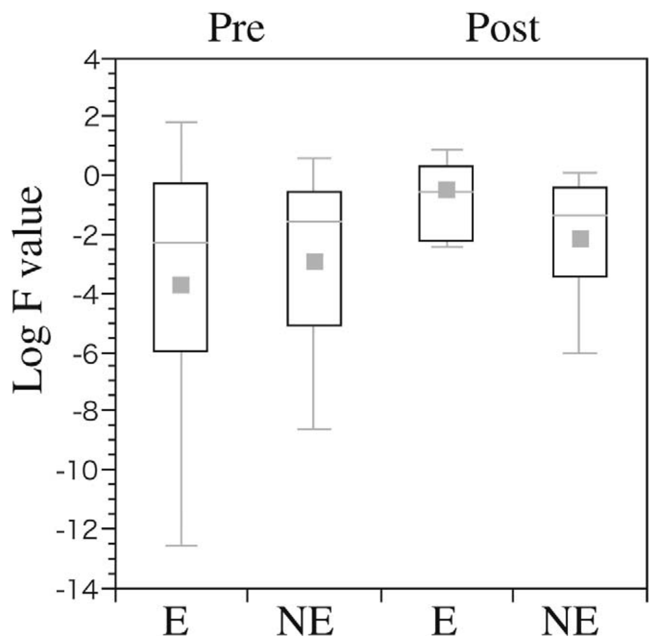

Figure 4. Comparison of lower dental arch form before and after treatment between the extraction and nonextraction groups. E = extraction group, NE = nonextraction group.

after treatment were compared between the extraction and nonextraction groups. For comparisons between groups, an unpaired *t*-test was used, while a paired *t*-test was used to compare radiographs obtained before and after treatment in each group. For model analysis, comparisons were made between the extraction and nonextraction groups using an unpaired *t*-test. For comparing the quantity of changes, a paired *t*-test was used. We used SPSS 14.0J (SPSS, Tokyo, Japan) for all statistical analyses.

Protocol for Preadjusted Appliance Technique

The subjects examined in the present study were treated using a preadjusted appliance (0.022 × 0.028 inch slot, MBT set up) according to the following procedure. The bracket height was set using the McLaughlin and Bennett[6] method for performing indirect bonding. The arch form (tapered, ovoid, square) was selected in accordance with the dental arch form, which was determined at the time of the first examination. After completing leveling and alignment of the lateral teeth using a 0.016-inch round heat-activated Ni-Ti wire and a 0.019 × 0.025 inch heat-activated Ni-Ti wire, a 0.019 × 0.025 inch stainless steel wire was attached for performing distal movement of the canine, followed by leveling and alignment of the incisor. The space was closed by sliding mechanics, while other details were adjusted by settling and transferring into retention.

RESULTS

Dental Arch Configuration

For the upper dental arch configuration, no statistically significant differences were observed before treatment between the extraction and nonextraction groups (Figure 3). As for the upper dental arch form after treatment, the log F values of the extraction group were significantly larger ($P < .05$), as the median was −0.33 and interquartile range was 2.29, compared with −2.76 and 3.07, respectively, for the nonextraction group. Furthermore, comparisons of the dental arch configuration before and after treatment in the extraction group revealed statistically significant differences ($P < .05$), as the median log F value before treatment was −1.35 and interquartile range was 4.97, compared with −0.33 and 2.29, respectively, after treatment. In contrast, no statistically significant difference was observed for the lower dental arch configuration before and after treatment or between the extraction and nonextraction groups (Figure 4).

Analysis of Cephalometric Radiographs

Our analysis of cephalometric radiographs obtained from the extraction and nonextraction groups before treatment (Table 1) demonstrated that the mean U1-APo of the extraction group (9.71 mm) was significantly larger than that of the nonextraction group (7.26 mm) ($P < .05$). However, no statistically significant dif-

Table 1. Comparison of cephalometric measurements between the 2 groups

Measurements	Extraction Group (n = 16)					Nonextraction Group (n = 10)				
	Pretreatment		Posttreatment			Pretreatment		Posttreatment		
	Mean	SD	Mean	SD	Difference	Mean	SD	Mean	SD	Difference
SNA (degrees)	82.17	3.61	82.37	3.65	0.2	81.89	3.33	81.73	3.69	−0.16
SNB (degrees)	79.11	4.16	79.36	3.76	0.25	78.63	3.94	78.68	3.98	0.05
Facial angle (degrees)	83.56	3.9	83.54	3.61	−0.02	85.68	4.6	84.56	4.18	−1.12
Mandibular plane (degrees)	33.85	4.3	33.35	4.54	−0.5	30.19	6.08	31.74	6.34	1.55
U1 to FH (degrees)	111.77	6.97	109.2	7.18	−2.57	111.01	11.04	112.65	5.6	1.64
L1 to Mandibular plane (degrees)	91.07	8.69	91.85	8.26	0.78	92.47	7.05	93.17	4.97	0.7
U1 to APO (mm)	9.71†	2.38	8.39	1.74	−1.31*††	7.26†	2.72	8.69	1.56	1.43††
L1 to APO (mm)	5.35	2.41	4.4††	1.8	−0.95	5.74	2.2	6.56††	1.34	0.82

† $P < .05$ (unpaired *t*-test); †† $P < .01$ (unpaired *t*-test); * $P < .05$ (paired *t*-test).

ferences were observed for other measurements obtained using the skeletal and dental measurements. As for the dental arch configuration after treatment, the mean L1-APo of the extraction group (4.40 mm) was significantly smaller than that of the nonextraction group (6.56 mm) ($P < .01$). However, no statistically significant differences were observed for the other measurements.

When the quantity of changes before and after treatment were compared, a statistically significant difference was observed between the extraction and nonextraction groups for U1-APo, which was decreased by 1.31 mm in the extraction group and increased by 1.43 mm in the nonextraction group ($P < .01$). For other measurement items, no significant differences were observed.

Analysis of Cast Models

Our comparisons of the cast models before treatment between the extraction and nonextraction groups revealed statistically significant differences in the upper posterior width (UPW) and lower posterior width (LPW). Further, the intermolar widths of the upper and lower arches of the extraction group were smaller (Table 2). Comparisons of the models after treatment revealed statistically significant differences in UPW, LPW, upper posterior length (UPL), and lower posterior length (LPL) between the groups. Also, the intermolar width and length of the upper and lower arches were smaller in the extraction group.

In the extraction group, comparisons of the models before and after treatment revealed a significant difference in UPW, while the intermolar width of the upper arch was decreased. Statistically significant differences were observed for upper arch length (UAL) and lower arch length (LAL) before and after treatment, while the upper and lower anterior lengths were increased. Statistically significant differences were also observed for UPL and LPL; the UPL and LPL were decreased. In the nonextraction group, comparisons of the models before and after treatment revealed significant differences in UAL and UPL, while the upper anterior and posterior lengths were increased.

As for maximum crown width, the extraction group showed significantly greater widths for all teeth except the second molar in the upper arch. In the lower arch, the width of the canine, as well as the first and second premolars, was significantly greater (Table 3). In addition, the arch length discrepancy (ALD) at the time of the first examination in the extraction group was significantly greater for both the upper (−8.16 mm) and lower arches (−6.54 mm) compared with those (−1.29 mm and −1.82 mm, respectively) in the nonextraction group.

DISCUSSION

In the present study of Class I crowding patients, no statistically significant differences were observed for the configuration of the upper and lower arches at the time of the first examination between the extraction and nonextraction groups. These results suggest that the dental arch form might be determined irrespective of the amount of discrepancy.

Ryu et al[7] investigated racial differences in regard to the dental arch form for the lower arch between Japanese and Indian females with normal occlusion. They reported that Japanese females had a smaller and more squared dental arch form, and showed more considerable variation than the Indian subjects, as their median log F value was −2.53, while that of the Indian subjects was −0.74. As for the lower arch form in the present extraction group, which was determined at the time of the first examination, the log F value was −2.28 and was considered to be similar to that of Japanese subjects with normal occlusion.

Table 2. Cast model analysis

	Extraction Group (n = 16)					Nonextraction Group (n = 10)				
	Pretreatment		Posttreatment			Pretreatment		Posttreatment		
Measurements	Mean	SD	Mean	SD	Difference	Mean	SD	Mean	SD	Difference
Upper arch width	36.18	3.67	36.97	2.08	−0.79	36.5	1.66	36.8	1.63	0.3
Upper posterior width	46.75†	2.59	45.62††	1.84	−1.13*	48.9†	2.35	49††	2.05	0.1
Upper arch length	12.38	2.13	15.29	1.16	−2.91**	13.0	0.93	14.4	1.20	1.4*
Upper posterior length	31.63	2.28	27.86††	1.48	−3.77**	31.8	1.12	32.5††	2.68	0.7*
Lower arch width	27.70	3.21	28.10	1.61	0.4	28.4	2.30	28.3	1.30	−0.1
Lower posterior width	40.4†	2.62	39.5††	1.88	−0.9	42.9†	2.10	43.1††	2.36	0.2
Lower arch length	8.0	1.70	9.90	1.07	−1.9**	8.8	1.22	9.9	1.37	1.1
Lower posterior length	26.2	2.53	22.8††	1.96	−3.8**	28.0	1.48	28.2††	1.76	0.2

† $P < .05$ (unpaired *t*-test); †† $P < .01$ (unpaired *t*-test); * $P < .05$ (paired *t*-test); ** $P < .01$ (paired *t*-test).

In the present study, the log F value for the upper dental arch was significantly increased from −1.35 before treatment to −0.33 after treatment in the extraction group. Since the log F value of the extraction group after treatment was larger than that of the nonextraction group (−2.76), the dental arch demonstrated a tapered pattern. In the nonextraction group, no statistically significant differences in log F values were observed for the upper and lower arch between the groups before and after treatment, indicating no changes in the dental arch form. As Hnat et al[8] reported, the dental arch form might be compensated by an increase in dental arch length. Accordingly, it can be considered that a decline in number of teeth might produce a tapered pattern. However, as a tapered pattern was only observed in the upper arch, we speculated that the factors involved might be different between the upper and lower arch. Heiser et al[4] studied the dental arch form using a three-dimensional method with extraction and nonextraction groups and reported that the anterior length of the upper dental arch was increased as a result of extraction, while the area of the anterior teeth was increased in both groups. In the present study, the anterior length of both the upper and lower dental arches was increased, which was considered to reflect similar changes.

Before treatment, ALD was −8.16 mm for the upper arch and −6.54 mm for the lower arch in the extraction group, while in the nonextraction group ALD was −1.29 mm for the upper arch and −1.82 mm for the lower arch. Because the ALD values for both arches were extremely large in the extraction group, we speculated that crowding might be uncommon in the nonextraction group, as those subjects had a dental arch form similar to normal occlusion.

As for the subjects in the present study, the width was greater for all teeth, excluding the upper second molar, in the extraction group than in the nonextrac-

Table 3. Tooth width and arch length discrepancy

	Extraction Group (n = 16)		Nonextraction Group (n = 10)		
Measurements	Mean	SD	Mean	SD	Significance[a]
Maxillary central incisor	9.09	0.46	8.39	0.24	**
Lateral incisor	7.63	0.32	7.03	0.6	*
Canine	8.38	0.4	7.92	0.35	**
1st premolar	7.59	0.41	7.2	0.35	*
2nd premolar	7.03	0.38	6.69	0.39	*
1st molar	10.67	0.54	10.17	0.4	*
2nd molar	10.18	0.56	10.06	0.91	NS
Mandibular central incisor	5.68	0.4	5.43	0.35	NS
Lateral incisor	6.25	0.35	6.02	0.44	NS
Canine	7.1	0.44	6.76	0.37	*
1st premolar	7.59	0.51	7.09	0.44	*
2nd premolar	7.54	0.56	6.89	0.48	**
1st molar	11.58	0.69	11.14	0.78	NS
2nd molar	11.02	0.63	10.59	0.83	NS
Maxillary arch length discrepancy	−8.16	4.43	−1.29	2.5	**
Mandibular arch length discrepancy	−6.54	4.27	−1.82	2.24	*

[a] NS indicates not significant.
* $P < .05$; ** $P < .01$ (unpaired *t*-test).

tion group. In addition, the widths of the canine and first and second premolars were greater in the lower arch. Accordingly, it was considered that crowding might be produced by the width of the crown.[9] Further, Shigenobu et al[10] speculated that ALD might be important for a symmetrical crowding pattern of the anterior teeth. It was considered that tapering of the upper dental arch in the present extraction group, which showed a large ALD value, might have resulted from an increase in anterior arch length to resolve crowding of the anterior teeth produced by a large amount of tooth width.

BeGole et al[11] suggested that intermolar width was likely to be increased by nonextraction treatment, and Weinberg and Sadowsky[12] reported that the dental arch expanded as a whole because of the performance of nonextraction therapy. In the present study, the length increased in the extraction group, whereas the intercanine and intermolar widths did not. Raberin et al[13] reported that an arch form that maintains the intercanine width should be selected, as the discrepancy was large in extraction cases. Further, Mutinelli et al[14] and Braun and Hnat[15] noted that it was important to determine the lower dental arch form by controlling the torque of the anterior teeth properly while maintaining intercanine width. We considered that the present findings in the extraction group supported the results of those previous studies, as the anterior teeth showed a tapered form while maintaining the intercanine width to resolve the large amount of ALD.

As for the dynamic state of the upper and lower anterior teeth, U1-APO was significantly reduced after treatment in the extraction group, which demonstrated posterior movement of the upper anterior teeth. Because U1-FH did not show any changes, it was considered that the teeth might have moved in a posterior direction by sliding mechanics, while the torque of the upper anterior teeth was kept and controlled properly. This result also suggested that a torque of -17° and angulation of 4° incorporated to the bracket for the upper central incisor would function effectively.

For the inclination of the lower anterior teeth, no significant difference was observed between before and after treatment. The lower incisor moved toward the posterior direction after treatment in the extraction group and toward the anterior direction in the nonextraction group. Nevertheless, a torque of -6° and angulation of 0° incorporated to the bracket for the lower incisor might be effective. Further, space remained after improvement of anterior teeth crowding, which suggested that the space was closed by mesial movement of the molars, as the intermolar width and anterior length of the dental arch were reduced.

On the basis of our findings, we considered that the sum of tooth widths of teeth anterior of the canine is greatly involved in determining the dental arch form. Further, it is suggested that treatment given to the upper and lower incisors by use of a preadjusted appliance is fully applicable for harmonizing the dental arch form of Japanese patients with Class I crowding.

CONCLUSION

- It is necessary to select an arch form that assumes a possible tapered pattern of the upper dental arch after extraction treatment in patients with Class I crowding.

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