Comparison of treatment effects with labial and lingual fixed appliances

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Pretreatment and posttreatment lateral cephalometric radiographs were evaluated for 120 patients—40 from each of three private practices. Twenty patients from each office had been treated with labial fixed appliances and 20 with lingual fixed appliances. There were no significant differences between labial and lingual appliances with respect to the change of any cephalometric measurement during treatment (posttreatment value minus pretreatment value). Differences among patients from the three offices were found only for upper incisor vertical position, and these appeared to reflect differences in treatment objectives rather than in appliances. However, several significant differences were found when changes during treatment were evaluated according to extraction pattern, without reference to the type of appliance used. There was no evidence that the mechanics required with lingual appliances necessarily led to any changes in treatment results, as determined by the cephalometric measurements used in this study. (Am J Orthod Dentofac Orthop 1991:99:202-9.)

Fixed, bonded, lingual appliances have been generally available since the early 1980s. These appliances have built-in mechanical differences from more widely used labial attachments. Bite opening, caused by occlusion of the lower incisors on the upper incisor lingual brackets, appears to create intrusive forces on the upper and lower incisors, while separation of upper and lower posterior teeth increases the tendency for posterior eruption. These conditions could produce anterior bite opening,[1,2] an increase in lower anterior facial height and the mandibular plane angle, and a hinging open of the mandible with a resulting increase in facial convexity.[3-9] Another feature of the lingual appliance is a shorter interbracket distance. Kurz and Bennett[10] suggest that this shorter distance decreases torque control and tends to lead to a more obtuse interincisal angle and more upright incisors in each arch, particularly in extraction cases.

These mechanical features of lingual appliances suggest that some differences between the results of treatment with labial and lingual appliances may be related to the appliance, rather than to the clinician's treatment objectives. If so, clinicians should take these differences into account when they select patients for lingual treatment.

The purpose of this study is to test for specific treatment differences and for other cephalometric differences between patients treated with labial and lingual fixed appliances.

MATERIALS AND METHODS

Sample selection

Records of 40 patients from each of three orthodontic offices (total sample size: 120) were examined. Twenty patients from each office had been treated with a labial appliance and 20 with lingual appliances (Table I). The following criteria were used for the selection of patients:

1. Patient was between 17 and 59 years of age at the start of treatment.

2. No functional appliance or surgical procedure had been used.

3. Ormco 0.018-inch appliances (Ormco Corp., Glendora, Calif.) had been used for all patients who wore lingual appliances.

4. Pretreatment malocclusion was either Class I or Class II.

5. No patient had pretreatment anterior open bite.

6. Treatment had begun between 1982 and 1987.

The results of treatment were not considered in the selection of cases. All cases that met the above criteria were made available, and the first 20 in each group were selected for study.

Data collection

All cephalometric radiographs were traced by the same investigator. Landmarks (Fig. 1) were digitized on a Numonics 2400 digitizer (Numonics Corp., Lansdale, Pa.). Point coordinates were stored in an IBM-PC XT computer, with the Orthodig digitizing program.[11] To evaluate digitizing error, 10 tracings were redigitized 2 months after their original evaluation. Errors were found to be consistent with the cephalometric measurement error in previous studies.[12] The greatest mean errors for angular and linear measurements were – 0.3° for U1-L1 and +0.16 mm for Lli-MP, respectively. Paired *t* tests for the first and second trials of the error analysis all had probabilities greater than 0.80. All measurement errors were less than 2 mm, or 3.5°, except for a 4° error in the OP-MP angle for one patient.

The following measurements were taken on all subjects:

1. Uli-SN (the perpendicular distance between the incisal edge of the upper central incisor and the sella-nasion line)

2. Ulcr-SN (the perpendicular distance between the upper central incisor center of resistance and the S-N line. The center of resistance was standardized as a point 16 mm apical to the incisal edge of the maxillary central incisors.)

3. Lli-MP (the perpendicular distance between the incisal edge of the lower central incisor and the mandibular plane. The mandibular plane was defined as the line formed by menton and constructed gonion.)

4. Llcr-MP (the perpendicular distance between the lower central incisor center of resistance and the mandibular plane. The center of resistance was standardized as a point 11 mm apical to the incisal edge of the mandibular central incisors.)

5 . U1-SN (upper incisor angulation, the angle formed by the long axis of the upper central incisor and the S-N line)

6. L1-MP (the angle formed by the long axis of the lower central incisor and the mandibular plane)

7. U1-L1 (interincisal angle, the angle formed by the long axes of the upper and lower central

incisors)

8. OP-MP (the angle formed by the occlusal plane and the mandibular plane, the occlusal plane being constructed by joining points bisecting the overbite of the central incisors and the occlusal contact of the first molars)

9. SN-MP (mandibular plane angle, the angle formed by the S-N line and the mandibular plane)

10. S-Gn (length of the Y axis, the distance between sella and gnathion)

11. N-S-Gn (Y-axis angle, the angle formed by the S-N line and the Y axis)

12. S-N-B (the angle formed by the S-N line and the nasion-point B line)

13. N-Me (total anterior facial height, the distance between nasion and menton)

14. Ans-Me (lower anterior facial height, the distance between the anterior nasal spine and menton)

15. S-Go (lower posterior facial height, the distance between sella and gonion)

Statistical analysis

Patients were divided into six groups according to the type of appliance used and the practitioner who had provided treatment. Records were examined in the offices of Dr. R.G. Alexander (Arlington, Texas), Dr. John C. Gorman (Marion, Indiana), and Dr. John R. Smith (Sanford, Florida). To provide confidentiality, each clinician is identified by a letter— A, B, or C, not necessarily in the same order as above. The cases were grouped according to the following criteria:

Group 1. Patients treated by Dr. A with 0.022-inch standard labial edgewise appliances

Group 2. Patients treated by Dr. A with 0.018-inch Ormco lingual appliances

Group 3. Patients treated by Dr. B with 0.018-inch pretorqued labial edgewise appliances

Group 4. Patients treated by Dr. B with 0.018-inch Ormco lingual appliances

Group 5. Patients treated by Dr. C with 0.018-inch pretorqued labial edgewise appliances

Group 6. Patients treated by Dr. C with 0.018-inch Ormco lingual appliances

Results were analyzed according to the extraction pattern used in treatment, as well as by office and appliance used. Since the number of cases for each practitioner for each extraction pattern was not sufficient for statistical analysis (Table I), the analysis of differences in results among the three extraction patterns was based on a pooled sample from all three offices.

Digitized landmarks were converted to cephalometric measurements with the assistance of the Orthodig program. Statistical analyses were performed on an IBM-PC XT computer with the

Systat package (Systat, Inc., Evanston, Ill.).[13]

Descriptive statistics for pretreatment values, posttreatment values, and the change during treatment (posttreatment value minus pretreatment value) were calculated for each of the six groups. Table II provides an interpretation of the values obtained from the calculation of changes during treatment.

A two-way analysis of variance was used to determine the effects of appliance and practitioner on each measurement. When a significant *F* ratio was observed, Tukey's HSD multiple comparison with an alpha of 0.05 was used to identify significantly different pairs of means.[14]

Data were also grouped according to the three patterns of extraction: no extractions, two upper premolars extracted, or four premolars extracted. Descriptive statistics for changes during treatment were calculated for each of these groups, and the labial and lingual cases were considered separately. A two-way analysis of variance, with extraction pattern and appliance (labial vs lingual) as the independent variables, was used to identify significant *F* ratios. Tukey's HSD multiple comparison was used as the a posteriori criterion to identify significantly different pairs of means.

RESULTS

Table III lists descriptive statistics for pretreatment values, sorted by practitioner and by appliance. The results of the two-way analysis of variance for practitioners and appliances, based on pre-treatment values, is shown in Table IV. The fact that there are no significant differences between patients who were treated with labial appliances and those treated with lingual appliances suggests that cephalometric criteria are not used *within* offices to select patients for labial or lingual treatment; all significant differences are *between* offices. The mean values for U1cr-SN and U1i-SN in office B were greater than in either of the other two offices, while anterior facial height was significantly greater in office B than in office A (Tables III and IV).

Statistics that describe the changes during treatment are shown in Table V. There were no significant differences between labial and lingual appliances *within* offices, with respect to the amount of change during treatment (Table VI), and statistically significant differences *between* offices were limited to upper incisor vertical position, with office A showing the greatest intrusion for both labial and lingual cases (Table VII).

Descriptive statistics for patients grouped according to extraction pattern are shown in Table VIII. A two-way analysis of variance (Table IX) indicates that there are no statistically significant differences between cases treated with labial and lingual appliances. The only statistically significant interaction between appliance and extraction pattern was for the S-N-B angle in nonextraction cases and in cases involving extraction of four premolars. Among nonextraction cases, the S-N B angle decreased 0.5° less in patients with labial appliances and in cases involving extracting four premolars, the S-N-B angle decreased 0.5° less in the patients with lingual appliances. Although not statistically significant, some clinically meaningful differences were found among the angulations of the upper incisor with respect to the S-N line in extraction cases. The mean decrease in the U1-SN angulation for both two-premolar extraction

and four-premolar extraction lingual appliance cases is several degrees greater than for similarly treated labial appliance cases. The lack of statistical significance is related to the high variability (standard deviation) in this angular change during treatment.

A number of highly significant differences between the extraction categories were independent of the type of appliances used (Table X). In particular, U1-SN angle, U1cr-SN, and U1i-SN increased in nonextraction cases only; the L1-MP angle decreased in cases with extraction of four premolars and increased more than 6° in nonextraction cases; L1cr-MP and L1i-MP decreased least in nonextraction cases; the U1-L1 (interincisal) angle increased an average of 6.4° with extraction of four premolars and decreased an average of 9.3° in nonextraction cases.

When data are grouped by office (Table V) or extraction pattern (Table VIII), the magnitude of upper incisor intrusion (U1cr-SN) is slightly greater for patients treated with lingual appliances than for those treated with labial appliances. This pattern is consistent within each office and within each extraction pattern. Although these differences are of borderline statistical significance (Tables VI and IX), the fact that they consistently average less than 1.0 mm suggests that the effect is of minimum clinical significance.

DISCUSSION

Other than case reports, there have been only two investigations concerning treatment effects with fixed lingual appliances. No previous study has compared labial and lingual cases treated by an individual practitioner, and none has evaluated differences in results among practitioners. In a study of patients treated with lingual appliances, Fulmer and Kuftinec[7] reported that increases in the mandibular plane angle were minimal (mean of 0.5° in nonextraction cases and 0.6° in extraction cases) and that torque control seemed adequate. Maxillary incisors did not show significant intrusion, but mandibular incisors were observed to intrude 2.0 mm in extraction cases. These findings are generally consistent with those of the present study. Although we did find 2.1 mm of lower incisor intrusion in cases with lingual appliances and extraction of four premolars, compared to 1.4 mm of intrusion in the corresponding labial-appliance cases (Table VIII), the difference is not statistically significant. Baker[8] reported a proclination of 2.0° and a depression of 0.5 mm for the mandibular incisors. The results of this study show a mean increase of 3.37° in L1-MP for lingual-appliance cases and a mean 1.4 mm intrusion of the lower incisor, but when these measurements are compared with those in the cases involving treatment with labial appliances, the differences are not statistically significant.

Clinical evaluations have suggested that the bite opening resulting from occlusion on the maxillary incisor bite plane by the lower incisors may increase lower facial height by allowing extrusion of molars.[3,4,6] This molar extrusion may, in turn, lead to posterior rotation of the mandible,[3,4,6] while the contact of the lower incisors with the biteplane on the upper incisor brackets may cause intrusion of upper and lower incisors.[3,5] Our results indicate a mean increase of 0.8 mm in lower facial height, 0.4° of opening of the Y axis, 0.5 mm of upper incisor intrusion, and 1.4 mm of lower incisor intrusion. However, these changes during treatment with lingual appliances did not significantly differ from those observed when labial appliances were used. The interaction between extraction pattern and appliance that influenced change in the

U1-SN angle tended to support the hypothesis of decreased incisor torque control in lingual appliance cases.[10] However, the differences were not statistically significant.

The only change during treatment that was significantly different among the three practitioners was the vertical movement of upper incisors (Table VI), and this difference may primarily reflect differences among the practitioners with respect to treatment goals. Observations in each office suggested that practitioner A used more mechanics specifically designed to intrude upper incisors (such as J-hook headgear) than the others. However, there were no differences with respect to change during treatment when data were grouped according to appliance.

Grouping the data by extraction pattern revealed several statistically significant differences (Tables IX and X). Extraction pattern clearly exerted more influence on the change during treatment than did either the appliance or the practitioner.

It should be noted that all of the practitioners in this study are members of the original Ormco lingual task force,[3] and have been using the appliance since 1980. It may be that these clinicians achieved results that are not typical for practitioners who are treating their first few cases with lingual appliances.

In summary, our analysis of cephalometric measurements in this study revealed no statistically significant differences in treatment results between labial and lingual appliances. Significant differences in results were found only when the cases were grouped with respect to practitioner or extraction pattern, rather than type of appliance used. It is important to note that differences in the length of treatment and in occlusion, as shown by dental casts, were not evaluated in this study. Although different techniques are required for successful management of the lingual appliance and the labial appliance, the cephalometric data evaluated in this study revealed no evidence that practitioners must limit the range of treatment goals when they use lingual appliances.

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FIGURES

Fig. 1

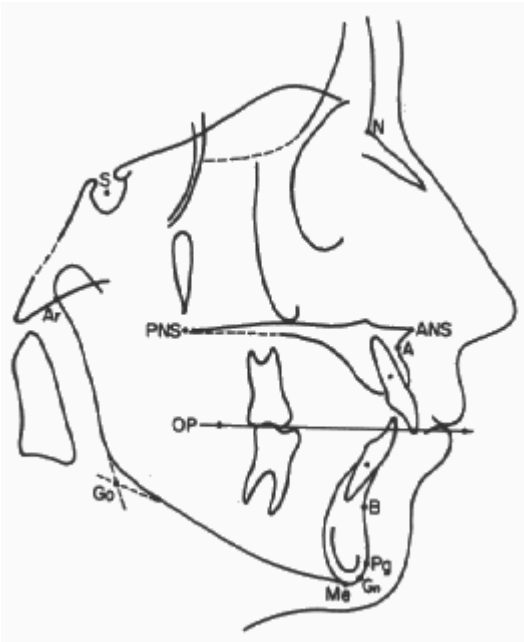

Fig. 1. Cephalometric landmarks. Nasion *(N),* sella *(S),* articulare *(Ar),* posterior nasal spine *(PNS),* anterior nasal spine *(ANS),* subspinale *(A),* incision superius *(Is),* incision inferius *(Ii),* supramentale *(B),* pogonion *(Pg),* gnathion *(Gn),* menton *(Me),* constructed gonion *(Go),* occlusal plane *(OP).* The points selected for the center of resistance of maxillary and mandibular central incisors are indicated but not labelled.

TABLES

Table I

Table I. Distribution of patients by office, appliance, and extraction pattern

Extraction pattern	*Office A*		*Office B*		*Office C*		*Total*	
	Labial	*Lingual*	*Labial*	*Lingual*	*Labial*	*Lingual*	*Labial*	*Lingual*
Nonextractions	6	5	9	14	12	9	27	28
Extraction of two premolars	5	5	6	2	3	6	14	13
Extraction of four premolars	9	10	5	4	5	5	19	19

Table II

Table II. Interpretation of negative-value changes during treatment

Cephalometric measurement	*Negative-value change*
Uli-SN (mm)	Upper incisor intrusion
Ulcr-SN (mm)	Upper incisor intrusion
Lli-MP (mm)	Lower incisor intrusion
Llcr-MP (mm)	Lower incisor intrusion
U1-SN (degrees)	Upper incisor root labial (crown lingual)
L1-MP (degrees)	Lower incisor root labial (crown lingual)
U1-L1 (degrees)	Decrease of interincisal angle
OP-MP (degrees)	Decrease of OP-MP angle
SN-MP (degrees)	Decrease of mandibular plane angle
S-Gn (mm)	Decrease of Y- axis length
N-S-Gn (degrees)	Decrease of Y- axis angle
S-N-B (degrees)	Distal movement of point B
N-Me (mm)	Decrease of anterior facial height
Ans-Me (mm)	Decrease of lower anterior facial height
S-Go (mm)	Decrease of posterior facial height

Table III

Table III. Descriptive statistics for pretreatment measurements, grouped by office and appliance

Cephalometric measurement	*Office A*				*Office B*			
	Labial		*Lingual*		*Labial*		*Lingual*	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Uli-SN (mm)	81.6	4.8	82.8	5.0	85.0	4.1	84.3	4.8
Ulcr-SN (mm)	66.8	4.7	68.3	4.8	70.5	3.9	69.8	4.9
Lli-MP (rnm)	41.4	3.3	42.5	3.5	43.0	4.6	43.5	3.9
Llcr-MP (mm)	31.3	3.3	32.4	3.3	33.1	4.6	33.4	3.9
Ul-SN (degrees)	100.0	6.9	102.7	10.9	92.3	11.0	100.4	10.8
Ll-MP (degrees)	97.5	5.1	97.7	5.9	95.4	8.9	94.5	3.7
Ul-Ll (degrees)	129.6	7.8	127.2	12.4	134.8	15.9	134.5	15.0
OP-MP (degrees)	16.8	3.7	14.9	3.5	16.9	5.7	17.3	3.6
SN-MP (degrees)	32.8	4.0	32.4	5.4	34.6	7.1	30.7	3.6
S-Gn (mm)	121.9	7.8	125.1	5.3	128.2	7.6	129.4	9.4
N-S-Gn (degrees)	67.8	3.1	68.3	3.9	68.2	4.3	65.7	2.2
S-N-B (degrees)	77.0	2.9	76.8	3.9	76.6	4.1	79.2	2.8
N-Me (mm)	117.6	7.0	120.7	8.1	124.4	7.1	122.9	8.4
Ans-Me (mm)	67.8	6.5	68.8	6.2	71.9	6.1	69.9	6.3
S-Go (mm)	77.8	7.4	79.7	6.7	80.6	7.4	83.1	6.6

Table III 2nd Half

Office C			
Labial		*Lingual*	
$\bar{x}$	*SD*	$\bar{x}$	*SD*
81.1	4.4	84.4	4.0
66.8	4.4	69.9	4.1
41.9	3.6	43.2	3.9
31.9	3.6	33.3	4.1
101.0	11.2	98.7	8.9
92.9	6.4	95.1	7.0
133.0	14.5	131.7	13.9
18.4	3.9	17.4	3.S
33.1	4.9	34.5	7.6
125.2	6.9	126.4	8.1
66.3	3.0	68.6	5.5
77.7	3.6	76.8	4.8
120.0	6.3	123.3	6.8
68.9	5.5	70.5	6.2
78.4	5.9	79.9	6.9

Table IV

Table IV. Two-way analysis of variance for differences and between two types of appliances

Chephalometric measurement	*Variance among offices*		*Variance between appliances*		*Interaction*	
	F ratio	*Significance*	*F ratio*	*Significance*	*F ratio*	*Significance*
Uli-SN (mm)	3.22	0.044	2.39	0.125	1.88	0.158
Ulcr-SN (mm)	3.60	0.031	2.54	0.114	1.86	0.161
Lli-MP (mm)	1.20	0.306	1.89	0.172	0.14	0.872
Llcr-MP (mm)	1.36	0.260	1.77	0.186	0.23	0.793
Ul-SN (degrees)	1.23	0.297	1.00	0.320	1.40	0.250
Ll-MP (degrees)	2.69	0.072	0.13	0.718	0.50	0.611
Ul-Ll (degrees)	2.15	0.122	0.29	0.590	0.06	0.939
OP-MP (degrees)	2.56	0.082	1.16	0.280	0.84	0.436
SN-MP (degrees)	0.59	0.554	0.92	0.339	2.29	0.106
S-Gn (mm)	4.81	0.010	1.76	0.188	0.24	0.787
N-S-Gn (degrees)	0.76	0.469	0.02	0.902	4.04	0.020
S-N-B (degrees)	0.72	0.489	0.47	0.494	2.39	0.097
N-Me (mm)	3.72	0.027	1.55	0.216	1.40	0.251
Ans-Me (mm)	1.82	0.167	0.02	0.903	0.97	0.382
S-Go (mm)	2.55	0.083	2.60	0.110	0.07	0.933

Table V

Table V. Descriptive statistics for the changes in cephalometric measurements during treatment, grouped by office and appliance

Chephalometric measurement	*Office A*				*Office B*			
	Labial appliance		*Lingual appliance*		*Labial appliance*		*Lingual appliance*	
	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*
Uli-SN (mm)	–0.6	2.0	–0.8	1.7	0.2	1.6	0.2	1.4
Ulcr-SN (mm)	–0.4	2.0	–1.2	1.5	0.2	1.6	0.0	1.3
Lli-MP (mm)	–1.4	1.5	–1.8	1.8	–1.6	1.7	–1.6	1.5
Llcr-MP (mm)	–1.4	1.5	–1.8	1.8	–1.5	1.6	–1.4	1.3
Ul-SN (degrees)	2.2	9.1	–5.1	9.9	0.6	12.0	–0.6	11.2
Ll-MP (degrees)	0.9	5.7	2.3	8.1	3.5	6.9	4.6	7.1
Ul-Ll (degrees)	–3.9	12.0	2.5	15.4	–4.4	16.0	–4.2	16.7
OP-MP (degrees)	–1.2	0.5	–0.4	0.2	–1.2	2.6	–1.5	3.1
SN-MP (degrees)	0.8	1.1	0.6	1.2	0.4	1.6	0.3	1.5
S-Gn (mm)	0.5	1.8	0.0	1.4	0.7	1.5	0.4	1.8
N-S-Gn (degrees)	0.5	1.1	0.4	1.0	0.1	1.2	0.4	1.2
S-N-B (degrees)	–0.6	1.0	–0.5	0.9	–0.2	1.0	–0.5	0.8
N-Me (mm)	1.1	1.6	0.3	1.7	0.6	1.9	0.7	1.8
Ans-Me (mm)	1.3	1.8	1.0	1.5	0.7	1.9	0.9	1.7
S-Go (mm)	0.1	1.4	–0.1	1.5	0.1	1.5	0.3	1.1

Table V 2nd Half

Office C			
Labial appliance		*Lingual applianc*	
$\bar{X}$	*SD*	$\bar{X}$	*SD*
0.6	1.2	–0.1	0.9
0.4	1.1	–0.2	1.1
–1.0	1.5	–1.1	1.4
–1.0	1.5	–1.1	1.4
–1.0	12.1	0.3	8.2
2.4	6.0	3.2	6.6
–1.9	16.2	–3.4	13.9
–2.4	2.6	–0.9	2.0
0.5	0.8	0.0	1.1
0.4	0.9	0.5	0.9
0.4	0.7	0.3	0.7
–0.3	0.5	–0.3	0.5
0.8	1.4	0.5	1.3
0.9	1.4	0.5	1.2
0.3	1.1	0.5	1.2

Table VI

Table VI. Two-way analysis of variance for differences between appliances in treatment effects* among offices and between appliances

Cephalometric measurement	*Among offices*		*Between appliances*		*Interaction*	
	F ratio	*Significance*	*F ratio*	*Significance*	*F ratio*	*Significance*
Uli-SN (mm)	5.41	0.006	1.30	0.256	0.57	0.566
Ulcr-SN (mm)	4.87	0.009	3.48	0.064	0.44	0.645
Lli-MP (mm)	1.42	0.247	0.30	0.587	0.18	0.837
Llcr-MP (mm)	1.40	0.251	0.20	0.657	0.30	0.740
Ul-SN (degrees)	0.23	0.793	1.68	0.198	1.90	0.154
Ll-MP (degrees)	1.28	0.281	0.73	0.394	0.02	0.981
Ul-Ll (degrees)	0.58	0.564	0.38	0.538	0.76	0.469
OP-MP (degrees)	0.82	0.445	1.71	0.193	1.10	0.335
SN-MP (degrees)	1.30	0.276	1.50	0.224	0.43	0.651
S-Gn (mm)	0.53	0.588	0.82	0.369	0.42	0.656
N-S-Gn (degrees)	0.36	0.697	0.005	0.942	0.33	0.720
S-N-B (degrees)	0.92	0.402	0.13	0.719	0.35	0.703
N-Me (mm)	0.04	0.965	1.25	0.266	0.58	0.562
Ans-Me (mm)	0.82	0.442	0.15	0.700	0.36	0.698
S-Go (mm)	0.83	0.440	0.25	0.617	0.26	0.771

*Treatment effects = posttreatment values – pretreatment values.

Table VII

Table VII. Group means and associated Tukey HSD values for appliance effects with statistically significant F ratios between offices

Cephalometric measurement	*Office A*	*Office B*	*Office C*	*Tukey*
	$\bar{X}$	$\bar{X}$	$\bar{X}$	*HSD*
Uli-SN (mm)	–0.7	0.2	0.3	0.57
Ulcr-SN	–0.8	0.1	0.1	0.55

Table VIII

Table VIII. Treatment effects grouped according to extraction pattern and type of appliance used

Cephalometric measurement	*Labial appliance*						*Lingual appliance*					
	No extractions		*Extraction of two premolars*		*Extraction of four premolars*		*No extractions*		*Extraction of two premolars*		*Extraction of four premolars*	
	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*	$\bar{X}$	*SD*
Uli-SN (mm)	0.4	1.4	–0.1	1.5	–0.3	2.1	0.1	1.2	–0.9	1.2	–0.4	1.7
Ulcr-SN (mm)	0.5	1.4	–0.4	1.5	–0.4	1.8	0.0	1.2	–1.2	1.2	–0.7	1.6
Lli-MP (mm)	–0.9	1.6	–2.1	1.7	–1.4	1.4	–1.0	1.2	–1.7	1.8	–2.1	1.7
Llcr-MP (mm)	–0.8	1.5	–1.9	1.5	–1.7	1.5	–0.8	1.1	–1.7	1.6	–2.1	1.8
Ul-SN (degrees)	3.2	9.1	–0.2	11.6	–2.5	12.8	2.2	10.0	–3.2	10.1	–7.1	7.2
Ll-MP (degrees)	5.4	5.6	2.2	4.6	–2.2	5.3	6.7	6.0	3.6	6.2	–1.8	6.7
Ul-Ll (degrees)	–9.2	13.4	–2.6	14.0	4.1	14.1	–9.4	13.8	–0.4	14.2	8.7	12.4
OP-MP (degrees)	–1.9	2.5	–2.3	3.6	–0.7	2.9	–1.1	2.7	–0.1	2.4	–1.2	2.2
SN-MP (degrees)	0.5	1.1	0.6	1.6	0.6	1.0	0.4	1.4	0.0	1.3	0.3	1.2
S-Gn (mm)	0.8	1.0	0.7	1.9	0.0	1.6	0.3	1.6	0.4	0.9	0.2	1.4
N-S-Gn (degrees)	0.3	0.8	0.6	1.3	0.2	1.0	0.5	0.8	0.3	1.1	0.1	1.1
S-N-B (degrees)	–0.1	0.8	–0.4	1.0	–0.7	0.8	–0.6	0.8	–0.4	0.8	–0.2	0.5
N-Me (mm)	0.9	1.2	1.1	2.5	0.6	1.5	0.5	1.6	0.6	1.7	0.4	1.7
Ans-Me (mm)	1.1	1.3	1.3	2.3	0.4	1.8	0.7	1.2	0.9	1.8	0.9	1.7
S-Go (mm)	0.2	1.4	0.4	1.5	–0.2	1.1	0.1	1.3	0.6	1.2	0.3	1.3

Treatment effects = posttreatment values – pretreatment values.

Table IX

Table IX. Two-way analysis of variance for differences in treatment effects by extraction pattern and appliance

Cephalometric measurement	*Extraction*		*Appliance*		*Interaction*	
	F Ratio	*Significance*	*F Ratio*	*Significance*	*F ratio*	*Significance*
Uli-SN (mm)	3.11	0.048	1.69	0.196	0.42	0.656
Ulcr-SN (mm)	5.84	0.004	3.90	0.051	0.25	0.779
Lli-MP (mm)	4.75	0.010	0.19	0.660	0.97	0.383
Llcr-MP (mm)	7.92	0.001	0.19	0.661	0.40	0.672
Ul-SN (degrees)	6.29	0.003	2.16	0.144	0.37	0.693
Ll-MP (degrees)	21.68	0.000	0.81	0.369	0.07	0.928
Ul-Ll (degrees)	15.02	0.000	0.71	0.402	0.35	0.707
OP-MP (degrees)	0.45	0.641	2.34	0.128	2.00	0.140
SN-MP (degrees)	0.23	0.795	1.96	0.164	0.33	0.718
S-Gn (mm)	1.27	0.284	0.50	0.482	0.82	0.445
N-S-Gn (degrees)	1.09	0.339	0.06	0.804	0.66	0.521
S-N-B (degrees)	0.25	0.777	0.01	0.921	4.59	0.012
N-Me (mm)	0.40	0.670	1.22	0.271	0.10	0.902
Ans-Me (mm)	0.51	0.600	0.09	0.761	0.92	0.400
S-Go (mm)	0.85	0.431	0.46	0.497	0.58	0.564

Table X

Table X. Group means and associated Tukey HSD values with statistically significant F ratios between extraction groups

Cephalometric measurement	*Nonextraction* $\bar{x}$	*Extraction of two Premolars* $\bar{x}$	*Extraction of four Premolars* $\bar{x}$	*Tukey HSD*
Uli-SN (mm)	0.3	–0.5	–0.3	0.58
Ulcr-SN (mm)	0.3	–0.8	–0.5	0.55
Lli-MP (mm)	–0.9	–1.9	–1.8	0.57
Llcr-MP (mm)	–0.8	–1.8	–1.9	0.55
U1-SN (degrees)	2.7	–1.6	–4.8	3.80
L1-MP (degrees)	6.1	2.9	–2.0	2.19
U1-L1 (degrees)	–9.3	–1.6	6.4	5.09

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