Original Article

Effects of Extraction and Nonextraction Treatment on Class I and Class II Subjects

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Abstract: This study aims to examine the profile as well as the dentoalveolar and skeletal effects of extraction or nonextraction treatment in a wide range of patients including Class I and Class II, division 1 cases. Results achieved with extraction and nonextraction modalities have also been compared. The study was performed on pretreatment and posttreatment lateral cephalograms of 87 orthodontic patients. There were no significant differences between the pretreatment values of extraction and nonextraction Class I groups, whereas SN-GoGn (°), maxillary incisor to A-Po (°), mandibular incisor to A-Po (mm), Co-Gn (mm), overjet (mm), and overbite (mm) measurements of extraction Class II group were significantly higher before the treatment. After treatment, these differences were eliminated in the Class II group; however, incisors were significantly protruded in both nonextraction groups. No other differences in profile or lip position were found between the extraction and nonextraction groups. The results of this study indicate that in successfully treated cases, whether by extraction or nonextraction, the same soft and hard tissue profile posttreatment end points were reached except for the incisor positioning, which is rather easier to anticipate than profile and soft tissue changes. The simple statement that extraction means a more retrusive or dished-in profile seems to be unacceptable. It seems that a more thorough assessment and investigation including pretreatment extent of crowding and factors related to anchorage, soft tissue thickness, and strain should be carried out. (*Angle Orthod* 2003;73:36–42.)

Key Words: Extraction; Nonextraction

INTRODUCTION

For more than 100 years, soon after that the practitioners recognized that orthodontic treatment can influence the patient's profile and esthetics, the extraction of teeth in orthodontics has been a matter of debate.[1]

Angle[2,3] believed that the face of the Greek God Apollo contained all the essentials of harmony and beauty. According to Angle,[2,3] maintenance of a full complement of teeth would establish the best harmony, and nature would allow this to happen through growth, development, and function. Angle's student Tweed,[4] on the other hand, was not pleased with the facial imbalance found in a great majority of the patients he had treated without extractions, and his clinical studies led him to re-treat more than 100 of his nonextraction patients with premolar extractions.

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Orthodontic treatment by removing teeth had been widely accepted for many types of patients for better long-term stability.[5–7] But nonextraction treatments have again gained widespread popularity[8,9] with the concerns of condylar displacement, narrowed smiles with dark corners, dished-in profiles with extractions, and suboptimal mandibular growth.[10–19]

Some treatments, including premolar extractions, produce changes in the facial profile. Therefore, it is useful for the clinician to know the effects of different treatment options and what they offer the patient.[20] Recent studies of extraction vs nonextraction treatment have focused on the profile effects of these treatments. Regardless of the composition of the panels that are asked to render an opinion on a particular profile view in some studies, extraction and nonextraction treatments do not seem to produce very different results.[15,21–25] Thus, the choice of treatment should depend not only on the profile but may be also on some other skeletal and dental parameters. The question then is not which treatment is better but rather under what conditions is each preferable.[20]

Therefore, this study aims to examine not only the profile but also the dentoalveolar and skeletal effects of extraction or nonextraction treatment in a wide range of patients including Class I and Class II, division 1 cases.

TABLE 1. Age and Gender Distribution of Patients Included in This Study

	Male	Female	n	Age, y	Treatment Period, y
Class I					
Extraction	9	13	22	14.51 ± 2.01	1.86 ± 0.29
Nonextraction	10	15	25	13.57 ± 1.83	1.59 ± 0.43
Class II					
Extraction	7	13	20	17.39 ± 3.65	2.04 ± 0.46
Nonextraction	8	12	20	12.71 ± 0.96	1.94 ± 0.41
Total			87	14.27 ± 2.76	1.85 ± 0.43

MATERIALS AND METHODS

Sample

A sample of 87 orthodontic patients (42 extraction and 45 nonextraction) was included in this retrospective study (Table 1). Three faculty members or graduate students under supervision of these same faculty members treated the patients. Class III patients and nonextraction patients who had not undergone at least 18 months of fixed-appliance therapy were excluded. Nonextraction treatments were initiated after all permanent teeth had erupted. The extraction sample consisted of premolar extractions in both arches. The patients were grouped as Class I extraction, Class I nonextraction, Class II extraction, and Class II nonextraction.

Measurements obtained

The same cephalometric device was used to obtain all cephalograms. Various sagittal and vertical measurements have been derived and are listed in Tables 2 and 3. Pretreatment and posttreatment lateral cephalograms were gathered for all 87 subjects. Lateral cephalograms were manually traced before being transferred to RMO JOE software (Rocky Mountain Orthodontics JOE, version 5.0, Denver, Colo) by a digitizer. Thirteen angular and six linear measurements were carried out. Measurements that are not included in the software were measured manually.

Landmarks used in the study are shown in Figure 1.

The following measurements were performed:

1. SNA (°): The angle formed by the planes Sella-Nasion and Nasion-Point A.
2. SNB (°): The angle formed by the planes Sella-Nasion and Nasion-Point B.
3. ANB (°): The angle formed by the planes Nasion-Point A and Nasion-Point B.
4. SN-GoGn (°): The angle formed by lines Sella-Nasion and Gonion-Gnathion.
5. Facial axis (°): The angle formed by the plane CC to Gnathion and the Basion-Nasion plane.
6. Occlusal plane to Sella-Nasion (°): The angle formed between the occlusal plane and Sella-Nasion.
7. A1 to SN Sella-Nasion plane (°): Angle from A1 (upper incisor) to Sella-Nasion plane.
8. A1 inclination to A-Po (°): The angle formed by the long axis of the upper incisor to a plane from hard tissue Point A to Pogonion.
9. IMPA (°): The angle formed by the long axis of the lower incisor and the mandibular plane.
10. B1 inclination to A-Po (°): The angle formed by the long axis of the lower incisor to a plane from hard tissue Point A to Pogonion.
11. Interincisal angle (°): The angle formed by the long axis of the upper and lower incisors.
12. Holdaway H angle (°): The angle formed by the esthetic plane and the Holdaway line.
13. Z angle (°): The chin and upper- or lower-lip (choose the most anterior lip) soft tissue profile line related to the Frankfort horizontal.
14. A1 to A-Po plane (mm): Measured from the tip of the upper incisor to a plane from hard tissue Point A to Pogonion.
15. B1 to A-Po plane (mm): Measured from the tip of the lower incisor to a plane from hard tissue Point A to Pogonion.
16. Condylion-Gnathion (mm): Measured from Condylion to Gnathion.
17. Lower lip to esthetic plane (mm): Measured from the most anterior point on the lower lip to a plane from the tip of the nose to the most anterior point on the chin.
18. Incisor overjet (mm): Measured from the tip of the lower incisor to the tip of the upper incisor along the occlusal plane.
19. Incisor overbite (mm): Measured from the tips of the upper and lower incisors perpendicular to the occlusal plane.

All statistical analyses were performed using the SPSS software package (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, Ill). For each variable, the arithmetic mean and standard deviation were calculated. A paired-samples *t*-test was used to evaluate the treatment changes within each group. To compare the changes observed in both groups, independent-samples *t*-test was performed.[26]

Two weeks after the first measurements, 30 radiographs were selected at random, retraced, and redigitized, and a paired-samples *t*-test was applied to the first and second measurements (both computer and handmade). The difference between the first and second measurements of the 30 radiographs was insignificant. Correlation analysis applied to the same measurements showed the highest *r* value, 0.996, for the SNB and the lowest *r* value, 0.897, for the facial axis measurement.[27]

RESULTS

The results of this study are presented in Tables 2 and 3.

TABLE 2. Pretreatment and Posttreatment Mean Values and Standard Deviations of Measurements for the Extraction and Nonextraction Class I Groups and Results of Statistical Comparisons

	Extraction						
							P-value
	Pretreatment		Posttreatment		Difference		Paired-Samples
	Mean	SD	Mean	SD	Mean	SD	*t*-test
SNA (°)	79.59	2.91	79.32	3.24	−0.27	2.27	.579
SNB (°)	77.00	2.91	77.36	3.05	0.36	1.84	.364
ANB (°)	2.59	0.85	1.91	1.11	−0.68	1.04	.006**
SN-GoGn (°)	36.95	5.80	35.95	5.54	−1.00	3.22	.160
Facial axis (°)	84.05	5.24	83.96	4.67	−0.09	3.02	.889
Occlusal plane to Sella-Nasion (°)	16.41	3.46	15.59	4.24	−0.82	3.23	.248
A1 to SN Sella-Nasion plane (°)	77.64	5.25	77.09	6.02	−0.55	6.09	.679
A1 inclination to A-Po (°)	27.68	5.79	26.27	5.61	−1.41	5.42	.236
IMPA (°)	91.86	6.38	90.95	5.36	−0.91	5.77	.468
B1 inclination to A-Po (°)	23.45	4.19	23.32	4.61	−0.13	4.51	.889
Interincisal angle (°)	128.95	8.89	130.59	9.16	1.64	8.76	.391
Holdaway H angle (°)	6.28	3.97	7.45	3.65	1.17	2.22	.021*
Z angle (°)	72.32	9.43	74.36	6.97	2.04	6.56	.158
A1 to A-Po plane (mm)	6.36	2.50	5.68	2.40	−0.68	1.32	.025*
B1 to A-Po plane (mm)	2.73	2.57	2.50	2.39	−0.23	1.66	.528
Condylion-Gnathion (mm)	111.77	5.47	114.86	4.82	3.09	4.30	.003**
Lower lip to esthetic plane (mm)	−1.86	3.24	−2.86	2.88	−1.00	2.20	.045*
Incisor overjet (mm)	3.82	1.10	2.89	0.75	−0.93	0.76	.000***
Incisor overbite (mm)	0.91	1.57	1.41	0.73	0.50	1.79	.205

* $P < .05$, ** $P < .01$, *** $P < .001$.

TABLE 3. Pretreatment and Posttreatment Mean Values and Standard Deviations of Measurements for the Extraction and Nonextraction Class II Groups and Results of Statistical Comparisons

	Extraction						
							P-value
	Pretreatment		Posttreatment		Difference		Paired-Samples
	Mean	SD	Mean	SD	Mean	SD	*t*-test
SNA (°)	80.61	3.70	78.17	2.43	−2.44	2.53	.001**
SNB (°)	74.72	3.12	74.72	2.39	0.00	1.71	1.000
ANB (°)	5.94	1.11	3.44	1.50	−2.50	1.58	.000***
SN-GoGn (°)	39.27	5.67	39.44	5.17	0.17	2.53	.783
Facial axis (°)	82.72	3.72	82.72	3.49	0.00	2.87	1.000
Occlusal plane to Sella-Nasion (°)	16.44	4.33	18.56	5.22	2.12	3.58	.023*
A1 to SN Sella-Nasion plane (°)	76.78	6.20	81.78	5.55	5.00	5.86	.141
A1 inclination to A-Po (°)	32.94	5.03	25.61	4.79	−7.33	6.48	.002**
IMPA (°)	93.17	6.30	93.06	5.84	−0.11	6.69	.945
B1 inclination to A-Po (°)	22.50	5.16	25.61	5.47	3.11	6.67	.064
Interincisal angle (°)	124.83	7.49	129.00	8.33	4.17	9.62	.084
Holdaway H angle (°)	2.78	2.34	4.61	2.38	1.83	2.36	.004**
Z angle (°)	69.28	7.85	68.44	7.33	−0.84	6.35	.585
A1 to A-Po plane (mm)	9.22	2.80	6.50	1.92	−2.72	2.35	.000***
B1 to A-Po plane (mm)	2.50	2.31	3.56	2.25	1.06	1.89	.030*
Condylion-Gnathion (mm)	113.94	5.20	116.11	4.79	2.17	5.25	.098
Lower lip to esthetic plane (mm)	−0.39	3.20	−1.00	2.83	−0.61	3.31	.444
Incisor overjet (mm)	6.89	2.08	3.11	0.68	−3.78	2.05	.000***
Incisor overbite (mm)	1.44	2.64	1.56	0.71	0.12	2.42	.848

* $P < .05$, ** $P < .01$, *** $P < .001$.

TABLE 2. Extended

Nonextraction							
						P-value	
Pretreatment		Posttreatment		Difference		Paired-Samples *t*-test	Independent-Samples *t*-test
Mean	SD	Mean	SD	Mean	SD		
79.04	4.19	78.72	4.39	−0.32	1.82	.388	.937
76.96	4.19	77.00	4.28	0.04	1.59	.901	.521
2.16	1.11	1.80	0.96	−0.36	1.19	.142	.331
35.32	6.39	34.92	6.28	−0.40	2.29	.391	.462
86.12	4.90	86.24	4.78	0.12	2.26	.793	.786
17.16	4.11	16.56	4.14	−0.60	3.61	.414	.829
77.52	6.61	74.64	5.45	−2.88	6.30	.031*	.205
26.96	5.01	29.12	4.70	2.16	5.22	.049*	.026*
93.00	6.44	94.76	6.21	1.76	6.42	.183	.143
23.80	7.09	26.56	5.39	2.76	8.13	.103	.145
129.32	10.82	124.72	7.74	−4.60	10.27	.035*	.031*
6.24	2.57	6.24	3.05	0.00	2.36	1.000	.085
73.12	7.01	72.00	8.12	−1.12	5.26	.298	.073
6.40	2.36	6.60	2.24	0.20	1.85	.593	.070
2.60	2.86	3.48	2.16	0.88	2.55	.098	.090
112.84	6.59	114.76	6.15	1.92	3.99	.024*	.338
−2.16	2.59	−1.36	3.03	0.80	2.10	.069	.006**
3.48	1.12	2.56	0.58	−0.92	1.00	.000***	.964
0.92	2.36	1.32	0.69	0.40	2.47	.425	.876

TABLE 3. Extended

Nonextraction							
						P-value	
Pretreatment		Posttreatment		Difference		Paired-Samples *t*-test	Independent-Samples *t*-test
Mean	SD	Mean	SD	Mean	SD		
79.33	3.96	78.17	3.35	−1.16	2.01	.025*	.102
73.78	3.59	75.61	3.47	1.83	1.25	.000***	.001**
5.44	1.42	2.72	1.13	−2.72	1.45	.000***	.663
34.67	5.44	35.44	5.91	0.77	1.99	.115	.425
85.06	4.05	85.39	4.03	0.33	3.33	.676	.749
17.28	4.52	17.17	4.81	−0.11	2.30	.840	.033*
73.72	7.05	78.67	5.78	4.95	6.23	.004**	.978
36.56	5.27	27.61	5.25	−8.95	6.15	.000***	.450
95.56	5.64	98.17	5.35	2.61	4.50	.025*	.161
20.22	4.60	27.56	5.25	7.34	3.97	.000***	.027*
123.56	6.24	124.94	8.08	1.38	7.90	.466	.351
2.50	2.28	6.00	2.81	3.50	2.01	.000***	.029*
69.22	9.10	70.83	9.38	1.61	6.24	.289	.252
9.56	2.59	6.00	2.27	−3.56	2.38	.000***	.298
0.28	1.96	3.00	2.50	2.72	1.64	.000***	.008**
108.50	5.44	114.28	5.22	5.78	5.55	.000***	.053
−0.89	2.54	−1.22	2.82	−0.33	1.88	.462	.759
9.06	2.62	3.06	0.94	−6.00	2.47	.000***	.006**
3.94	1.98	1.72	1.45	−2.22	2.18	.000***	.005**

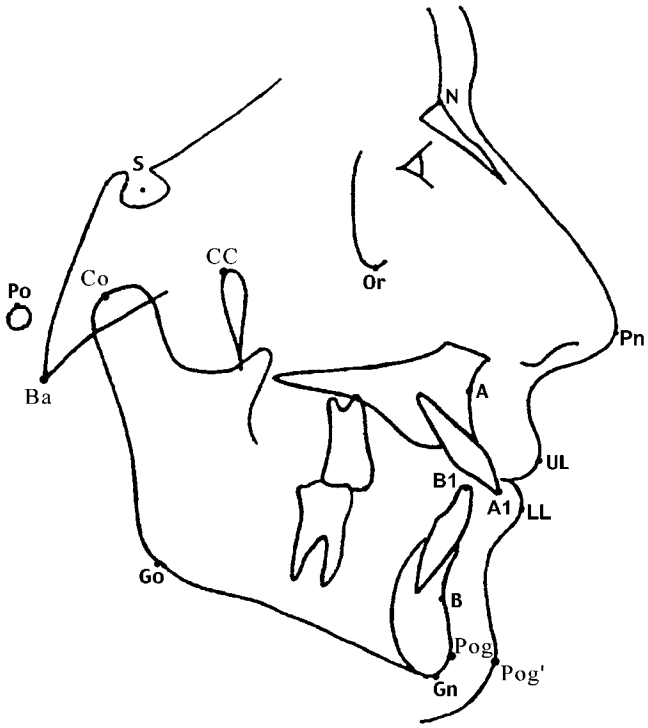

FIGURE 1. Hard and soft tissue landmarks used in this study.

Pretreatment and posttreatment comparison of Class I groups

No significant differences were observed between the extraction and nonextraction Class I groups before treatment. After the treatment, however, the nonextraction group revealed significant differences from the extraction group, with IMPA, B1 to A-Po (°), and interincisal angle all being increased in the nonextraction group.

Pretreatment and posttreatment comparison of Class II groups

SN-GoGn, A1 to A-Po (°), B1 to A-Po (mm), Co-Gn (mm), overjet, and overbite measurements were significantly higher for the extraction Class II group before the treatment. Treatment eliminated the differences in B1 to A-Po (mm), Co-Gn (mm), overjet, and overbite. But the difference of SN-GoGn persisted. Posttreatment values showed significant differences in the facial axis and IMPA measurements.

Treatment changes (Class I)

A comparison of the treatment changes for extraction and nonextraction Class I groups is shown in Table 2. Significant treatment differences in the extraction Class I group were found in ANB, Holdaway angle, A1 to A-Po plane, Co-Gn, LL-E, and incisor overjet measurements. Significant treatment differences in the nonextraction Class I group were found in A1 to SN, A1 to A-Po, interincisal angle, Co-Gn, and incisor overjet measurements. Significant differences between groups were found in A1 to A-Po, interincisal angle, and LL-E measurements. Upper incisor and lower lip were more prominent and proclined in the nonextraction group, whereas the interincisal angle was significantly decreased in this group as a result of changes in the upper-incisor position.

Treatment changes (Class II)

A comparison of the treatment changes for extraction and nonextraction Class II groups is shown in Table 3. Significant treatment differences in the extraction Class II group were found in the SNA, ANB, Occ-SN, A1 to A-Po (°), Holdaway angle, A1 to A-Po plane (mm), B1 to A-Po plane (mm), and incisor overjet measurements. Significant treatment differences in the nonextraction Class II group were found in SNA, SNB, ANB, A1 to SN, A1 to A-Po (°), IMPA, B1 to A-Po plane (°), Holdaway angle, A1 to A-Po plane (mm), B1 to A-Po plane (mm), Co-Gn, overjet, and overbite measurements. Significant differences between groups were found in SNB, Occ-SN, B1 to A-Po plane (°), Holdaway angle, B1 to A-Po plane (mm), overjet, and overbite measurements.

DISCUSSION

Before treatment, the two groups of Class I malocclusions presented similar hard and soft tissue facial characteristics with no significant differences between the measurements. The treatment objective for these patients regarding lower-incisor position was to place these teeth in a stable position on their bony bases. This position was determined on a custom basis for each patient. After treatment, the two groups were still almost similar with only three significant differences. In the nonextraction group, the incisors were positioned forward and were more proclined. But no other significant hard and soft tissue differences could be found.

The two Class II, division 1 groups, on the other hand, were different in many parameters. The before-treatment values showed a more hyperdivergent growth pattern and more proclined incisors in the extraction group and a smaller mandibular body with larger overjet and overbite in the nonextraction group. After the treatment, the only growth pattern values that were still different were the posttreatment differences in the facial axis and IMPA.

After successful completion of treatment, a comparison of the extraction and nonextraction groups revealed no significant differences in any measurements except for those of incisor positioning. These findings are in accordance with the findings of Zierhut et al[28] and Finnoy et al[29] who reported almost similar morphologies between extraction and nonextraction groups after 14 and 3–5 years, respectively. In the study of Finnoy et al,[29] the pretreatment extraction group exhibited a lower incisor that was more pro-

cumbent and proclined relative to the NB line. Paquette et al[15] also had a similar group of patients where they found that after treatment, despite the different incisor positions, there were no significant differences in lower-lip position relative to the esthetic plane in the long term. This study also presented finished extraction and nonextraction groups with different final incisor positions but similar lip position values.

In this study, the mandibular incisors were retracted in both extraction groups; however, the differences were insignificant. In a study by Zierhut et al,[28] mandibular superimpositions revealed that during treatment the lower incisor in the extraction group was retracted, whereas no change occurred in the nonextraction group. Zierhut et al[28] state that this different incisor change during treatment offsets the pretreatment differences in lower-incisor position between groups so that after treatment, the incisor position is the same in each group. In this study, the lower lip was also retracted more relative to the nose and chin in the extraction group, but this difference in lip change was not reflected in any differences in facial profile between groups after treatment. These findings are in accordance with the work of Zierhut et al.[28]

Finnoy et al[29] also established a greater retraction of the lower incisor in their extraction group during treatment, with insignificant change in the nonextraction group. They did not find any intergroup differences in the extent of retraction of the lips relative to the esthetic plane. Paquette et al[15] observed that after treatment, the lower incisors were significantly more proclined in the nonextraction group, whereas a slight retraction was noted in the extraction group. A possible explanation for this difference in findings is given by Zierhut et al.[28] According to their explanations, the sample studied by Paquette et al[15] started treatment with no differences between groups in initial incisor position, which would be in harmony with their selection of a borderline extraction sample. According to Zierhut et al,[28] it is reasonable to assume that the difference in extraction and nonextraction mechanics and space closure would be reflected in the corresponding differences seen in their posttreatment lower-incisor position. In the current study, the pretreatment sample characteristics showed almost similar incisor positioning in both the Class I and Class II extraction and nonextraction groups. Thus, the same treatment changes described by Paquette et al[15] and Zierhut et al,[28] namely, incisor position being the same in each group after active treatment, were not found in this study, with a more protrusive incisor positioning in both nonextraction groups. But we noted a greater lower-lip retraction relative to the esthetic plane in the extraction samples of this study, which is in accordance with the works of Paquette et al[15] and Zierhut et al.[28]

Lip position in both the Class I and II groups before the treatment were protrusive relative to the nose and chin on the basis of Ricketts'[30] proposed esthetic standards of −4 mm for the upper lip and −2 mm for the lower lip. After active treatment, the lip position was the same in each group, with both groups still exhibiting a lip protrusion slightly greater than Ricketts' ideals and the values reported for untreated normal subjects of this age group by Bishara et al,[31] Beget,[32] and Nanda et al[33] except for the Class I extraction group with an average LL-E value of −2.86 mm.

According to Zierhut et al,[28] a better understanding of factors that contribute to the observed profile changes would certainly assist the clinician in treatment planning by allowing anticipation of the soft tissue response to changes of the underlying skeleton and dentition with treatment and with normal maturation. These authors state that few pretreatment hard or soft tissue characteristics or changes concurrent with active treatment were strong predictors of profile outcomes either after treatment or in the long term.

Predictors were found for the position of the lower lip posttreatment and long-term postretention. The more retruded the lower lip was to esthetic plane pretreatment, the more likely it was to be retruded after treatment and in the long term. In addition, the less severe the pretreatment skeletal Class II malocclusion, as defined by the skeletal ANB angle, the more likely the lower lip was to be retrusive relative to esthetic plane posttreatment. Finally, the greater the lower-lip thickness before treatment, the more retrusive the lower lip in the long term. This final association may be attributable to the presence of initial lower-lip eversion secondary to excess overjet.

According to the authors of this article, pretreatment extent of crowding and method of anchorage preparation and usage are also factors that should be considered when trying to anticipate the effects of extraction and nonextraction treatments. In a study by Ong and Woods,[34] in each of the groups, individuals in whom maximum incisor retraction had occurred appeared to have consistently less crowding and, in turn, greater residual space available for retraction of the anterior segment than other individuals in the same groups. These authors suggest that because such wide individual variation has been found in response to orthodontic treatment with any of the investigated premolar extraction sequences, each case should be assessed on an individual basis when making a detailed treatment plan rather than by simply choosing a particular extraction sequence on the basis of published mean incisal changes for different extraction sequences. Another suggestion by Zierhut et al[28] is that the studies evaluating the soft tissue profile and lip thickness should also consider the effect of lip strain on the accuracy of measurements of static lip position and response. Lip tension will vary between individuals and between time periods for any one individual. Inability to control or quantify this variable remains a shortcoming of retrospective soft tissue cephalometric studies.

The results of this study show that in successfully treated cases, whether teeth were extracted or not, for a combination of reasons, the same soft and hard tissue profile end

points were reached after treatment except for the incisor positioning, which is rather easier to anticipate than profile and soft tissue changes. Although long-term follow-up of this sample is still being carried out, the simple statement that extraction means a more retrusive or dished-in profile seems to be unacceptable. It seems that a more thorough assessment and investigation including pretreatment extent of crowding and factors related to anchorage, soft tissue thickness, and strain should be carried out.

CONCLUSIONS

The soft tissue facial profiles of patients with Class I or Class II malocclusions that were successfully treated with extraction and nonextraction treatments were the same after active treatment.

The pretreatment extent of crowding and the method of anchorage preparation and usage should also be considered when trying to anticipate the effects of extraction and nonextraction treatments in future studies.

REFERENCES

1. Bishara SE, Cummins DM, Jakobsen JR. The morphologic basis for the extraction decision in Class II, Division 1 malocclusions: a comparative study. *Am J Orthod Dentofacial Orthop.* 1995;107: 129–135.
2. Angle EH. *Malocclusion of the Teeth and Fractures of the Maxillae.* 6th ed. Philadelphia, Pa: SS White Dental Mfg Co; 1900: 15–23.
3. Angle EH. *Malocclusion of the Teeth.* 7th ed. Philadelphia, Pa: SS White Dental Mfg Co; 1907.
4. Tweed CH. *Clinical Orthodontics.* Vol 1. St Louis, Mo: Mosby; 1966:31–82.
5. Rossouw PE. *A Longitudinal Study of the Stability of the Dentition Following Orthodontic Treatment* [PhD dissertation]. Stellenbosch, Republic of South Africa: University of Stellenbosch; 1992. In: Bowman SJ, Johnston LE. The esthetic impact of extraction and nonextraction treatments on Caucasian patients. *Angle Orthod.* 2000;70:3–10.
6. Sandusky WC III. *A Long-Term Postretention Study of Tweed Extraction Treatment* [master's thesis]. Memphis, Tenn: University of Tennessee; 1983. In: Bowman SJ, Johnston LE. The esthetic impact of extraction and nonextraction treatments on Caucasian patients. *Angle Orthod.* 2000;70:3–10.
7. Franklin GS, Rossouw PE, Woodside DG. A longitudinal study of dental and skeletal parameters associated with stability of orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1995;108:452–453.
8. Weintraub JA, Vig PS, Brown C, Kowalski CJ. The prevalence of orthodontic extractions. *Am J Orthod Dentofacial Orthop.* 1989;96:462–466.
9. O'Connor BMP. Contemporary trends in orthodontic practice: a national survey. *Am J Orthod Dentofacial Orthop.* 1993;103:163–170.
10. Sadowsky C. The risk of orthodontic treatment for producing temporomandibular mandibular disorders: a literature overview. *Am J Orthod Dentofacial Orthop.* 1992;101:79–83.
11. Luecke PE III, Johnston LE Jr. The effect of maxillary first premolar extraction and incisor retraction on mandibular position: testing the central dogma of ''functional orthodontics''. *Am J Orthod Dentofacial Orthop.* 1992;101:4–12.
12. McNamara JA Jr, Seligman DA, Okeson JP. Occlusion, orthodontic treatment, and temporomandibular disorders: a review. *J Orofac Pain.* 1995;9:73–90.
13. Greene CS. Etiology of temporomandibular disorders. *Semin Orthod.* 1995;1:222–228.
14. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. *Am J Orthod Dentofacial Orthop.* 1995;108:162–167.
15. Paquette DE, Beattie JR, Johnston LE Jr. A long-term comparison of nonextraction and premolar extraction edgewise therapy in ''borderline'' Class II patients. *Am J Orthod Dentofacial Orthop.* 1992;102:1–14.
16. Beattie JR, Paquette DE, Johnston LE Jr. The functional impact of extraction and nonextraction treatments: a long-term comparison in patients with ''borderline,'' equally susceptible Class II malocclusions. *Am J Orthod Dentofacial Orthop.* 1994;105:444–449.
17. Luppanapornlarp S, Johnston LE Jr. The effects of premolar-extraction treatment: a long-term comparison of outcomes in ''clear-cut'' extraction and nonextraction patients. *Angle Orthod.* 1993; 63:257–272.
18. Livieratos FA, Johnston LE Jr. A comparison of one-stage and two-stage nonextraction alternatives in matched Class II samples. *Am J Orthod Dentofacial Orthop.* 1995;108:118–131.
19. Johnston LE Jr. *Growing jaws for fun and profit: a modest proposal.* In: McNamara JA Jr, ed. What Works, What Doesn't, and Why. Craniofacial Growth Series 35. Ann Arbor, Mich: Center for Human Growth and Development, The University of Michigan; 1998:63–86.
20. Bowman SJ, Johnston LE. The esthetic impact of extraction and nonextraction treatments on Caucasian patients. *Angle Orthod.* 2000;70:3–10.
21. Bishara SE, Cummins DM, Jacobsen JR, Zaher AR. Dentofacial and soft tissue changes to Class II Division 1 cases treated with and without extractions. *Am J Orthod Dentofacial Orthop.* 1995; 107:28–37.
22. Young T, Smith R. Effects of orthodontics on the facial profile: a comparison of change during nonextraction and four premolar extraction treatment. *Am J Orthod Dentofacial Orthop.* 1993;103: 452–458.
23. Bravo LA. Soft tissue facial profile changes after orthodontic treatment with four premolars extracted. *Angle Orthod.* 1994;64:31–42.
24. Scott SH, Johnston LE Jr. The perceived impact of extraction and nonextraction treatments on matched samples of African American patients. *Am J Orthod Dentofacial Orthop.* 1999;116:352–358.
25. Drobocky OB, Smith RJ. Changes in facial profile during orthodontic treatment with extraction of four first premolars. *Am J Orthod Dentofacial Orthop.* 1989;95:220–230.
26. Kirkwood BR. *Essentials of Medical Statistics.* London, UK: Blackwell Science; 1996.
27. Houston WBJ. The analysis of errors in orthodontic measurements. *Am J Orthod.* 1983;83:382–390.
28. Zierhut EC, Joondeph DR, Artun J, Little RM. Long-term profile changes associated with successfully treated extraction and nonextraction Class II Division 1 malocclusions. *Angle Orthod.* 2000; 70:208–219.
29. Finnoy JP, Wisth PJ, Boe OE. Changes in soft tissue profile during and after orthodontic treatment. *Eur J Orthod.* 1987;9:68–78.
30. Ricketts RM. Planning treatment on the basis of the facial pattern and an estimate of its growth. *Angle Orthod.* 1957;27:14–37.
31. Bishara SE, Hession TJ, Peterson LC. Longitudinal soft-tissue profile changes: a study of three analyses. *Am J Orthod.* 1985; 88:209–223.
32. Beget BC. *A Cephalometric Study of Profile Changes to Age 32 in Orthodontic ''normals''* [thesis]. Seattle, Wash: University of Washington; 1973.
33. Nanda RS, Meng H, Kapila S, Goorhuis J. Growth changes in the soft tissue facial profile. *Angle Orthod.* 1990;60:177–190.
34. Ong HB, Woods MG. An occlusal and cephalometric analysis of maxillary first and second premolar extraction effects. *Angle Orthod.* 2001;71:90–102.