The Online
ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
78th Anniversary 1930–2008

The Angle Orthodontist: **Vol. 70, No. 3, pp. 208–219.**

Long-Term Profile Changes Associated with Successfully Treated Extraction and Nonextraction Class II Division 1 Malocclusions

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ABSTRACT

This study was undertaken to compare the post-treatment and long-term soft tissue profiles of successfully managed and stable Class II, division 1 malocclusions treated with either 4 first premolar extractions or nonextraction therapy. It was hypothesized that, if sound extraction decisions were made according to accepted treatment objectives and successful treatment outcomes were achieved, there should be no differences between groups in soft tissue profiles post-treatment and long-term post-retention. The sample consisted of 63 Caucasian adolescents (23 extraction, 40 nonextraction). Correction of the malocclusion was achieved using a combination of cervical headgear concurrent with mandibular growth and maxillary incisor retraction. Pretreatment, post-treatment, and long-term post-retention lateral cephalometric radiographs were evaluated. The soft tissue facial profiles of the extraction and nonextraction samples were the same following active treatment and long-term post-retention. Progressive flattening of the facial profile was observed in both samples. This flattening was attributed to the maturational changes associated with continued mandibular growth and nasal development and was not influenced by whether or not teeth were removed. Long-term lip positions were more retrusive than the ideals suggested by Ricketts and Steiner, but close to the values reported for normal, untreated adults of similar ages. The pretreatment position and thickness of the lower lip as well as the initial maxillomandibular skeletal relationship may be predictors of post-treatment or long-term lower lip position.

KEY WORDS: Soft tissue profile, Extraction, Nonextraction, Post-treatment, Post-retention.

Accepted: August 1999. Submitted: January 1996.

INTRODUCTION Return to TOC

Orthodontists continue to debate the issue of extracting permanent teeth to improve dentoskeletal relationships. Much of the negative commentary on extraction has centered on the claim that the extraction of 4 premolars produces an unesthetic soft tissue profile by a " flattening" or "dishing-in" of the lips relative to chin and nose. This supposition appears to be based in large part on opinion and anecdotal case reports and lacks well-documented support in the refereed literature. Furthermore, inherent to this conclusion are the unproven assumptions that changes in the hard tissue directly and equally affect the overlying soft tissue profile, and that normal maturation does not play a significant role in post-treatment and long-term profile outcomes. As Liebermann[1] reminds us, " .our role in the long range facial changes that take place over the life of our patient may be less significant than we think."

Studies that have compared treatment effects on the soft tissue profile in extraction and nonextraction samples are few in number, but are of some value in the resolution of this debate. Finnoy et al[2] found that there were very few soft tissue profile differences in 2 groups of subjects with Class II division 1 malocclusion treated with and without extraction therapy 3 to 5 years post-treatment. However, significant differences in the soft tissue profiles existed before treatment between the extraction and nonextraction samples. Looi and Mills[3] also evaluated lip and incisor changes in extraction and nonextraction groups of subjects with Class II division 1 malocclusions. Although they found greater retraction of both the incisors and the lower lip in the extraction group, valid comparison between groups was difficult due to the substantial differences in the mechanotherapy used to treat each group. In addition, lip changes were measured from midcranial skeletal reference lines, with no quantification of lip change relative to soft tissue chin and nose. Paquette, Beatty, and Johnston[4] compared the effects of extraction and nonextraction therapy on the profile in Class II division 1 malocclusions with "borderline" arch length deficiencies. They found that the denture was significantly more protrusive in the nonextraction sample at the completion of treatment, as well as at recall more than 10 years later. However, despite a statistically significant retrusive denture, the extraction subjects were just as " likely to view their outcome as an improvement" as were their nonextraction counterparts. Finally, 2 companion studies by Dobrocky and Smith[5] and Young and Smith[6] found that, in spite of significantly more mean lip retraction in their extraction group, the individual variations in facial change, as determined by the standard deviations, were similar between groups. Most important, they found that the "frequency of undesirable facial changes," as measured by comparison with ideal nasolabial and labiomental angles and lip position relative to facial reference lines, was similar for the extraction and nonextraction samples.

The concept that extraction therapy flattens the profile assumes that a greater amount of incisor retraction takes place secondary to tooth removal and that the soft tissues act as a passive drape following the underlying dental changes by a corresponding and predictable amount. The literature, however, does not support this assumption. Studies quantifying the response of soft tissue relative to changes in hard tissue are numerous, with equivocal results. Most studies have described a relationship between incisor and lip retraction, but the strength of this relationship varies greatly between studies.[3,7–14] It is generally concluded that the relationship between hard and soft tissue change is subject to large individual variation, and the presumption that this individual variability differs between extraction and nonextraction groups appears unjustified.

Long-term assessment of the soft tissue profile must also consider the normal maturational changes that occur and the considerable individual variation. Growth of the nose and chin in untreated adolescents has been shown to far exceed concomitant change in the lips.[15–18] This normal maturation change tended to continue postadolescence, resulting in further "relative retraction" of the lips.[15–19] Nose and chin growth have also been shown to exceed the lip changes observed in adolescents undergoing active treatment.[11,12,20]

The purpose of this study was to compare the post-treatment and long-term soft tissue profiles of successfully managed and stable Class II division 1 malocclusions treated with either 4 first premolar extraction or nonextraction treatments.

MATERIALS AND METHODS Return to TOC

Sample

The sample consisted of 63 American Caucasian patients (33 females, 30 males) treated by faculty or graduate students of the Department of Orthodontics at the University of Washington. The sample was part of a larger sample evaluated in a previous study by Fidler et al[21] of the long-term Class II stability of successfully treated Class II division 1 malocclusions. Subjects were included if they presented with a pretreatment Class II division 1 malocclusion showing a molar relationship of at least "end-on," a minimum overjet of 5 mm, and a successful treatment result as determined by model evaluation. Three experienced faculty members at the University of Washington Department of Orthodontics determined the acceptability of subjects by subjective evaluation of intercuspation, tooth alignment, and incisor relationship. Cephalometric characteristics and long-term post-treatment occlusal relationships were not considered in the sample selection.

Specific criteria for inclusion in this study included the availability of high-quality pretreatment (T1), post-treatment (T2), and long-term post-retention (T3) lateral cephalometric radiographs that clearly showed the soft tissue profile. The extraction group was limited to subjects treated with 4 first premolar extractions only, with all other permanent teeth present from first permanent molar to contralateral first permanent molar. The nonextraction group had all permanent teeth present from first permanent molar to contralateral first permanent molar. The sample included 23 subjects (11 males, 12 females) treated with extraction and 40 (19 males, 21 females) treated with nonextraction therapy. The mean ages for the extraction and nonextraction groups at T1, T2, and T3, and the mean active treatment and mean post-retention durations are shown in Table 1. Fifteen subjects from the study conducted by Fidler et al[21] were excluded because the extraction combination did not meet these sample criteria or because the radiographs did not adequately reveal the soft tissue profile.

All subjects were treated during adolescence with fixed edgewise mechanotherapy. Class II correction was achieved primarily using extraoral force in the form of cervical headgear to redirect or inhibit maxillary growth with concurrent facial growth and maxillary incisor retraction. No patients in this sample were treated with either functional appliances or orthognathic surgery.

Cephalometric analysis

Lateral cephalometric radiographs used in this study were made using a standardized Broadbent cephalometric technique. The pretreatment (T1), post-treatment (T2), and long-term post-retention (T3) lateral cephalometric radiographs were traced and superimposed by the same investigator. Landmarks used on each radiograph are shown in Figure 1. The linear and angular variables measured for each radiograph are given in Tables 2 through 8. Changes in these variables were calculated between T1 and T2 and between T2 and T3. An increase in a variable was recorded as positive and a decrease was recorded as negative. Overall, maxillary, and mandibular superimpositions were manually performed for each subject from T1 to T2 and from T2 to T3. A linear distance representing a change over time between landmarks was measured on the superimpositions using the Fowler Ultra-Cal II digital caliper (Fred V. Fowler Co, Inc, Newton, Mass). These measurements were also made from T1 to T2 and from T2 to T3. A forward change was recorded as positive and a backward change as negative. All linear measurements were made to the nearest 0.01 mm and the angular measurements were made to the nearest 0.5 degree.

Overall superimposition was done to evaluate relative changes in the soft tissue profile resulting from both growth and treatment response between all 3 times. Overall superimpositions were made using the “best fit” of the ethmoid triad, specifically the greater wings of the sphenoid, platinum sphenoidum (sphenoethmoidal plane), and the surrounding detailed anatomy[22] (Figure 2). Changes evaluated using this superimposition technique were measured along a line parallel to the average occlusal plane for the 3 times. This “average occlusal plane” was determined by averaging the angle of the 3 occlusal planes to a line common to each of the superimposed tracings. It was then transferred to the T1 tracing.

To evaluate incisor and lip changes in maxilla and mandible, while eliminating the effects of growth, maxillary and mandibular superimpositions were performed. Maxillary superimpositions were made on the anterior and posterior borders of the zygomatic process, allowing the floor of the orbit to rise in a ratio of 1.5:1 mm in relation to the lowering of the palatal plane[23] (Figure 3). Mandibular superimpositions were made using the “best fit” of the internal anatomy of the symphysis, using the mandibular canal and inferior border of the third molar crypt as guides [24] (Figure 4). Measurements made from the maxillary and mandibular superimpositions were also made parallel to the average occlusal plane.

Pretreatment overjet was measured from diagnostic models taken at T1. Lower incisor to mandibular plane angle was taken from measurements made on this same sample by Fidler et al.[21]

Method error study

All radiographs were retraced and all variables remeasured for 10 cases selected at random to determine intra-examiner error in tracing, superimposition technique, and measurements. These duplications were performed a minimum of 2 weeks apart. The error of the method was calculated using Dahlberg's formula.[25]

where D is the difference between double measurements and N is the number of duplicated measurements. The mean error for linear measures was between 0.1 mm and 1.2 mm and for angular measures was between 0.4° and 1.6°.

Analysis of data

Means of the variables measured from the lateral cephalometric radiographs at T1, T2, and T3 were calculated. To compare profile status at T1, T2, and T3, between-group differences were assessed using 2-sample *t*-tests for unpaired data (independent samples).

Means were also calculated for the changes in the linear and angular profile measures and for changes measured from the superimpositions for T1 to T2 and T2 to T3. To determine if these changes were significantly different between extraction and nonextraction groups, 2-sample *t*-tests for unpaired data were used.

A large number of *t*-tests were carried out between groups. In order to reduce the possibility of some *t*-tests achieving significance due to chance alone, Bonferroni corrections were carried out separately for *t*-tests between groups for each time period and between time periods between groups. Only those *t*-tests with *P*-values less than the corresponding Bonferroni correction were considered significant. The significance level for this correction was .002 for the measurements made from each separate radiograph at T1, T2, and T3 and .001 for the changes between time periods.

To determine if there was any association between lip position at T2 or T3 and the profile status at T1, or the changes in profile during treatment, a stepwise backward elimination regression procedure was employed. Regression models were built for the upper as well as the lower lip, looking separately at the associations with pretreatment variables and with treatment changes in these variables. A correlation coefficient equal to or greater than 0.70 was considered clinically significant.

RESULTS Return to TOC

Results for the comparison of the extraction and nonextraction groups are presented in Tables 2 through 4. *t*-tests with *P*-values less than .05 are indicated to note that, without the Bonferroni correction, these would be considered significant. Considerable individual variation was observed in both the profile measures and changes between time periods. All subjects grew during the study period, as evidenced by a mean change in the position of articulare of 6.84 mm from T1 to T2 and 4.62 mm from T2 to T3.

Pretreatment

Pretreatment mean hard and soft tissue profile measurements for the extraction and nonextraction groups are presented in Table 2. No significant differences between groups were found except in the position of the lower incisor and the amount of chin prominence. In the extraction group, the lower incisor was significantly further forward relative to APg and NB lines and significantly more proclined relative to the NB line. Hard tissue chin prominence, as measured by Pg relative to the NB line, was significantly greater in the nonextraction group.

Post-treatment

Post-treatment mean hard and soft tissue profile measurements for the extraction and nonextraction groups are presented in Table 3. No statistically significant differences between the extraction and nonextraction groups were found.

Long-term post-retention

Long-term post-retention hard and soft tissue profile mean measurements for the extraction and nonextraction groups are presented in Table 4. No statistically significant differences between the extraction and nonextraction groups were found for the hard and soft tissue profile measurements long-term post-retention.

Treatment changes (T1 to T2)

A comparison of the treatment changes for the extraction and nonextraction groups is shown in Tables 5 and 6. Significant differences between groups were found for the changes in lower lip and lower incisor only. Significantly greater retraction of the lower lip relative to the esthetic and S planes was observed in the extraction group. Mandibular superimpositions also revealed that the extraction group exhibited significantly more retraction of the lower lip and lower incisor during the treatment period. No other intergroup differences were found for treatment changes. Retraction of the upper lip relative to esthetic plane also occurred, with no significant difference between groups. No significant differences were observed between groups in the amount of mandibular growth as measured by change at articulare. Nasal development and forward movement of soft tissue chin as measured on the overall superimpositions were also not significantly different between groups during treatment.

Long-term post-treatment changes (T2 to T3)

Long-term post-retention changes for the extraction and nonextraction groups are presented in Tables 7 and 8. Significant changes did occur from post-treatment to long-term (mean 14 years), but these changes were not significantly different between the extraction and nonextraction groups. The upper and lower lips became more retrusive relative to esthetic and S planes. Overall superimpositions revealed that this change was due to significant nasal development and forward movement of the soft tissue chin. No significant differences were observed between groups in the amount of long-term nasal development, forward soft tissue chin movement, or mandibular growth as measured by change at articulare.

Changes pretreatment (T1) to long-term post-treatment (T3)

No significant differences between groups were found in the changes from T2 to T3. Consequently, the differences between groups found from T1 to T3 reflect those found from T1 to T2. Therefore, a separate consideration of the composite changes that occurred from T1 to T3, was not necessary.

Regressions

Backwards stepwise regression analyses were run to determine if the pretreatment status of any of the profile variables or if any of the treatment changes could be used as predictors of lip position relative to the esthetic plane post-treatment or long-term. Associations with correlations of .70 or greater were found for the post-treatment and long-term positions of the lower lip only.

Lower lip position relative to esthetic plane at T2

Positive associations were found between the position of the lower lip relative to the esthetic plane at T2 and the position of the lower lip relative to esthetic plane at T2 and the size of the ANB angle at T1. The correlation coefficients were 0.84 and 0.74, respectively.

Lower lip position relative to esthetic plane at T3

A positive correlation coefficient of 0.74 was found between the position of the lower lip relative to esthetic plane at T3 and the position of the lower lip relative to the esthetic plane at T1. A negative association was found between the position of the lower lip relative to the esthetic plane at T3 and the thickness of the lower lip at T1. The correlation coefficient was −0.90.

DISCUSSION Return to TOC

Prior to treatment, the 2 groups of Class II division 1 malocclusions presented with almost identical hard and soft tissue profile characteristics with only 2 significant differences. In the extraction group, the lower incisor was positioned further forward and was more proclined relative to skeletal landmarks. The position and inclination of the upper incisor was the same in each group. Despite this difference in lower incisor position, the 2 groups did not differ in mean pretreatment overjet, which was 8.3 mm in the extraction group and 8.5 mm in the nonextraction group. The second difference was that the nonextraction group presented with a larger hard tissue chin button, which was not reflected, however, in significant differences between groups in hard and soft tissue convexity measurements or in lip position relative to the nose and chin. The initial soft tissue profiles of each group were the same.

Correction of the Class II malocclusions was accomplished primarily with cervical headgear to redirect or inhibit maxillary anterior development with concurrent mandibular growth and maxillary incisor retraction. After successful completion of treatment, comparison of the extraction and nonextraction groups revealed no differences in any measures of hard or soft tissue profile between the extraction and nonextraction groups. Following an average post-retention period of 14 years, group comparisons also revealed no differences in any profile measures. In short, the facial profiles of the extraction and nonextraction groups were the same following treatment and long-term post-retention.

These findings are comparable to those reported by Finnoy et al,[2] who found “strikingly similar morphology” of the hard and soft tissue profiles in their comparison of extraction and nonextraction groups 3 to 5 years post-retention. They found very few differences in soft tissue profile and no differences in incisor and lip position. As in the present study, their pretreatment extraction group exhibited a lower incisor that was more procumbent and proclined relative to the NB line. Paquette, Beattie, and Johnston[4] also started with very similar profiles in their “borderline” extraction sample. They found that following treatment, lip retrusion relative to esthetic plane was greater in their extraction group, while the incisors were more proclined and procumbent relative to skeletal reference lines in their nonextraction group. It is interesting to note that this difference in incisor position between groups was still evident after an average of 14.5 years post-retention, while the post-treatment difference in lower lip position relative to esthetic plane was no longer significant.

In the present study, mandibular superimpositions revealed that during treatment the lower incisor in the extraction group was retracted, while no change occurred in the nonextraction group. This dissimilar incisor change during treatment offset the pretreatment differences between groups in lower incisor position so that following treatment, incisor position was the same in each group. 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 following treatment.

Finnoy et al[2] also found greater retraction of the lower incisor in their extraction group during treatment, with negligible change in the nonextraction group. They did not find any intergroup differences in the amount of retraction of the lips relative to the esthetic plane. Paquette et al[4] observed that following treatment the lower incisors were significantly more proclined in the nonextraction group, while slight retraction was noted in the extraction group. A possible explanation for this difference in findings is that the sample studied by Paquette et al[4] started treatment with no differences between groups in initial incisor position, which would be in accord with their selection of a “ borderline extraction” sample. 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 post-treatment lower incisor position. In the present study, pretreatment sample characteristics showed a more protrusive and procumbent lower incisor position in the extraction group initially. Accordingly, the same treatment changes described by Paquette et al,[4] and also found in this study, resulted in the incisor position being the same in each group following active treatment. In agreement with the present investigation, Paquette et al[4] also noted more lower lip retraction relative to esthetic plane in their extraction sample.

Although the lips were more retrusive relative to esthetic plane in both groups following treatment, the amount of this change was the same for each group. This decrease in facial profile convexity secondary to orthodontic treatment has also been reported by numerous other investigators.[2,9,14] Cranial base superimpositions revealed that the chin and nose moved forward relative to the lips by similar amounts in both groups, and it appeared that this mandibular growth and nasal development contributed more to the flattening of the profile than did actual lip retraction. The amount of mandibular growth and nasal development that occurred during treatment was not statistically different between extraction and nonextraction groups.

During the mean post-retention period of 14 years, significant flattening of the profile continued to occur, but these changes were also the same in each group. Consequently, the long-term facial profiles were the same, independent of whether or not premolar extraction was performed. This continued decrease in facial convexity was also observed during a 3- to 5-year post-retention interval by Finnoy et al,[2] who observed that this soft tissue change was the same in spite of differences in long-term incisor position. In the present study, the significant and similar amounts of mandibular growth and nasal development observed during the post-retention interval surpassed the slight forward movement of the lips and resulted in further long-term retrusion of the lips relative to the nose and chin. A thinning of the upper lip occurred during this period as well. As there were no differences between groups in these post-retention changes, it appears that the flattening of the

profile that occurred with time was primarily due to maturational changes associated with continued mandibular growth and nasal development and is not influenced by tooth removal. Progressive flattening of the facial profile has been well documented in numerous untreated samples[16,19] as well as in long-term post-treatment studies.[2,4] These long-term post-treatment studies also found, incidentally, that there were no differences in long-term lip position when comparing extraction and nonextraction samples.

Prior to treatment, lip position in both groups was protrusive relative to the nose and chin based upon the esthetic ideals proposed by Ricketts[26] −4 mm for the upper lip and −2 mm for the lower lip. Lip position relative to the S line was also more protrusive than Steiner's ideal of the lips lying tangent to this plane.[27] Although the initial profiles were also more protrusive than the values reported by Forsberg and Odenrick[28] for untreated normals of this age group, they were very similar to values reported by others.[18,19,29]

Following active treatment, lip position relative to the nose and chin was the same in each group, with both groups exhibiting moderately more lip retrusion than Ricketts ideals and the values reported for untreated normals of this age group by Bishara et al,[29] Beget,[18] and Nanda et al.[19] The lips were considerably more retrusive, however, when compared with Steiner's ideal. Long-term lip retrusion was considerably greater than the ideals suggested by both Ricketts and Steiner, but was only slightly more retrusive than the values reported for normal untreated adults of similar age by Beget,[18] and of a slightly lower age group reported by others.[28,30]

In agreement with previous studies,[2,12,17,18,29] soft tissue convexity decreased during treatment and this decrease progressed with time, independent of extraction. The soft tissue ANB and NAPG angles as well as the H angle decreased similarly throughout the study period in both groups. It is of interest to note that at the end of treatment as well as long-term post-retention, the soft tissue ANB and H angles were very similar to the values reported for untreated normals of the same average age.[18] The H angle did not reach the ideal values proposed by Holdaway[31] until long-term post-retention.

A better understanding of what contributes 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 and with normal maturation. Few pretreatment hard or soft tissue characteristics or changes concurrent with active treatment were strong predictors of profile outcomes either after treatment or long-term. Predictors were found for the position of the lower lip post-treatment and long-term post-retention. The more retruded the lower lip was to esthetic plane pretreatment, the more likely it was to be retruded after treatment and 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 post-treatment. Finally, the greater the lower lip thickness pretreatment, the more retrusive the lower lip long-term. This final association may be due to the presence of initial lower lip eversion secondary to excess overjet.

Consistent with other studies,[2–9,11–15,20,28–30] large individual variation was found in the hard and soft tissue profile measurements both during and after treatment. This was especially true for lip position relative to the esthetic plane.

Studies evaluating the soft tissue profile and lip thickness must 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 use of Ricketts' esthetic plane[26] and other measures to assess the profile in this study comes with the subtle implication that these standards may be good indicators of whether or not a face is esthetic. The perception of an esthetic face is much more than the sum of these sagittal measurements. The view of the entire face (not necessarily in a static position), the balance and harmony of the parts, and the 3-dimensional character all play roles in each individual's perception of what constitutes a pleasing facial appearance.

This study demonstrated that in successfully treated cases where teeth were extracted for a combination of reasons (and the cases therefore differed initially in lower incisor position and hard tissue chin prominence from nonextraction cases) the same soft and hard tissue profile endpoints were reached post-treatment and long-term. The results cannot be extrapolated to extraction and nonextraction cases that are perfectly matched pretreatment. It would be interesting to evaluate matched extraction and nonextraction cases with significant pretreatment arch length deficiencies, protrusion, or both, or with minimal pretreatment arch length deficiencies and protrusion. Further studies are needed to provide information regarding the soft tissue responses in these types of matched samples.

CONCLUSIONS Return to TOC

The soft tissue facial profiles of patients with Class II division 1 malocclusion who were successfully treated with extraction and nonextraction treatment were the same following active treatment and long-term post-retention.

The facial profile continued to flatten both during treatment and long-term. This progressive decrease in soft tissue convexity was primarily due to the maturational changes associated with continued mandibular growth and nasal development, and was not influenced by whether or not teeth were removed.

Long-term lip position was more retrusive than the ideals suggested by Ricketts and Steiner, but were close to the values reported for normal, untreated adults of similar age.

The pretreatment position and thickness of the lower lip as well as the initial maxillomandibular skeletal relationship may be predictors for post-treatment or long-term lower lip position.

ACKNOWLEDGMENTS

The Washington Dental Service Foundation and the University of Washington Orthodontic Alumni Association supported this study.

REFERENCES Return to TOC

1. Lieberman MA, Gazit E. Facial profile as affected by extraction or non-extraction decisions. *Quintessence Int.* 1982; 13:447–454. [PubMed Citation]

2. Finnoy JP, Wisth PJ, Boe OE. Changes in soft tissue profile during and after orthodontic treatment. *Eur J Orthod.* 1987; 9:68–78. [PubMed Citation]

3. Looi LK, Mills JR. The effect of two contrasting forms of orthodontic treatment on the facial profile. *Am J Orthod.* 1986; 89:507–517. [PubMed Citation]

4. 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. [PubMed Citation]

5. 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. [PubMed Citation]

6. Young TM, Smith RJ. Effects of orthodontics on the facial profile: a comparison of changes during nonextraction and four premolar extraction treatment. *Am J Orthod Dentofacial Orthop.* 1993; 103:452–458. [PubMed Citation]

7. Bloom LA. Perioral profile changes in orthodontic treatment. *Am J Orthod.* 1961; 47:371–379.

8. Rudee DA. Proportional profile changes concurrent with orthodontic therapy. *Am J Orthod.* 1964; 50:421–434.

9. Hershey HG. Incisor tooth retraction and subsequent profile change in postadolescent female patients. *Am J Orthod.* 1972; 61:45–54. [PubMed Citation]

10. Wisth PJ. Soft tissue response to upper incisor retraction in boys. *Br J Orthod.* 1973; 1:199–204.

11. Anderson JP, Joondeph DR, Turpin DL. A cephalometric study of profile changes in orthodontically treated cases ten years out of retention. *Angle Orthod.* 1973; 43:324–336. [PubMed Citation]

12. Angelle PL. A cephalometric study of the soft tissue changes during and after orthodontic treatment. *Trans Eur Orthod Soc.* 1973;267–280.

13. Roos N. Soft-tissue profile changes in class II treatment. *Am J Orthod.* 1977; 72:165–175. [PubMed Citation]

14. Talass MF, Talass L, Baker RC. Soft-tissue profile changes resulting from retraction of maxillary incisors. *Am J Orthod Dentofacial Orthop.* 1987; 91:385–394. [PubMed Citation]

15. Pelton WJ, Elsasser WS. Studies of dentofacial morphology, IV. Profile changes among 6,829 white individuals according to age and sex. *Angle Orthod.* 1955; 25:199–207.

16. Subtelny JD. A longitudinal study of soft tissue facial structures and their profile characteristics, defined in relation to underlying skeletal structures. *Am J Orthod.* 1959; 45:481–507.

17. Beget BC. *A Cephalometric Study of Profile Changes to Age 32 in Orthodontic "normals"* [thesis]. Seattle, Wash: University of Washington; 1973.

18. Nanda RS, Meng H, Kapila S, Goorhuis J. Growth changes in the soft tissue facial profile. *Angle Orthod.* 1990; 60:177–190. [PubMed Citation]

19. Wisth PJ. Changes of the soft tissue profile during growth. *Trans Eur Orthod Soc.* 1972;123–131.

20. Koch R, Gonzales A, Witt E. Profile and soft tissue changes during and after orthodontic treatment. *Eur J Orthod.* 1979; 1:193–199.

[PubMed Citation]

21. Fidler BC, Årtun J, Joondeph DR, Little RM. Long-term stability of Angle Class II, division 1 malocclusions with successful occlusal results at end of active treatment. *Am J Orthod Dentofacial Orthop.* 1995; 107:276–285. [PubMed Citation]

22. Elmajian KE. *A Serial Study of Facial Growth as Related to Cranial Base Morphology* [thesis]. Seattle, Wash: University of Washington; 1959.

23. Doppel DM, Damon WM, Joondeph DR, Little RM. An investigation of maxillary superimposition techniques using metallic implants. *Am J Orthod Dentofacial Orthop.* 1994; 105:161–168. [PubMed Citation]

24. Bjork A. Variations in the growth pattern of the human mandible: longitudinal radiographic study by the implant method. *J Dent Res.* 1963; 42:suppl 1400411

25. Dahlberg G. *Statistical Methods for Medical and Biological Students.*. New York, NY: Interscience Publications; 1940.

26. Ricketts RM. Planning treatment on the basis of the facial pattern and an estimate of its growth. *Angle Orthod.* 1957; 27:14–37.

27. Hambleton RS. The soft-tissue covering of the skeletal face as related to orthodontic problems. *Am J Orthod.* 1964; 50:405–419.

28. Forsberg CM, Odenrick L. Changes in the relationship between the lips and the aesthetic line from eight years of age to adulthood. *Eur J Orthod.* 1979; 1:265–270. [PubMed Citation]

29. Bishara SE, Hession TJ, Peterson LC. Longitudinal soft-tissue profile changes: a study of three analyses. *Am J Orthod.* 1985; 88:209–223. [PubMed Citation]

30. Sarnäs KV, Solow B. Early adult changes in the skeletal and soft-tissue profile. *Eur J Orthod.* 1980; 2:1–12. [PubMed Citation]

31. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning, Part 1. *Am J Orthod.* 1983; 84:1–28. [PubMed Citation]

TABLES Return to TOC

TABLE 1. Mean Sample Characteristics

TABLE 2. Profile Measurements, Extraction Vs Nonextraction Groups at T1[a]

TABLE 3. Profile Measurements, Extraction Vs Nonextraction Groups at T2[a]

TABLE 4. Profile Measurements, Extraction Vs Nonextraction Groups at T3[a]

TABLE 5. Significant Changes, Extraction Vs Nonextraction, T1–T2[a]

TABLE 6. Significant Changes From Superimpositions, Extraction Vs Nonextraction Groups, T1–T2[a]

TABLE 7. Significant Changes, Extraction Vs Nonextraction Groups, T2–T3[a]

TABLE 8. Significant Changes From Superimpositions, Extraction Vs Nonextraction Groups, T2–T3[a]

FIGURES Return to TOC

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FIGURE 1. Cephalometric landmarks

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FIGURE 2. Overall superimposition

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FIGURE 3. Maxillary superimposition

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FIGURE 4. Mandibular superimposition

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FIGURE 5. Rickett's E plane and Steiner's S plane

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This study was submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry.

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