Comparison of soft tissue profile changes in serial extraction and late premolar extraction

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Abstract: To assess soft tissue profile changes through time, a comparison was made of patients treated by serial extraction without subsequent orthodontic treatment (n=28), patients treated with serial extraction and orthodontic treatment (n=30), and patients treated orthodontically with late extraction (n=30). Cephalometric radiographs were traced and digitized; linear and angular measurements were made with a custom computer program that allowed digitization of specific soft tissue points. Maxillary, mandibular, and overall cephalometric superimpositions and linear measurements of change from the superimpositions were done by hand. Statistical analyses were made to determine if significant differences existed within each group at each time period and between groups at each time period, as well as between males and females at each time period. Data were also analyzed to determine if significant correlations existed between any hard tissue variable and any soft tissue variable, or between any soft tissue variable and any other soft tissue variable. It was found that in those patients treated with late premolar extraction, the most labial point of the mandibular incisor was more posterior from pretreatment to posttreatment than in the serial extraction group. While a great number of associations existed between variables, no significant differences were found between the soft tissue profiles of these three groups of patients. The gender differences that were found to exist were most likely due to normal maturational changes, not the treatment itself.

Key Words: Soft tissue profile; Serial extraction; First premolar extraction

Clinical examination and space analysis may, in some cases, reveal an arch length deficiency that warrants the extraction of teeth. The orthodontist then faces the question of when best to extract: during the mixed dentition or at a later date, when the remaining permanent teeth have erupted.

Serial extraction was first described by Robert Bunon in 1743,[1] but it wasn't until the late 1940s that the idea was popularized by Kjellgren[2] and Hotz.[3] Much of what has been written about serial extraction since that time has been descriptive in nature and has been concerned primarily with the indications and limitations of its use in clinical practice, expected intra-arch relationships, the procedure itself, and the timing and sequence of extractions.[4-7] The analyses of cases treated with serial extraction has been primarily limited to elements such as stability of the arch length and width, the amount of crowding occurring after treatment, and the effect timing of extractions has on the position of the adjacent teeth.[8-11]

Many studies have addressed change in the facial profile that occur with orthodontic treatment, and specifically with the extraction of four first premolars. One primary focus of these studies has been the relationship between incisor movement and changes in lip position.[12-17] Another finding is that lip prominence may decrease during the treatment period.[12,16,18,19] Many authors have included an evaluation of soft tissue changes in relation to the changes in the underlying hard tissue, and found positive relationships,[14-17,19-22] while others maintain that soft tissue and hard tissue changes appear to be unrelated.[23-25]

An analysis of the soft tissue profile changes occurring with serial extraction has not been within the scope of previous studies, and only one study (by Seely[26]) has attempted to evaluate the differences between profiles of patients treated with serial extraction and those treated with late premolar extraction. Seely compared patients who had had serial extractions with nongrowing patients who had had late premolar extractions.

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Table 1
Summary of sample patient characteristics

Group	Treatment	N	Males	Females	Ages in years-months T0	T1	T2	T3
A	Serial extraction, no treatment	28	13	15	09-09	13-06		24-03
B	Serial extraction with treatment	30	6	24	09-06	12-04	14-04	29-02
C	Late extraction with treatment	30	4	26		12-06	15-04	32-02

Compared with the present study, the sample sizes were smaller, the statistics less sophisticated, and the results suspect, such that a new evaluation was warranted. Considering the frequency with which these procedures are employed, a comparison of effects the different protocols might have on profile esthetics seems necessary.

The purpose of this study was to evaluate soft tissue profile changes within and between groups of patients treated with serial extraction with and without subsequent orthodontic treatment and patients treated with late extraction of four first premolars. In addition, associations between hard tissue and soft tissue measurements were determined, and differences between the male and female patients analyzed. A difference found in facial profile changes between the groups could certainly provide relevant clinical information. If, for example, the patients treated with late premolar extraction exhibited significantly flattened profiles, while serially extracted patients demonstrated well-balanced profiles, the clinician might opt for a serial extraction plan. On the other hand, if the late premolar extraction patients exhibited equally well-balanced or perhaps more well-balanced facial profiles, the clinician might choose to delay extractions until the eruption of the permanent dentition is complete. It was hypothesized that the profiles of those patients treated with late premolar extractions would not differ significantly from the profiles of patients whose dentition underwent a period of "drifting" following serial extraction.

Materials and methods

The sample consisted of cephalometric radiographs from 88 patients. Seventy-six percent of the patients were treated in the private practices of faculty members and 24% were treated in the graduate orthodontic clinic of the Department of Orthodontics at the University of Washington. The sample consisted of three groups. Patients in group A were treated with serial extraction but without subsequent orthodontic treatment (n=28; 13 males, 15 females). Patients in group B were treated with serial extractions, and they also received subsequent orthodontic treatment using standard edgewise technique (n=30; 6 males, 24 females). Group C consisted of adolescent patients whose orthodontic treatment included extraction of the four first premolars after the eruption of the permanent dentition (n=30; 4 males, 26 females). Patient characteristics are summarized in Table 1. Patients were chosen based on their treatment plan and adherence to specific requirements regarding the initial records. Patients with similar arch length deficiencies and age at initial records were chosen. It was not possible to exactly match the initial ages of group C to groups A and B, as their initial records were taken after the eruption of the permanent dentition. However, the patients for group C were chosen as young as possible in an attempt to minimize the differences between the three groups at initial records.

The general criteria for inclusion in all three sample groups at the stage of initial records were: Angle Class I malocclusion, no congenitally missing or malformed teeth (peg-shaped laterals, for example), and no sign of lip strain. Treatment plans were based on deficiency in arch length. Patients with minimal arch length deficiencies who had teeth extracted to reduce a bimaxillary protrusion were not included. High quality cephalometric radiographs that clearly showed the soft tissues, taken with a standardized Broadbent technique with the teeth in centric occlusion, were required.

Criteria specific to each group were as follows:

Group A: Serial extraction, no treatment

1. The initial radiographs were taken prior to the eruption of all second premolars.
2. The second radiograph was taken after the completion of serial extraction, at the time when orthodontic treatment would have been initiated.
3. The final radiographs were taken after growth was complete (18 years for females and 21 years for males).
4. The first premolars were extracted during the final phase of serial extraction.
5. No active or passive appliance therapy was used.

Group B: Serial extraction, with orthodontic treatment

1. The initial radiographs were taken prior to the eruption of all second premolars.
2. The second radiograph was taken prior to the initiation of orthodontic treatment.

3. The third radiograph was taken at the completion of orthodontic treatment.
4. The final radiographs were taken after growth was complete (18 years for females, 21 years for males).
5. The first premolars were extracted during the final phase of serial extraction.
6. Comprehensive orthodontic treatment using fixed, traditional edgewise appliances followed the serial extraction phase.

Group C: Late extraction with treatment

1. Initial radiographs were taken after complete eruption of the permanent dentition and prior to orthodontic treatment.
2. The second radiograph was taken at the completion of treatment.
3. The final radiograph was taken a minimum of 10 years postretention.
4. Patients had comprehensive orthodontic treatment using fixed, traditional edgewise appliances.

Measurements were taken of the three groups at the following time periods:

Group A
- A0 Pre-extraction
- A1 Postextraction
- A3 Late postextraction

Group B
- B0 Pre-extraction
- B1 Postextraction, prior to initiation of orthodontic treatment
- B2 Posttreatment
- B3 Postretention

Group C
- C1 Pretreatment
- C2 Posttreatment
- C3 Postretention

Lateral cephalometric radiographs were traced by hand by the primary author on frosted acetate tracing paper using a 0.5 mm 2H mechanical pencil. Eighteen landmarks were identified for each cephalogram and marked with colored pencils that were coded for each time period. The tracings were digitized using a custom Quick Ceph program (version 9.6, Orthodontic Processing, Coronado, Calif), which allowed digitization of specific soft tissue points, and a Numonics digitizing tablet (Montgomeryville, Penn). Figure 1 shows the landmarks used in this study. Linear and angular variables were measured, as shown in Figures 2 through 8. Changes were calculated between the measured variables from T0 to T1, from T1 to T2, from T2 to T3, from T1 to T3, and from initial to final records for all three groups. Measurements were made to the nearest 0.01 mm, with positive notations representing increases and negative notations indicating decreases.

Overall, maxillary and mandibular superimpositions for each patient were made by hand by the primary author. The overall superimposition was made using the best fit of the ethmoid triad (the greater wings of the sphenoid, the sphenoethmoidal plane, and the surrounding anatomy).[27] Maxillary superimpositions were made using the best fit of the posterior and anterior portions of the zygomatic process of the maxilla, with vertical changes in the orbital and palatal plane at a ratio of 1.5 to 1.[28] Mandibular superimpositions were made using the best fit of the internal anatomy of the symphysis, the mandibular canal, and the third molar crypts. Measurements from the superimpositions are illustrated in Figures 9 through 11.[29]

Analysis of data

To determine if significant changes occurred in each individual group, paired t-tests (p=0.00009) were used. Due to the large number of tests run, a Bonferroni correction was used to reduce the possibility of items appearing significant by chance, thus the resulting p-values are very small. An analysis of covariance was run to determine if significant differences (p=0.0002) existed between the three groups. To reduce the subject-to-subject variability inherent in measurements of individuals, variables known to have an effect on the measurements were incorporated into the ANOCOVA tests. For treatment effects, these were age at first measurement, change in age from first to second measurement, the baseline measurement itself (except in measurements taken from superimpositions), and sex. For the comparison of sex effects, an adjustment was made for the treatment group, but not for sex.

To determine if associations existed between any one soft tissue variable and another, or between any hard tissue variable and any soft tissue variable, Pearson product-moment correlations were calculated, with r-values of 0.70 representing the minimum level of clinical significance. Analysis of differences between males and females was done with two-sample t-tests.

To determine the intraexaminer error in tracing, digitizing, superimposition technique, and measurements, 10 cases were selected at random and two radiographs from each were retraced, digitized, and superimposed. These duplications were made a minimum of 1 month apart. The error of the method was determined using Dahlberg's formula, where error= $(\sqrt{D^2})/2N$. The mean error for linear measurements (n=58) was 1.8 mm, and the mean error for angular measures (n=6) was 2.8°.

Results

Changes from T0 to T1 (pre-extraction to postextraction)

No statistically significant differences were found between the serial extraction groups for pre-extraction to postextraction, using either adjusted or unadjusted values.

Changes from T1 to T2 (postextraction/pretreatment to posttreatment)

Analysis for the postextraction/pretreatment to posttreatment period revealed that a significant difference existed between groups for the position of the most labial point of the mandibular incisor, as measured from mandibular superimposition. The late extraction with treatment group, group C, had a mean change of -2.21 mm, while the serial extraction with treatment group, group B, did not show a significant change in mandibular incisor position (-0.04 mm). This measurement was found to be statistically significant in both the adjusted and unadjusted values.

Changes from T2 to T3 (posttreatment to long-term postretention) and from T1 to T3 (postextraction to long-term postextraction)

No statistically significant differences were found between the three groups for either the posttreatment to long-term postretention or postextraction to long-term postextraction periods, using either the adjusted or unadjusted values.

Sex differences

There were no statistically significant sex differences from T0 to T1 or from T1 to T2. Several values were found to be significant between males and females from T2 to T3. Males had larger measurements for all values. The soft tissue thickness measured between A-point and soft tissue A-point was greater by 3.04 mm in males, and the soft-tissue thickness measured between the most labial point on the mandibular incisor and lower lip was greater by 2.25 mm. The perpendicular distance from soft tissue pogonion to the facial plane was greater by 1.28 mm. Vertical facial height measurement was greater by 4.70 mm. From the overall superimpositions, the following measurements were also found to be greater for males than females: soft tissue nasion, tip of the nose, soft tissue A-point, upper lip, lower lip, soft tissue B-point, soft tissue pogonion, B-point, and pogonion.

Associations between variables

The analysis of associations between soft tissue variables and from

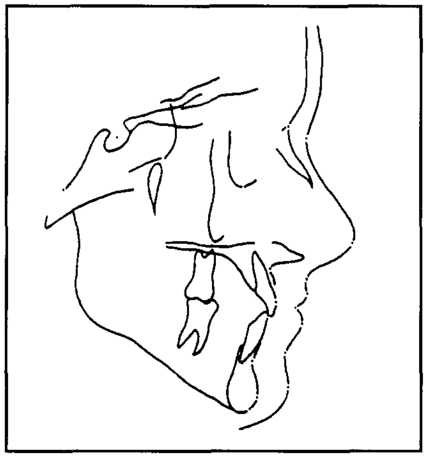

Figure 1
Anatomic and soft tissue landmarks

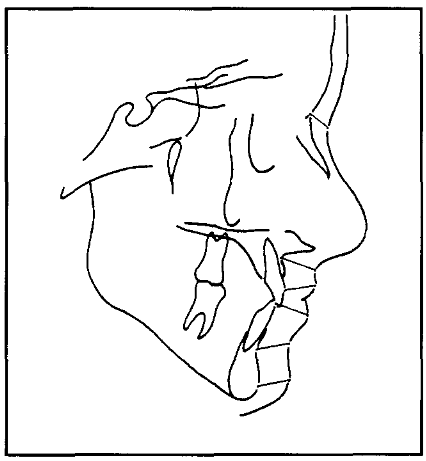

Figure 2
Measurement of soft tissue thicknesses

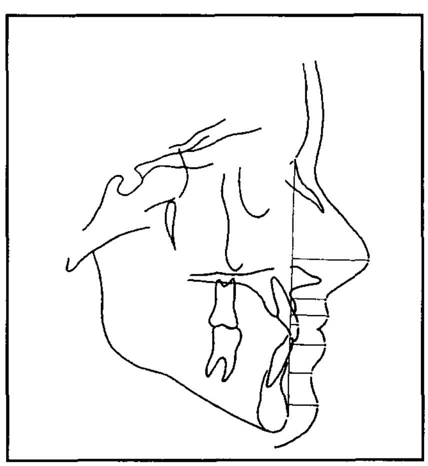

Figure 3
Distances measured perpendicular to facial plan

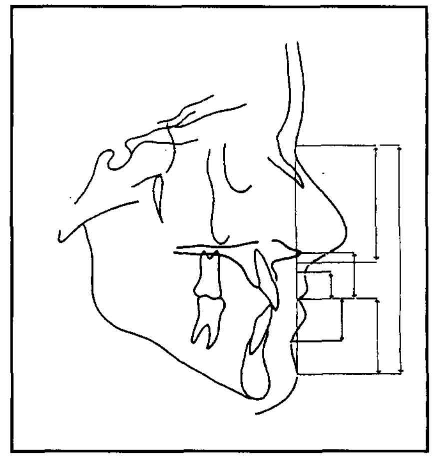

Figure 4
Vertical measurements of the soft tissue profile

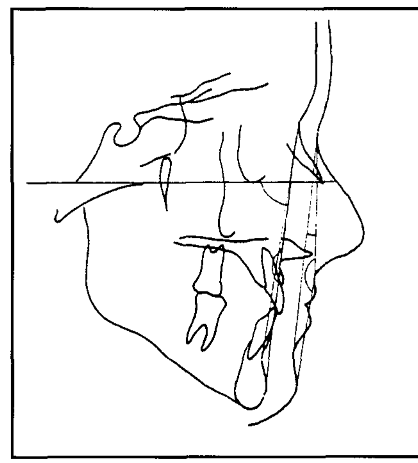

Figure 5
Angular profile measurements

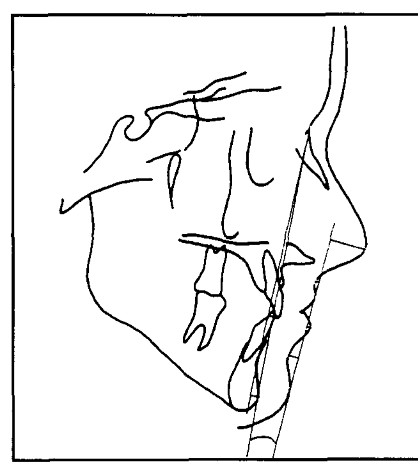

Figure 6
Holdaway's H-angle and measurements perpendicular to it

hard tissue to soft tissue variables resulted in an overwhelmingly large number of significant correlations. Some associations were discarded in an attempt to limit the information to what would be considered pertinent to orthodontic treatment and in the evaluation of changes in facial profiles. These correlations included repeated variables, e.g., upper lip to Holdaway : upper lip to Steiner's plane; unrelated landmarks, e.g., nasion : lower incisor position; correlations between digitized landmarks and superimposition measurements; correlations of the same measurement on two different superimpositions; and associations unrelated to orthodontic treatment, e.g., nasion : soft tissue nasion. The resulting correlations are presented in Table 2.

In the analysis of significant correlations, certain trends could be found. For hard tissue to soft tissue correlations, an association was found between the soft tissue angle of convexity : ANB during the periods T0 to T1 and T1 to T2. During the period of orthodontic treatment, T1 to T2, significant associations were observed between the lower lip and mandibular incisor position, and soft tissue B-point and mandibular incisor position. An association was found for the serial extraction, no treatment group and the late extraction with treatment group, but not for the serial extraction with treatment group, during the T0 to T1 period for ANB to soft tissue A-point. From measurements made on the overall superimpositions, associations were found between B-point and soft tissue B-point for all groups, and between B-point and the lower lip for the serial extraction, no treatment and late extraction with treatment groups, but not for the serial extraction with treatment group, from T1 to T2.

Most of the significant soft tissue-to-soft tissue correlations were found during orthodontic treatment and long-term. Associations existed between the upper lip and soft tissue A-point, and between the lower lip and upper lip when measured perpendicular to the facial plane, to Ricketts' esthetic plane, on the maxillary superimpositions, and on the overall superimpositions. Associations were found between the soft tissue angle of convexity and soft tissue A-point during the periods T0 to T1 and T1 to T2. Many associations were found from the measurements of the overall superimpositions: upper lip to soft tissue A-point, lower lip to upper lip, soft tissue B-point to soft tissue A-point, soft tissue B-point to lower lip, soft tissue pogonion to

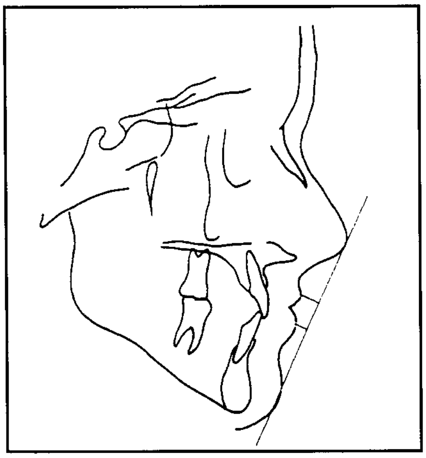

Figure 7
Perpendicular measurements to Ricketts' esthetic plane

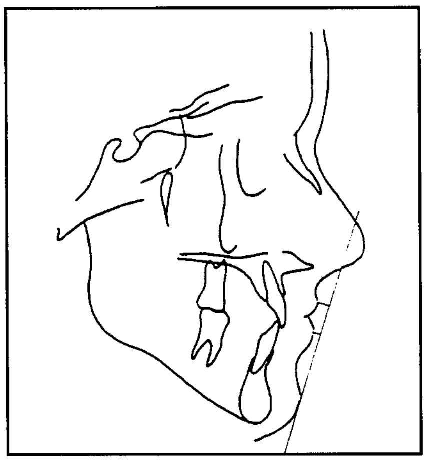

Figure 8
Perpendicular measurements to Steiner's plane

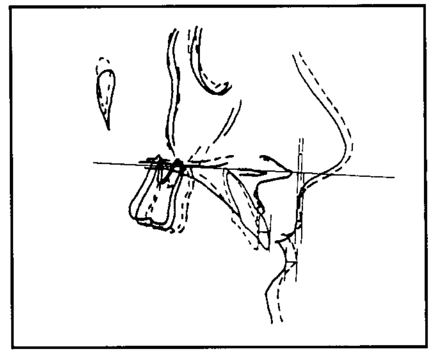

Figure 9
Measurements from maxillary superimposition

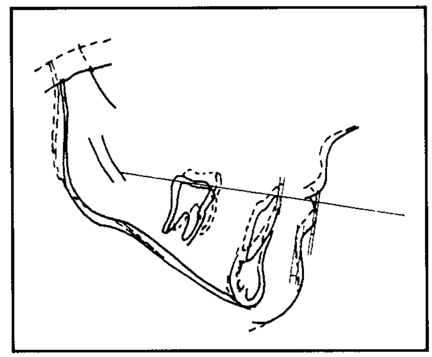

Figure 10
Measurements from mandibular superimposition

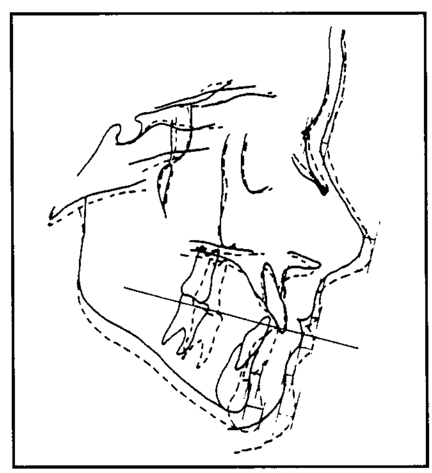

Figure 11
Measurements of anteroposterior changes from overall superimposition

lower lip, and soft tissue pogonion to soft tissue B-point for almost all groups at all time periods.

Discussion

Records in the postretention sample at the University of Washington were collected randomly. The patients selected from the postretention sample for this study were chosen based on certain criteria. In each case, an extraction protocol was chosen as the means of eliminating an arch length deficiency, whether it was a serial or late premolar extraction case. Patients with arch length deficiencies less than 4 mm were excluded, as were patients with mentalis strain or a "double protrusive" lip profile. Because the variable of growth is difficult to adjust for, patients were also chosen who were as near to each other in age as possible when initial records were taken.

The average ages of the serial extraction patients, both untreated and treated, were similar: 9-9 and 9-6, respectively. While it was not possible to select patients for group C in this age range, the youngest possible late extraction patients were chosen (none was older than 15-0, range: 9-1 to 15-0) in an attempt to reduce the variability inherent in changes due to growth. To further reduce some of the unexplained variability, corrections were made in the statistical analysis. However, in the analysis of the statistical results, both the adjusted and unadjusted values were evaluated and found to be very similar, which increases the certainty that the findings are indeed the significant values.

In analyzing the changes in each individual group, certain patterns emerged. In the first time period, T0 to T1, which is the period of drift of the dentition after serial extraction, only two changes were found to be significant: nose length and pogonion to nasion–B-point. This was undoubtedly due to the growth of the patient and not to the treatment itself. The second time period, T1 to T2, represents the treatment time for groups B and C. During this time, facial height increased in both groups, and other changes attributable to growth, such as increases at nasion and the nose, were observed. Only two significant changes related to the orthodontic treatment were observed in the serial extraction group: the position of the maxillary incisor, and the length of the lower lip. Conversely, several changes were found to be significant for the late extraction group: the positions of upper and lower incisors, the position of the upper and lower lips in anteroposterior measurements and relative to the reference lines of Steiner and Ricketts, positions of the upper and lower soft tissue A- and B-points, lip length, and the soft tissue angle of convexity. Changes in positions of the upper and lower lips have been documented in several studies,[12-14,17-20] primarily the amount of lip retraction seen with maxillary and mandibular incisor retraction. Changes in the lips in relation to Ricketts' esthetic plane agree with previous findings by Drobocky and Smith.[13] In contrast to findings in this study, Anderson[19] determined that the soft tissues overlying A- and B-points are not affected by orthodontic treatment. Another finding in this study was a significant change in lip length. Yogosawa[20] found that decreases in lip length result from incisor retraction, particularly in patients who were protrusive at the start of orthodontic treatment.

In the final time period, T2-T3/T1-T3, which represents the changes occurring long-term postretention or postextraction, a number of changes were significant in all three groups: changes at pogonion, nasion, and the nose; an increase in facial height; and a decrease in the ANB angle. Other significant changes in each group were similar in location, but not identical.

For the serial extraction, no treatment group, changes at A- and B-points and changes in the upper and lower lips relative to both Steiner's and Ricketts' planes were observed. For the serial extraction with treatment group, upper lip thickness, soft tissue A-point, and upper lip measured perpendicular to the facial plane showed significant decreases, as did the upper and lower lip to Ricketts' and Steiner's planes. For the late extraction with treatment group, changes at soft tissue A-point and upper lip measured perpendicular to the facial plane were also significant. Only the upper lip was found to have significant changes relative to Ricketts' and Steiner's planes, and a change at A-point was also found in the overall superimposition. Of the three groups, the serial extraction, no treatment patients exhibited a greater number of significant differences, a finding that was most likely due to a slightly longer time span between measurements, including more of the adolescent growth period.

When comparisons were made between the groups at each time period, only one measurement was found to be significant in both the adjusted and unadjusted values. In the late extraction with treatment group, the mandibular incisor was more lingually positioned at the end of orthodontic treatment than in the serial extraction with treatment group. While this was a significant finding, other factors need to be considered. In tracing a cephalometric radiograph, the most labially positioned incisor is used. It is possible in any case to have one incisor that is more labially positioned than the others, resulting in measurements that are based not on the average position of the anterior teeth, but on one unusually positioned incisor. Perhaps in the late extraction patients a labially positioned incisor was more commonly found due to crowding, which was alleviated to some extent in the serial extraction patients. Another possible explanation for this occur-

Table 2
Correlation coefficients (r-values) demonstrating associations between variables

Correlations	Superimposition	T0-T1 SENT	T0-T1 SET	T1-T2 SET	T1-T2 LET	T2-T3 SET	T2-T3 LET	T1-T3 SENT
Hard tissue to soft tissue								
Mandibular 1 labial : maxillary 1 labial						0.70		0.91
Lower lip : mandibular 1 labial				0.76	0.75			
Soft B-point : labial mandibular 1		0.84		0.89	0.80			
ANB : soft A-point		0.84		0.81	0.74	0.71	0.86	0.78
Soft tissue angle of conv : maxillary 1							0.96	
Soft tissue angle of conv : ANB		0.92	0.85	0.89	0.84			
Lower lip : maxillary 1 labial	Maxillary			0.74				
Soft B-point : mandibular 1 labial	Mandibular			0.84	0.81			
A-point : upper lip	Overall				0.70			0.86
A-point : soft A-point	Overall	0.86			0.74	0.75		0.87
B-point : lower lip	Overall	0.91	0.84		0.82	0.76	0.72	0.81
B-point : soft B-point	Overall	0.98	0.92	0.78	0.90	0.94	0.82	0.94
B-point : A-point			0.85			0.77	0.77	0.87
Soft tissue to soft tissue								
Upper lip : soft A-point			0.87	0.88	0.95	0.88	0.81	0.95
Lower lip : upper lip				0.80	0.86	0.82	0.71	0.87
ST angle of conv : soft A-point		0.91	0.85	0.85	0.85			
Soft B-point : lower lip				0.79	0.74	0.70		
Lower lip/E plane : upper lip/E plane		0.86		0.82	0.75	0.82	0.74	0.85
Lower lip/S plane : upper lip/S plane				0.74	0.68	0.73		
Lower lip : upper lip	Maxillary			0.83	0.88	0.87	0.75	0.91
Soft A-point : upper lip	Maxillary		0.90	0.89	0.96	0.84	0.80	0.97
Soft B-point : lower lip	Mandibular			0.77	0.72			0.79
Upper lip : soft A-point	Overall	0.91	0.93	0.92	0.98	0.93	0.88	0.95
Lower lip : upper lip	Overall	0.91	0.88	0.94	0.92	0.89	0.94	
Soft B-point : soft A-point	Overall				0.90	0.83	0.71	0.84
Soft B-point : lower lip	Overall	0.87	0.88	0.85	0.94	0.89	0.88	0.92
Soft tissue pogonion to lower lip	Overall	0.91		0.76	0.88	0.77	0.90	0.91
Soft tissue pogonion : soft B-point	Overall	0.97	0.91	0.82	0.95	0.93	0.93	0.96

rence lies in the treatment mechanics. A considerable amount of Class III elastic wear could result in increased retraction of the mandibular incisors. On the other hand, it is possible that the change measured is an accurate representation of the effect late premolar extraction has with orthodontic treatment.

Of more relevance to this study is the observation that the change in lower incisor position was not reflected in any change in the lower lip or other soft tissues. It has long been postulated that extraction leads to greater retraction of anterior teeth, and that these changes in hard tissues are accompanied by direct changes in soft tissues,[30] a theory that assumes soft tissues passively drape over hard tissues. Many studies have looked at the relationship between hard and soft tissue change, and the results are varied.[12,14,15,17,19,21,23,24,31-33] The general conclusion has been that the changes demonstrate large individual variation. In this study, the amount of individual variation did not differ significantly between groups, thus, no differences were found in soft tissue profile changes, even with the finding of a significant change in a hard tissue measurement in one group.

As mentioned previously, the greatest number of changes observed in the tests within individual groups occurred in the late extraction with treatment group during the treatment period from T1 to T2. However, during the postretention and postextraction periods, the number of changes observed in each group were similar, and no differences were found between the groups. Thus, while one group exhibited greater change during the treatment period, the various treatment modalities did not result in different facial profiles long-term.

An analysis of differences between male and female patients revealed only significant long-term findings, from T2 to T3 (T1 to T3 for serial extraction, no treatment patients). The majority of findings were from the overall superimposition, and males were found to have greater changes than females in all significant values. These changes are most likely attributable to normal growth. Previous studies[25,34-37] of facial changes occurring with growth have shown the changes in these parameters to be greater in males than females.

A number of correlations of r=0.70 and greater were found that associated soft tissue variables to each other and to hard tissue variables. Variables considered redundant or not pertinent to this study were omitted (as described).

From hard tissue to soft tissue correlations, an association was found between the soft tissue angle of convexity : ANB during the periods T0 to T1 and T1 to T2, which corresponds with the periods of greatest growth, and is in agreement with studies[12,19,38] that have evaluated changes in the convexity of the profile with normal maturation. Associations were found between lower lip and the labial of the mandibular incisor, with *r* values of 0.76 and 0.75. These values are comparable to the correlation seen by Rudee (r=0.70), and are larger than those seen by Hasstedt[39] (r=0.52) and O'Rielly (r=0.56). The correlation seen between lower lip and labial of the maxillary incisor (r=0.74) for the serial extraction with treatment group was much higher than those found in previous studies (r=0.49, 0.48, 0.33).[12,14,40] Associations were also seen between B-point and lower lip, and between B-point and soft tissue B-point, which agrees with the finding by Ricketts[41] that the sublabial area follows the change in position of the root of the lower incisor.

Overall, more associations were found for the serial extraction with treatment and late extraction with treatment groups during the treatment period T1 to T2 than during the other time periods. This finding could be attributed to the treatment: Teeth were under active orthodontic movement, and the overlying tissues experienced corresponding movement. Alternatively, the associations could be attributed to the time period: The patients were experiencing active growth. Correlations between the upper lip and lower lip to Steiner's plane and Ricketts' E-plane should be expected with the growth of the nose and increase in chin prominence, which occur with normal maturation.[22,24,42] The association found between the soft tissue angle of convexity and soft tissue A-point appears to be an obvious one: Soft tissue A-point is the vertex of the angle measured.

While a great number of associations were found both for changes in hard tissue and soft tissue measurements, and certain trends were found, they were not readily identifiable. This ill-defined distribution appears to be reflected in the lack of significant differences in profile changes for the three groups of patients.

Conclusions

Findings from this study suggest that the following conclusions can be drawn:

1. There were no differences in soft tissue profiles after active orthodontic treatment, drift of the dentition, or long-term between the three groups of patients.

2. During active treatment, a greater lingual change in position of the mandibular incisor was found for the patients who had late premolar extraction followed by orthodontic treatment, but this change was not reflected in the position of the lower lip.

3. Late extraction with treatment patients exhibited a larger number of significant findings within the group during the treatment period; however, there were no differences between the profiles of the three groups long-term.

4. The larger number of significant changes in the serial extraction, no treatment group is most likely due to the longer period between measurements, which included considerably more growth.

4. During the periods of drift and orthodontic treatment, there were no differences between profiles of male and female patients. During the long-term period, males had greater absolute measurements, but profiles of males and females remained similar. These observations are most likely due to the sex variation found in normal growth patterns.

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