Soft Tissue Profile Change Produced by Reduction of Mandibular Prognathism

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An esthetically pleasing profile is the result of the relative size and position of various hard and soft tissues of the face. Little evidence exists to demonstrate that one set of proportions is superior to another in terms of function or physical health. Substantially more evidence exists that cultural values dictate favorable proportions within rather narrow limitations. In our society, modifications of facial proportions, whether the variations are acquired or inborn, are sought and attempted with relative frequency.

Facial profile proportions are usually the result of variations in size and/or position of the jaws and/or the teeth. Such variation is predominantly in the anteroposterior and/or vertical planes of space. When a variation results from imbalanced tooth relations existing on jaws in good relationship, an improvement may be accomplished by tooth movement alone. Such tooth movement is commonly orthodontically achieved, but in some cases may be accomplished surgically. When a variation results from imbalanced jaw relations, tooth movement can only compensate for the jaw variation. If the imbalance is great and growth is complete, the relative jaw positions can only be corrected by surgery.

One major jaw imbalance occurs in mandibular prognathism. This condition is an anterior positioning of the mandible relative to the maxilla with varying vertical imbalances superimposed. When such jaw relations occur, the forces of the facial musculature on the teeth are changed and tooth movement compensations usually occur. Frequently the maxillary incisors are anteriorly inclined and the mandibular incisors are posteriorly inclined. If such a case is approached surgically, the teeth will dictate the surgical positioning of the jaws. If the teeth are in compensated positions, the surgery will correct only that portion of the jaw imbalance not compensated for by the teeth. Consequently, in order to achieve a full correction of the jaw imbalance, it is necessary to remove the dental compensations and properly relate the teeth to their respective jaws prior to surgery.

A combined orthodontic and surgical approach has been used in the majority of severe prognathic cases treated at the University of Minnesota. Presurgical orthodontic treatment allows improvement in dental arch form, tooth alignment and the dental-skeletal relationship within each jaw. Consequently, at surgery a more ideal skeletal relationship plus a better dental interdigitation is achieved. The orthodontic appliances also facilitate stable intermaxillary fixation.

Obviously, treatment planning would be aided by the ability to predict the direction and amount of soft tissue movement relative to a given hard tissue movement. Several studies have reported qualitative soft tissue changes resulting from the surgical correction of mandibular prognathism.[1-3,5,6] The objective of this study was to quantitate the changes of soft tissue landmarks relative to hard tissue landmarks in cases of mandibular prognathism treated by a combined orthodontic-surgical approach.

Methods and Materials

Cephalometric records of ten patients initially demonstrating mandibular prognathism with varying degrees of vertical problems were examined in this study. The patients included seven females and three males ranging in age from thirteen to twenty years at the start of treatment. Treatment was accomplished by the coordinated efforts of the Orthodontic and Oral Surgery Divisions, School of Dentistry, University of Minnesota.

The ten patients reported in this study met the following criteria:

1. Skeletal and dental mandibular prognathism treated by a combined orthodontic-surgical technique.
2. Records contained lateral head radiographs exposed at the following times:
   a. Pretreatment
   b. Presurgery - one or two days prior to surgery
   c. Fixation - sometime between the second and sixth week following surgery
   d. Postfixation - after the removal of fixation and usually following postsurgical orthodontic treatment.
3. Traceable quality of radiographs sufficient to visualize skeletal landmarks and soft tissue profile.
4. Radiographs taken with patient's teeth in occlusion and soft tissue profile judged in an unstrained, relaxed position with lips lightly touching.

The changes in the soft tissue profile of each patient were evaluated

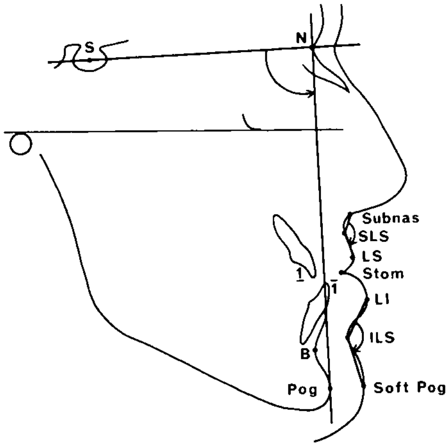

Fig. 1. Reference planes, hard and soft tissue landmarks used in this study.

using tracings of lateral cephalometric radiographs exposed using standard cephalometric techniques. Figure 1 illustrates a typical tracing with the reference planes and cephalometric landmarks used in this study. Sella-nasion and nasion-pogonion reference planes were established in the horizontal (HRP) and vertical (VRP) planes of space, respectively. Angle sella-nasion-pogonion was constructed on the pretreatment cephalogram for each patient and transferred to each patient's subsequent x-rays oriented along sella-nasion. The hard tissue landmarks used were: sella turcica (S), nasion (N), pogonion (Pog), point B and the incisal edges of the upper and lower central incisors.

The integumental landmarks were:

Subnas — Subnasale: the point where the maxillary lip and the nasal septum form a definite angle; or, if a gentle curve, the most concave point in this area.

SLS — Superior labial sulcus: the deepest midline point in the upper lip as determined by reference to VRP.

LS — Labrale superius: the most prominent midline point of the upper membranous lip as determined by reference to VRP.

Stom — Stomion: the point at which the upper and lower lip meet.

LI — Labrale inferius: the most prominent midline point of the lower membranous lip as determined by reference to VRP.

ILS — Inferior labial sulcus: the deepest midline point in the lower lip as determined by reference to VRP.

Soft Pog — Soft tissue pogonion: the most prominent point on the soft tissue chin as determined by reference to VRP.

Perpendiculars were constructed from the vertical reference plane to the various hard and soft tissue landmarks. Changes for each cephalometric landmark relative to the horizontal or vertical reference plane were noted on the tracing of each patient's radiograph. In addition to horizontal and vertical changes, angular changes subnasale-SLS-LS and LI-ILS-soft tissue pogonion were noted.

Changes in profile during presurgical orthodontic treatment were calculated as the differences between the location of the various landmarks from the pretreatment cephalogram to the presurgery cephalogram.

Presurgical orthodontic treatment predominantly involves dental changes with associated changes in the lip area of the soft tissue profile. Two maxillary premolars were extracted in five cases. In one of these cases two mandibular first premolars were already missing.

The surgical repositioning of the mandible results in extensive changes in the skeletal and integumental profiles. Changes in profile following surgery were calculated as the differences between the location of the various landmarks from the presurgery cephalograms to the fixation cephalogram. The date of the fixation cephalogram was at least seven days after surgery. This length of time allowed postoperative swelling to subside. The presence of swelling would distort the soft tissue and mask the actual integumental changes.

The surgical treatment for repositioning the mandible in nine cases was the bilateral subcondylar vertical osteotomy as described by Hinds and Robinson. One case was treated using the Obwegeser sagittal split technique. Surgery was performed at the University of Minnesota Hospital by the Division of Oral Surgery.

An intermaxillary acrylic wedge splint extending bilaterally from the most posterior tooth in the arch to the cuspid region was used in eight cases. These wedge-shaped splints opened the bite two to four millimeters in the molar area but allowed dental contact at the cuspids. This produced maximum vertical overbite of the incisor. The splint also helped in positioning of the mandible at the time of surgery. Three to five soft 20 gauge wire ties between the upper and lower orthodontic archwires were used for intermaxillary fixation for six weeks.

The postfixation profile changes were calculated as the differences between the location of the various landmarks from the fixation cephalogram to the postfixation cephalogram. Postfixation orthodontic treatment included final arch coordination with the use of intermaxillary elastics for vertical closure. The cases were retained with either a rubber tooth positioner or a maxillary Hawley appliance and, where indicated, a fixed lower cuspid-to-cuspid retainer.

Over-all results reported represent changes in the profile calculated as the difference between the location of the various landmarks from the pretreatment cephalogram to the postfixation cephalogram.

Results

The total over-all movement of the soft and hard tissue profiles from the pretreatment to the postfixation periods is illustrated in the shadowgrams in Figures 2-11. In nine of the ten cases the over-all net effect of treatment was posterior movement of the mandibular soft and hard tissue profiles. In the vertical plane of space the response among the ten patients was more variable with some lower facial heights decreasing, some increasing, and some not substantially changed. The correlations between soft and hard tissue movements during the various phases of treatment are shown in Tables I, II, and III.

In the horizontal plane movements of the lower incisor were correlated with similar movements of the lower lip (LI) during the presurgical orthodontic period. This movement may have been anterior or posterior depending on the dental crowding or spacing present. In the postfixation period horizontal movements of LI were also correlated with the same movements of the maxillary incisor. No correlations were present in the vertical plane of space (Tables I, III).

Stomion was correlated with movement of the mandibular incisor during the presurgical orthodontic period in the horizontal plane. In addition, movement of stomion also showed a correlation with maxillary incisor movement during the postfixation period (Tables I, III). These changes were probably a result of the changed incisor relationships following surgery. Again, no correlations were demonstrated in the vertical plane of space.

The angle of the lower lip, LI-ILS-soft pogonion, decreased during the presurgical orthodontic and surgical periods. Only during the postfixation period did this angle increase again in all patients. The over-all effect was a decrease in nine of the patients.

TABLE I

Correlation Coefficient, r, Between Movements of Soft Versus Hard Tissue Landmarks During Presurgical Orthodontic Treatment

Soft - Hard	Horizontal	Vertical
LI vs. $\overline{1}$	0.9041*	0.3337
Stomion vs. $\overline{1}$	0.7780*	0.5380
SLS vs. $\underline{1}$	0.8702*	0.4710
LS vs. $\underline{1}$	0.8018*	0.2269

* Significant at the 1% level

TABLE II

Correlation Coefficient, r, Between Movements of Soft Versus Hard Tissue Landmarks During Surgery

Soft - Hard	Horizontal	Vertical
ILS vs B point	0.9546*	0.6533**
Soft pogonion. vs. pogonion	0.9783*	0.5576

* Significant at the 1% level
** Significant at the 5% level

Over-all maxillary incisor movements varied considerably in the horizontal plane of space. Over-all crown movement was either anterior (Figs. 2-4, 6, 11), posterior (Figs. 5, 7, 10) or not changed (Figs. 8, 9). The correlations between maxillary incisor and upper lip movements are shown in Tables I and III. During presurgical orthodontics a high correlation was present between movement of the maxillary incisor and the upper lip (SLS, LS). This movement was primarily toward the anterior. During the surgery period the upper incisor moved inferiorly and posteriorly, probably as a result of intermaxillary fixation. During the postfixation period a good correlation was present between hard and soft tissue movements of the maxillary incisor and the upper lip. These movements were usually anterior and slightly superior. Again, movement of hard and soft tissues was not significantly correlated in the vertical plane of space.

TABLE III
Correlation Coefficient, r, Between Movements of Soft Versus Hard Tissue Landmarks During Postfixation

Soft - Hard	Horizontal	Vertical
LI vs. 1	0.7700*	0.4771
Stomion vs 1	0.7504*	0.4099
SLS vs. 1	0.8394*	0.3206
LS vs. 1	0.7946*	0.3814

* Significant at the 1% level

Subnasale displayed very little movement in any direction during all phases of treatment. The angle of the upper lip, subnasale - SLS-LS, decreased during presurgical orthodontics and increased during the postsurgery and postfixation periods. The over-all result was a net increase.

Table II shows the effect of surgical mandibular reduction on mandibular soft tissue landmarks. Tissues located away from the teeth (ILS and soft pogonion) were reduced horizontally in a nearly equal amount of hard tissue reduction. This was not true vertically. The change in incisor relations probably also interfered with similar lip changes and these correlations were not significant.

Discussion

The untreated mandibular prognathism patient presents with a discrepancy in jaw size or position between the maxilla and the mandible. Commonly, the teeth are partially compensating for the discrepancy. The mandible is relatively too far anterior and consequently the lower incisors are usually tipped posteriorly. The maxillary incisors are more variable but most often are anteriorly inclined in varying degrees.

Orthodontic correction alone of such a problem must be designed to push these dental compensations to even greater amounts. Clearly, this is often an unstable and esthetic compromise when gross discrepancies in jaw size or position exist. In the orthodontic-surgical approach the presurgical orthodontic objectives are just the opposite. All dental compensations are removed. When the teeth are appropriately related to their respective jaws, the jaw-to-jaw discrepancy will appear clinically more severe. This is not only desirable but beneficial to treatment. The interdigitation requirements of the dentition determine the positioning of the jaws at surgery. Surgery done in the presence of abnormal tooth positions will result in jaw positioning dictated by these same tooth positions. Usually this will mean only a partial correction of the mandibular prognathism. If the discrepancy has been temporarily worsened by removing dental compensations, the surgery can fully correct the jaw imbalance.

It should be noted that the major effects of routine orthodontic therapy are limited to the dentoalveolar areas. Teeth can be tipped or translated to new positions in the alveolus. Their stability in these positions will depend on the forces acting on the teeth from the dental occlusion and the musculature. If the teeth are very crowded, space can be gained only by extending the arch outward or extracting teeth. In prognathic individuals maxillary crowding is common and maxillary premolars were extracted in five of the ten patients. In mandibular prognathism dental crowding is less frequent in the usually too large mandible.

The presurgical orthodontic phase of treatment may be summarized as a time for removal of dental compensations. The effects on the profile were limited to horizontal, lip-postural changes produced by forward or backward movement of incisor crowns. Lip movement occurred in the same direction as dental crown movement (anterior or posterior) at from 75 to 90 per cent the amount (Table I).

The changes in soft tissue profile at the time of surgery closely followed the changes in hard tissue in direction and amount in the horizontal plane (Table II). ILS and soft pogonion followed

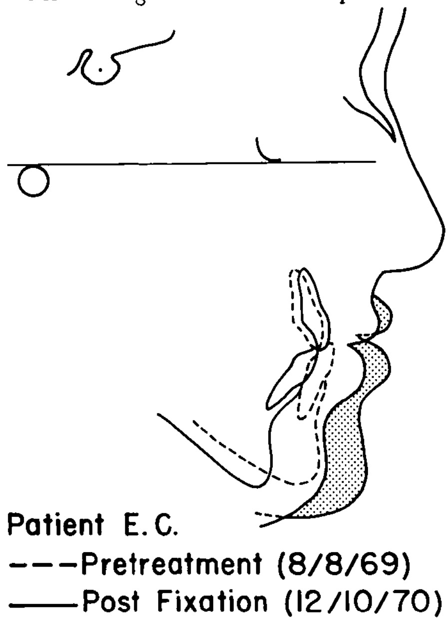

Fig. 2 Patient E. C. Dashed line pretreatment (8/69), continuous line postfixation (12/70).

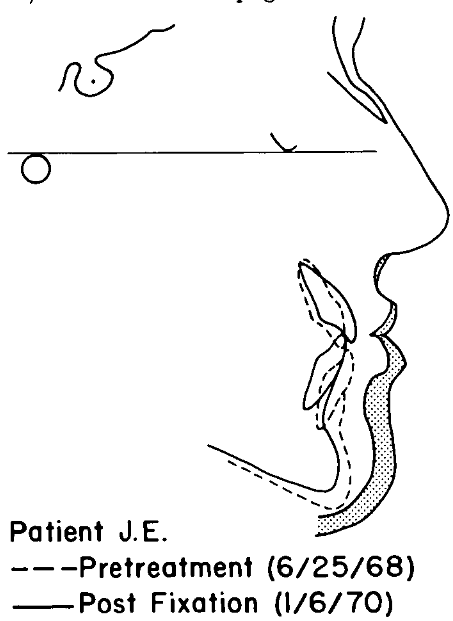

Fig. 3 Patient J. E. Dashed line pretreatment (6/68), continuous line postfixation (1/70).

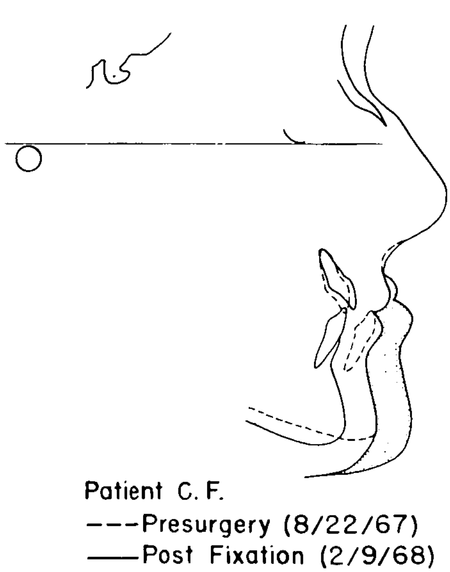

Fig. 4 Patient C. F. Dashed line pretreatment (8/67), continuous line postfixation (2/68).

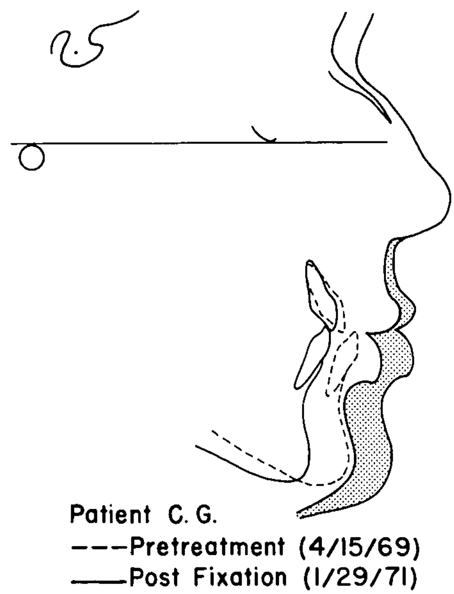

Fig. 5 Patient C. G. Dashed line pretreatment (4/69), continuous line postfixation (1/71).

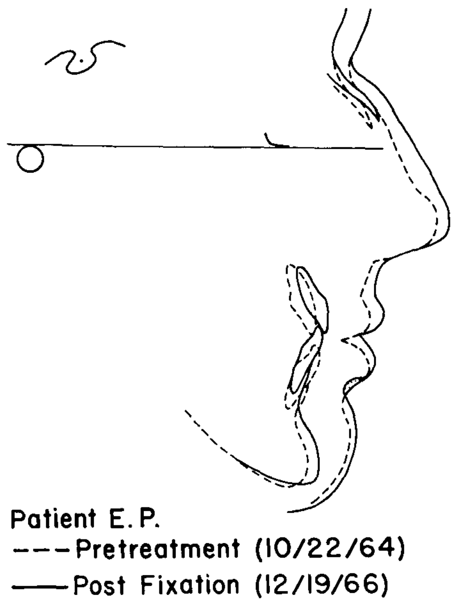

Fig. 6 Patient E. P. Dashed line pretreatment (10/64), continuous line postfixation (12/66).

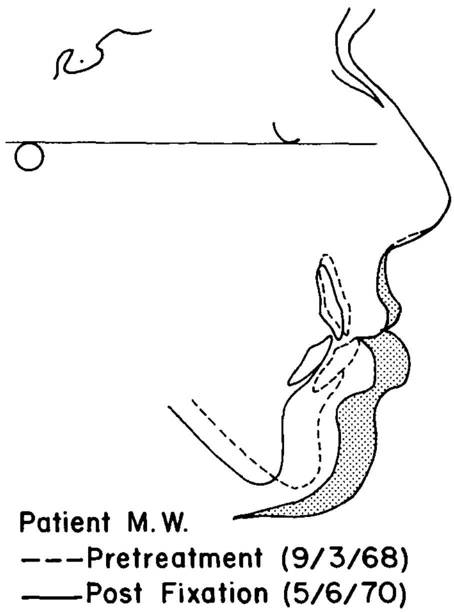

Fig. 7 Patient M. W. Dashed line pretreatment (9/68), continuous line postfixation (5/70).

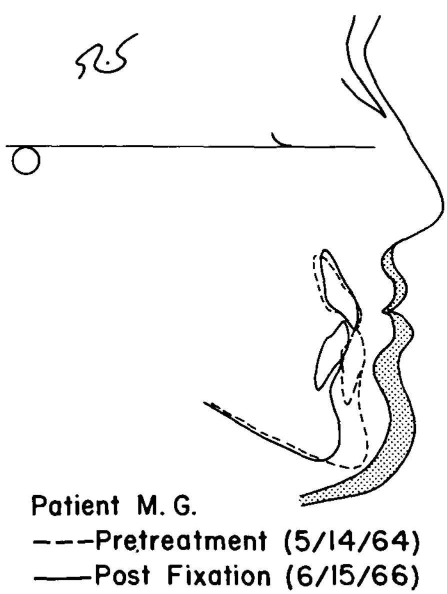

Fig. 8 Patient M. G. Dashed line pretreatment (5/64), continuous line postfixation (6/66).

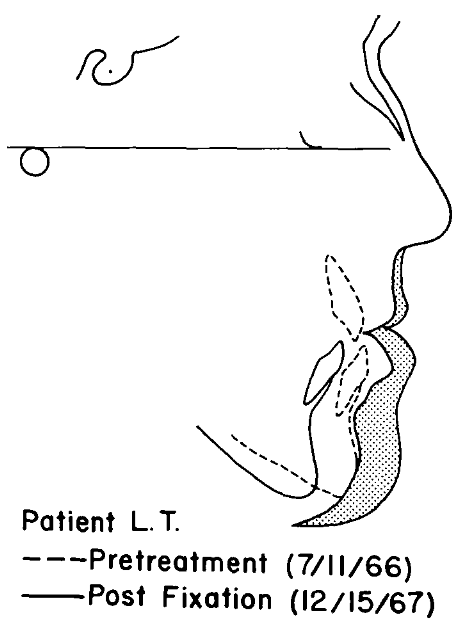

Fig. 9 Patient L. T. Dashed line pretreatment (7/66), continuous line postfixation (12/67).

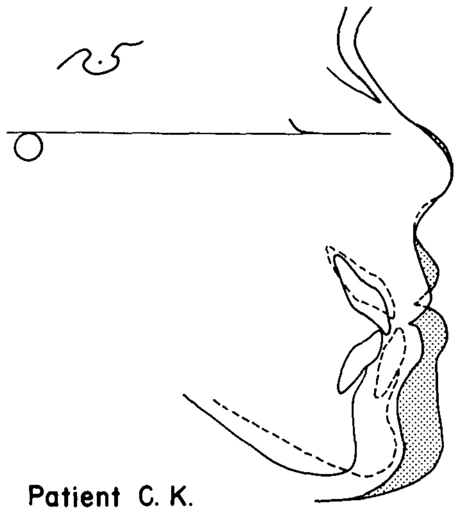

Fig. 10 Patient C. K. Dashed line pretreatment (8/64), continuous line postfixation (6/66).

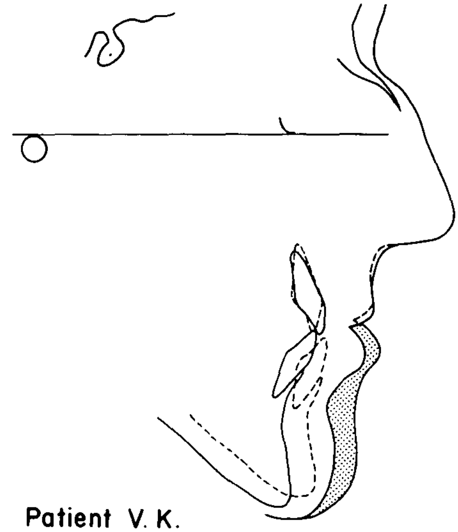

Fig. 11 Patient V. K. Dashed line pretreatment (1/69), continuous line postfixation (2/71).

B point and pogonion, respectively, on almost a 1:1 basis, a useful tool in treatment planning. Since the maxillary and mandibular incisor relations were drastically changed at surgery, the correlations of lip position to incisor position were less significantly correlated. The usual occurrence was that, as the lower incisor was positioned posterior to the upper incisor, the upper incisor became influential on the soft tissue overlying both the upper and lower incisors.

The postfixation phase of treatment involved finishing orthodontic tooth movement following the removal of surgical fixation of the jaws. The changes were relatively small and variable. In the horizontal plane soft tissue landmarks tend to follow tooth movement in direction and amount.

The group of patients studied showed significant correlations between changes in soft and hard tissue landmarks in the horizontal plane but not in the vertical direction. There are several possible explanations for the low correlation coefficients obtained on vertical measurements. The landmarks selected for this study were located such that the movement of the bony landmark would influence the soft tissue point. The landmarks were most appropriate to evaluate horizontal rather than vertical changes. Some of the traditional landmarks are designated "the deepest" or "the most prominent" point on a vertical tissue contour. Landmarks defined in this manner may move vertically over the surface of the tissue. This possibility would permit the soft tissue landmarks to change vertically somewhat independently of the bony landmarks and thereby not reflect the soft to hard tissue vertical relationship that logically should exist. In addition, the vertical changes are relatively small in comparison with horizontal changes produced by surgical repositioning of the mandible. In the majority of patients the mandible was translated very little vertically during its posterior displacement. Different landmarks or another system of measurement may better reflect the relatively small vertical changes which occur during treatment.

Variation in individual skeletal patterns and consequent variation in orthodontic and surgical procedures may also account for the low correlations in vertical changes.[4] The tonicity of the facial musculature can vary with skeletal pattern and influence the integumental response to dental and skeletal changes. Variability in measurements such as mandibular plane angle and anterior facial height were a result of differences in surgical positioning to accommodate varying skeletal patterns in the patients. For example, in some cases the mandible was rotated to increase the incisor overbite (decreasing the mandibular plane angle) more than others.

In addition to the variability introduced by the above factors, a study of this kind may contain a certain amount of inherent error in the form of radiograph tracing error, differences in muscular tonus on radiographs of the same patient, and error in locating the rather vaguely defined soft tissue landmarks. This type of error may mask or exaggerate the relatively small vertical changes in soft tissue.

Only one of the patients examined in this study exhibited measurable facial growth during treatment. Patient E.P. (Fig. 6) grew during the presurgical orthodontic treatment period. It can be assumed then that the changes observed for all other patients were not significantly influenced by growth.

Additional studies of the relationship of soft tissue changes to dental and skeletal changes are indicated. The relationship of hard versus soft tissue changes in the vertical direction requires further investigation utilizing more sensitive methods of quantitative analysis. Further examination of the soft tissue changes in relation to skeletal pattern is needed. A group of mandibular prognathic patients exhibiting a high mandibular plane angle and a severe vertical problem (anterior open bite) should be compared with another group of patients showing low mandibular plane angles with little or no vertical problem.[4]

Investigation of soft tissue changes occurring as a result of different types of surgery, for example, maxillary or mandibular advancements, is warranted. Such investigation may show that the integumental response to these surgical procedures varies from that of the mandibular set back procedure.

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