Soft tissue response to mandibular advancement and genioplasty

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Changes in facial esthetics after orthognathic surgery should be predictable if the results are to be satisfactory. The skeletal elements are moved in a planned and controlled manner, but the soft tissue drape is not as precisely managed. This study was on 31 patients who had undergone a mandibular advancement by means of a sagittal split osteotomy, 17 of whom had also received an advancement genioplasty and 6 received a maxillary impaction. The results showed a consistent 1:1 ratio of soft to hard tissue advancement at pogonion and B point, and that predictions could be accurate in both anteroposterior and vertical directions. When a genioplasty was added to the advancement, however, the results were much less consistent. The mean ratio was 0.9:1 of soft tissue to skeletal movement at pogonion, but the average difference between hard and soft tissue movement was ±2.6 mm. Thus the prediction of anteroposterior soft tissue changes was quite inaccurate. Changes in the vertical dimension were also more marked in the genioplasty group. The lower lip also showed a variable response, particularly in the genioplasty group, where the mean ratio was 0.5 mm lip advancement per 1.0 mm skeletal change, but again a range of 4.0 mm in either direction. There were no meaningful changes 1 year after surgery. (Am J Orthod Dentofac Orthop 1992;101:550-5.)

Surgical advancement of the severely retrognathic mandible to establish a more functional occlusion and to improve facial esthetics has become a routine treatment option. While there has been considerable research interest in the behavior of the osseous structures,16 far less attention has been directed toward the soft tissue response to surgery.16-19 Presurgical planning usually includes some form of cephalometric prediction tracing, and more recently, computer software has been developed with the objective of simplifying the process. The accuracy of any prediction, however achieved, is absolutely dependent on knowledge of the behavior of the soft tissues. Such information as is currently available indicates that the average soft tissue response at pogonion and B point is approximately equal to the mandibular advancement.10-13

However, when a genioplasty is performed, the soft tissue response shows considerable individual variation and is also dependent on whether the procedure is performed alone or in combination with other surgery.14-18 In a recent report on reliability of prediction tracing, Popsosil19 found that genioplasty prediction contributed to inaccuracy in 7 of 15 cases of two-jaw surgery.

LITERATURE REVIEW

Mandibular advancement

Lines and Steinhauser10 reported on nine cases of mandibular advancement in which the postoperative follow-up had been a minimum of 3 months. The ratio of soft tissue response to hard tissue movement at pogonion was 1.0:1, and at the level of labrale inferius was 0.67:1.

Quast, Biggerstaff, and Haley11 reported on soft tissue response after 1 year in 18 cases. Ratios at both pogonion and B point were 0.97:1; however, the ratio at labrale inferius was 0.38:1. The depth of the sublabial furrow decreased by 1.7 mm.

Mommaerts and Marxer12 reported on the soft tissue response to mandibular advancement after 1 year in 35 cases. Ratios at pogonion and labrale inferius were 1.03:1, and 0.55:1, respectively. In addition the soft tissue thickness under menton remained the same, and the sublabial furrow depth decreased. The behavior of the lower lip at labrale inferius was noted to be variable.

Hernandez-Orsini et al.13 in 31 cases of mandibular advancement noted a 0.94:1 ratio of soft to hard tissue movement at pogonion, but a 0.43:1 ratio of movement at labrale inferius.

Genioplasty

The literature on genioplasties deals with a variety of procedures and materials. Therefore the results re-

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Portions are not strictly comparable. The articles mentioned below are those considered most relevant to the present study.

Bell and Dann reported the results of advancement genioplasty on 11 subjects with various dentofacial deformities. Eight had undergone horizontal sliding osteotomies, and three had silicone implants. The mean ratio of soft tissue response to advancement of pogonion was 0.60:1.

McDonnell, McNeill, and West reported the results of advancement genioplasty in 15 retrognathic subjects, all of whom had a one or two step advancement genioplasty, whereas nine also had a mandibular advancement. The mean ratio of soft to hard tissue pogonion was 0.75:1. Horizontal changes were measured parallel to Frankfort horizontal, which presented problems in extremely retrognathic cases. Busquets and Sassouni found in a similar study, a ratio of 0.8:1 at the level of pogonion, and a ratio of 0.4:1 at the level of labrale inferius.

Scheideman, Legan, and Bell studied soft tissue changes with combined mandibular setback and advancement genioplasty in six subjects. They reported a 1:1 ratio at the level of pogonion, higher than previous ratios possibly because a concomitant setback reduces tension on genial soft tissues.

Gallagher, Bell, and Storum reported on soft tissue changes associated with advancement genioplasty performed in conjunction with superior repositioning of the maxilla in 10 subjects. The mean ratio at the level of pogonion was 0.87:1.

The aim of this study was to investigate the nature and consistency of the soft tissue profile response to mandibular advancement surgery, with and without an advancement genioplasty, and to assess the long term stability of the soft tissue changes.

SAMPLE

Longitudinal records were available for 31 patients who had undergone a sagittal split mandibular advancement procedure, performed by one surgeon at the Hospital for Sick Children. Eleven had also received an advancement genioplasty, and six had received an advancement genioplasty and maxillary superior repositioning. In all cases transosseous wiring and intermaxillary fixation were used. The mean age at the time of surgery was 19.5 years with a range from 11.2 to 35.6 years.

Three lateral cephalograms of each patient were analyzed: the preoperative record, the 1-year postoperative record (mean: 14 months after surgery), and the 3-year postoperative record (mean: 35 months after surgery). Each radiograph was taken in centric occlusion with the lips in repose by a trained radiographic technician.

Records earlier than 1 year after surgery were not used to avoid errors that might be introduced by persistent edematous tissue, by bony remodeling, or by continued muscle adaptation.

METHOD

Radiographs were traced on acetate paper and, with an Hewlett Packard 9111A graphics tablet, 52 soft tissue points and 8 hard tissue points were digitized and entered into an Hewlett Packard 9836 minicomputer. The landmarks used for measurements are presented in Fig. 1. In addition, the sublabial furrow was measured. The latter is defined as the shortest distance from soft tissue B point to a line connecting labrale inferius to soft tissue pogonion. An additional 43 soft tissue points were used to generate the mean profile plots.

A critical step in the analysis was the choice of a reference plane to separate vertical from horizontal movements of the skeletal and soft tissue landmarks. It was decided that the facial plane (nasion-pogonion) of the 1-year postoperative radiograph for each subject, having been created as the ideal or normal plane of the face for that person, was the most satisfactory vertical reference line. The same line was subsequently transferred to the preoperative and 3-year postoperative cephalograms by means of superimposition on the structures of the cranial base.

All horizontal linear measurements were made perpendicular to this base line, and all vertical linear measurements...
Table I. Horizontal changes at 1 year after surgical advancement of the mandible

<table>
<thead>
<tr>
<th>Vertical measurements</th>
<th>Surgical group</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Advance</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No genioplasty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plus genioplasty</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>n = 14</td>
<td>n = 17</td>
<td>n = 31</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline-lower incisor</td>
<td>6.79</td>
<td>3.39</td>
<td>6.59</td>
<td>4.52</td>
</tr>
<tr>
<td>Baseline-labrale inferius</td>
<td>5.39</td>
<td>3.33</td>
<td>3.50*</td>
<td>4.09</td>
</tr>
<tr>
<td>Baseline-B point</td>
<td>6.83</td>
<td>2.42</td>
<td>8.61</td>
<td>4.77</td>
</tr>
<tr>
<td>Baseline-B (soft)</td>
<td>6.92</td>
<td>2.90</td>
<td>8.48</td>
<td>3.66</td>
</tr>
<tr>
<td>Baseline-pogonion</td>
<td>6.28</td>
<td>2.21</td>
<td>12.93*</td>
<td>6.46</td>
</tr>
<tr>
<td>Baseline-pogonion (soft)</td>
<td>6.28</td>
<td>2.17</td>
<td>11.26*</td>
<td>4.32</td>
</tr>
<tr>
<td>B point-pogonion</td>
<td>-0.54</td>
<td>1.20</td>
<td>4.32*</td>
<td>6.84</td>
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<tr>
<td>B point-pogonion (soft)</td>
<td>-0.54</td>
<td>1.24</td>
<td>2.65*</td>
<td>6.59</td>
</tr>
<tr>
<td>B (soft)-SLF</td>
<td>-1.30</td>
<td>1.77</td>
<td>-1.29</td>
<td>2.01</td>
</tr>
</tbody>
</table>

Positive values indicate forward movement.
Negative values indicate backward movement.
*Indicates significant difference between surgical groups (p < 0.01).
**Indicates overall significant change at 1 year (p < 0.01).
***Indicates overall significant change at 1 year (p < 0.0001)

Table II. Ratios of soft to hard tissue horizontal advancement

<table>
<thead>
<tr>
<th></th>
<th>Genioplasty</th>
<th>No genioplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labrale inferius: lower incisor</td>
<td>0.5:1</td>
<td>0.8:1*</td>
</tr>
<tr>
<td>B point (soft):B point (skeletal)</td>
<td>1.0:1</td>
<td>1.0:1</td>
</tr>
<tr>
<td>Pogonion (soft):pogonion (skeletal)</td>
<td>0.9:1</td>
<td>1.0:1</td>
</tr>
</tbody>
</table>

*Indicates significant difference between surgical groups.

were made parallel to it. The horizontal measurements thus represented an accurate indication of the thickness of the soft tissue overlying the facial skeleton for all patients at the postoperative period, regardless of minor changes in the orientation of the head or variations in cranial base planes that would not necessarily correspond to facial structure. Furthermore, this base line introduced less of a vectoral component into the measurements for those preoperative cases that were extremely retrognathic.

Statistical analysis was accomplished with the SAS program and involved one-way analysis of variance. Tukeys HSD test was used to determine differences between time periods and between surgical groups. Pearson correlation coefficients were calculated to examine the relationship between variables.

FINDINGS
One year after surgery

Horizontal changes. All the changes induced by mandibular surgery were significant for the sample as a whole (Table I).

There were no significant differences (p < 0.05) between those (six cases) who had undergone additional maxillary superior repositioning and those (25 cases) who had mandibular surgery only. Accordingly the sample was considered as two homogenous groups, genioplasty and nongenioplasty.

The overall mean mandibular advancement measured at B point was 7.7 mm (range 2.9 to 18.0 mm), with no significant difference between the genioplasty and nongenioplasty groups. There was a corresponding advancement at soft tissue B point of 7.8 mm. The additional advancement of pogonion with genioplasty resulted in significant differences between the two groups for measurements involving pogonion.

Ratios of soft tissue response to hard tissue movement are given in Table II. There appears to be an equivalent soft tissue response to skeletal movement at pogonion and B point, with no significant difference between the two surgical groups. However, this does not reflect the variability encountered.

The mandibular advancement only group, with a mean skeletal advancement at pogonion of 6.3 mm (range 2.9 to 9.8 mm), showed a corresponding soft tissue movement within 1 mm in 13 of the 14 cases. In one case the soft tissue movement was 1.7 mm greater than the skeletal movement.

In the mandibular advancement plus genioplasty group, however, there was great variability. There was a mean advancement at pogonion of 12.9 mm with a range 6.9 to 22.7 mm. In only four cases was the soft
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In the advancement-only group, there was a mean thinning of 1.4 mm but a range from 4.3 mm thinning to 2.2 mm thickening of the lower lip. The genioplasty group was even more variable, with only six patients within 1 mm of the 3.1 mm average thinning. The range was 7.8 mm thinning to 2.3 mm thickening of the lower lip. No correlation was found between the behavior of the lip and the amount of incisor change.

It might be suspected that the variability in response at labrale inferius would be related to the degree of bite opening. Regression analysis, however, showed no correlation either with overbite reduction (U1-L1) or increase in total facial height (N-Me).

There was a consistent and highly significant reduction in depth of the sublabial furrow of 1.3 mm from a preoperative mean of 6.9 mm.

Vertical changes. There were few significant changes in vertical dimensions after surgery (Table III). Preoperatively the vertical separation of soft and hard tissue pogonion averaged 9.2 mm in the genioplasty group and 5.2 mm in the nongenioplasty group. In 29 of 31 cases the soft tissue pogonion was superior to skeletal pogonion. After surgery there was a 3.9 mm decrease in this vertical separation in genioplasty cases, but a decrease of only 0.4 mm in the nongenioplasty cases. The vertical position of soft tissue pogonion changed significantly with respect to the underlying hard tissue structures.

Three years after surgery

There were no statistically significant differences between the 1- and 3-year postoperative measurements. Lower facial height (Me-Li) underwent a 1.3 mm reduction in the nongenioplasty group, after having shown a postoperative increase at the 1-year time period. The vertical position of soft tissue pogonion in the genioplasty group continued to lower by 0.8 mm. There was a slight thinning of the soft tissue overlying B point in the genioplasty group.
Table III. Vertical changes at 1 year after surgical advancement of the mandible

<table>
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<tr>
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<td>No genioplasty</td>
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<td>n = 14</td>
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<td>n = 31</td>
<td>n = 31</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Nasion-menton</td>
<td>2.12</td>
<td>4.54</td>
<td>-0.40</td>
<td>5.48</td>
</tr>
<tr>
<td>Overbite</td>
<td>-2.79</td>
<td>3.78</td>
<td>-1.05</td>
<td>4.30</td>
</tr>
<tr>
<td>Menton-L1</td>
<td>0.22</td>
<td>1.37</td>
<td>-1.66</td>
<td>3.52</td>
</tr>
<tr>
<td>Menton (soft)-stomion inferior</td>
<td>2.84</td>
<td>2.64</td>
<td>-0.08</td>
<td>5.79</td>
</tr>
<tr>
<td>Menton-B</td>
<td>0.07</td>
<td>1.62</td>
<td>-1.02</td>
<td>3.11</td>
</tr>
<tr>
<td>Menton-B (soft)</td>
<td>0.35</td>
<td>1.39</td>
<td>-1.34</td>
<td>5.54</td>
</tr>
<tr>
<td>Vertical B-B (soft)</td>
<td>0.27</td>
<td>1.71</td>
<td>-0.32</td>
<td>4.52</td>
</tr>
<tr>
<td>Menton-pogonion</td>
<td>0.77</td>
<td>1.61</td>
<td>-0.37</td>
<td>3.88</td>
</tr>
<tr>
<td>Menton-pogonion (soft)</td>
<td>0.42</td>
<td>1.89</td>
<td>-4.25*</td>
<td>5.93</td>
</tr>
<tr>
<td>Vertical pogonion-pogonion (soft)</td>
<td>-0.36</td>
<td>2.14</td>
<td>-3.87*</td>
<td>7.17</td>
</tr>
<tr>
<td>Menton-menton (soft)</td>
<td>-0.27</td>
<td>1.77</td>
<td>-0.09</td>
<td>3.87</td>
</tr>
</tbody>
</table>

Negative value indicates upward movement. Positive value indicates downward movement.
*Indicates significant difference between surgical groups (p < 0.01).
**Indicates overall significant change at 1 year (p < 0.01).
***Indicates overall significant change at 1 year (p < 0.0001).

The mean profile plots (Figs. 2 and 3) graphically demonstrate the difference between the preoperative profile and the final 3-year postoperative profile.

DISCUSSION

The prediction of the soft tissue response that will follow a mandibular advancement appears to be a straightforward procedure in general. The thickness of the soft tissue overlying the bone showed minimal change with surgery, and one could expect to predict the vertical and horizontal position of the soft tissue chin within a millimeter in almost every case. There were three situations in the study where this generalization did not apply.

When a genioplasty was added to the mandibular advancement, the results were much less consistent. The soft tissue chin advancement averaged 1.7 mm different from that which would have been predicted with a simple 1:1 ratio, and several cases were more than 3.0 mm different. Linear regression analysis confirmed this poor correlation between hard and soft tissue advancement at pogonion ($R = 0.34$).

If the fine placement of chin point is of primary importance to facial esthetics, a variation of plus or minus 3.0 mm in the result could represent a considerable disappointment to the patient and the clinicians.

There are several possible explanations for this variability. The cases requiring genioplasty were often the more severe cases, and soft tissue drape in severe retrognathia is usually abnormal. Individual assessment is essential in such cases. Also, minor variations in the surgical management of tissues occur from patient to patient, so that variation in results in the sensitive chin area should not be surprising.

A second inconsistency was in the behavior of the lower lip in the two groups. A difference of 2 to 3 mm in either direction from the predicted movement could be expected. Simple ratios do not appear to adequately predict the structural changes that occur when the often everted lower lip is allowed to unfurl as the jaw relationship is normalized.

The ratios indicate that the thinning or unfurling of the lower lip at the vermilion border was especially marked in the genioplasty cases. Our clinical impression, however, was that the surgical management of the soft tissues with the genioplasty procedure then in use in our center produced a drawing in of the lower lip. The technique was changed in later cases. Surgeons should evaluate their own genioplasty cases to establish the soft tissue response to their particular surgical technique.

The third difficult situation with regard to prediction is in the vertical dimension. Advancement genioplasty caused a profound change in the vertical relationship of hard and soft tissue structures. Before surgery the soft tissue pogonion was positioned superior to the skeletal pogonion, especially in the genioplasty cases. After surgery the soft tissue pogonion in the genioplasty group...
had moved inferiorly, thus producing a similar configuration in both groups since the relationships in the nongenioplasty group were unchanged. This marked vertical change was partly due to the genioplasty producing a definite chin point, and therefore a greatly improved soft tissue drape, especially in the previously severe retrognathic cases.

CONCLUSIONS

The 1:1 ratio of soft to hard tissue advancement at pogonion and B point after mandibular advancement was very consistent. Predictions could be made with confidence. In cases with genioplasty as well as advancement, the mean ratios of soft to hard tissue movement at pogonion and B point were approximately 1:1, but were very inconsistent. Predictions could be expected to err by as much as 3.0 mm in either direction.

After genioplasty the soft tissue pogonion moved inferiorly relative to the underlying pogonion. The behavior of the lower lip was significantly different in nongenioplasty and genioplasty cases. The lip thinned by 1.4 mm and 3.1 mm, respectively, but there was wide variability in both groups.

With the exception of slight thinning of soft tissue over B point as a result of bony remodeling, changes after 1 year were minimal. No change after 1 year was either statistically significant or clinically apparent.

REFERENCES


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