A Retrospective Study of Advancement Genioplasty Using a Special Bone Plate

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This study evaluates skeletal stability and the remodeling process of the advanced genial segment when a single bone plate is used to stabilize the segment following osteotomy of the inferior border of the mandible. Thirty-nine patients with a minimum of 6 months follow-up who had advancement genioplasty stabilized with a Paulus chin plate were analyzed using cephalometrics and clinical examination. The results showed that stability of the result was excellent; pogonion maintained its immediate postsurgical horizontal position at longest follow-up. The remodeling pattern observed was similar to that reported in other studies using alternate forms of fixation in spite of the fact that the bone plate covered the areas where most remodeling occurs.

Osteotomy of the inferior border of the mandible (OIBM) is perhaps the most useful and versatile surgical procedure for correction of chin and/or facial deformities. Over the years, several variations on the original technique, which was performed through an extraoral approach,1 have been introduced. Undoubtedly, the greatest advance was Trauner and Obwegeser's2 recommendation for the use of an intraoral approach.

Despite the fact that the OIBM has been considered a very stable procedure,3-7 there are many factors that can have a negative effect on stability. The pull of the suprahyoid musculature and perimandibular connective tissues attached to the advanced distal segment have been shown to play a role in skeletal relapse of mandibular osteotomies.8,9 The combination of mandibular advancement with OIBM tends to increase the tension generated by these tissues and may lead to an increased risk of skeletal relapse.10,11

The advanced genial segment has traditionally been stabilized with wire osteosynthesis. Studies have shown that this usually affords good stability,3-6 but the possibility of posterior and inferior displacement of the advanced genial segment has been raised by numerous investigators.5,11-14 One problem with the use of wires is the occasional difficulty in advancing the genial segment a given amount with accuracy.15 When the wires are tightened, the genial segment frequently advances the entire thickness of the symphysis, whether or not this is the planned amount. Furthermore, if a large advancement is necessary, wire osteosynthesis may offer insufficient means of fixation. It was because of this problem with wires that McDonnel and coworkers reported their use of a multistep osteotomy, where two osteotomy cuts are made and the symphysis is advanced in layers.3 However, even with this method, inferior rotation of the distal segment occurs.3 According to some authors, the multistep osteotomy must be used when the genial segment is to be advanced more than 10 mm with wire osteosynthesis.16 Other modifications to the surgical technique have been reported. Michelet's technique of OIBM has been advocated by several authors as a suitable technique to enhance stability.13-15,17 This technique uses a tenon and mortise construction, which resists the pulling action of the suprahyoid muscles after advancement.

Several modifications to stabilization techniques, such as increasing the number of wires and a new wire configuration, have been tried. However, the only modification that attempts to provide three-dimen-
sional stability to the genial segment is use of fixation appliances that are more rigid than wires. Kirschner wires and Steinmann pins have been used and are thought to produce good stability. However, no studies have evaluated their effectiveness. Bone plate osteosynthesis is another stabilization modality that may provide sagittal, transverse, and vertical stability. The use of plate and screw fixation with OIBM is becoming more widespread. However, there is lack of data in the literature about stability of the use of plate and screw fixation in advancement genioplasties by means of OIBM. The objective of this study was to evaluate a group of patients who underwent OIBM with stabilization of the advanced genial segment by means of a special bone plate.

**Material and Methods**

**Sample Selection**

All patients in a 3-year period who fulfilled the following inclusion criteria were studied: 1) advancement genioplasty via an OIBM performed using an intraoral approach; 2) the advanced segment was stabilized by a single bone plate; 3) preoperative, immediate postoperative, and long-term cephalograms (>6 months) of good quality were available; and 4) no bone grafts or hydroxylapatite were used.

**Surgical Technique**

The patients underwent the traditional OIBM using a broad soft-tissue pedicle as described in the literature. A single titanium plate specially designed for advancement genioplasty (Paulus Bone Plates, Walter Lorenz, Jacksonville, FL) was used in all patients. This bone plate comes prebent in a double-L configuration to conform to the shape of the proximal and distal segments following advancement genioplasty (Fig 1). It comes in various sizes to advance the genial segment in 2-mm increments from 2 to 14 mm. The plate has two holes on each of its flanges, which accept 2-mm bone screws. After completing the osteotomy using a reciprocating saw, the genial segment was mobilized to allow passive repositioning. The appropriate plate was chosen according to the amount of advancement determined from the treatment plan. Very little adaption of the flanges of the plates was necessary, but proper contouring was performed when needed to allow close adaption of the flanges to the bone. Two bicortical self-threading screws were first placed to secure the plate to the genial segment. Once the plate was attached to the genial segment, traction of the subhyoid muscles held the plate and genial segment against the proximal, or tooth-bearing segment. After the plate was attached to the mandible (Fig 2), the genial segment was evaluated for symmetry; if asymmetrical, the segment was simply rotated to proper position. The wound was thoroughly irrigated with normal saline and closed in two layers.

**Cephalometric Analysis**

Lateral cephalometric radiographs were taken in the same machine at three times: immediately preoperatively (within 1 week of surgery); immediately postoperatively (within 8 days of surgery); and at least 6 months after surgery. Cephalometric tracings and superimpositions were performed by one investigator and checked by another to verify accuracy. A template of the mandible was traced from the preoperative cephalogram, which included the bony contours, teeth, radiopaque fillings, orthodontic appliances, and any other easily recognized anatomical structure. The occlusal plane was also drawn on this tracing to serve as a reference line for later calculations. This tracing was subsequently superimposed on the immediate postoperative and long-term cephalograms; the new chin positions were traced onto this same template and the following points determined:

1. pogonion (Pg): the most anterior point along the convexity of the bony genial prominence (in relation to the facial plane);
2. soft-tissue pogonion (SPg): the most anterior point along the convexity of the soft-tissue genial prominence (in relation to the facial plane);
3. menton (Me): the most inferior point of the mandibular symphysis.

The tracings were then digitized by one investigator. The horizontal and vertical position of the aforementioned points (in relationship to the preoperative occlusal plane) were calculated by the computer. The displacement of these points resulting from surgery was derived by calculating the difference between the preoperative and immediate postoperative positions. The
displacement of these points resulting following surgery was derived by calculating the difference between the immediate postoperative and long-term postoperative positions. The immediate postoperative film was not used to calculate the soft-tissue changes because of the presence of edema. Therefore, it was only possible to evaluate the overall soft-tissue changes. A descriptive analysis of each series of tracings was also performed to describe the pattern of bone remodeling.

**Statistical Analysis**

The surgical and postsurgical changes were individually analyzed using the paired $t$ test to determine if the change was significantly different than 0. The surgical and postsurgical changes were correlated using Pearson's correlation coefficients to determine if postsurgical change was affected by the amount of surgical change.

**Qualitative Analysis**

A qualitative assessment of the patients' chin region was made at the latest follow-up visit. This consisted of careful examination to determine if the plate could be palpated either intraorally or extraorally. The patients were questioned about sensitivity, sensibility, or other complaints about the genial advancement.

**Results**

In the 3 years between 08/18/87 to 08/16/90, the records of 39 patients fulfilled the inclusion criteria and were included in this study. The sample consisted of 6 males and 33 females ranging in age from 13 to 48, with an overall mean of 22.7 years. Follow-up ranged from 6 to 43 months, with an overall mean of 20.2 months. None of the patients developed postsurgical infections at any time.

**Horizontal Displacement**

The average advancement of Pg for the 39 patients was 5.7 mm ($\pm 2.33$) with a range of 0.96 to 11.7 mm. This amount of advancement was highly statistically significant ($P < .001$). Following surgery, there was almost complete stability of pogonion; the mean change was 0.04 mm of anterior displacement ($\pm 0.25$). There was no significant correlation between the amount of surgical and postsurgical change. The horizontal changes at Me were very similar to those at Pg (Table 1).

**Vertical Displacement**

The average vertical change at Pg was 1.9 mm ($\pm 1.83$) superiorly, with a range of 0.48 to 6.74 mm. This amount of change was statistically significant ($P < .001$). Following surgery, there was a mean inferior movement of Pg of 0.9 mm ($\pm 1.19$), ranging from 0.49 to 3.82. This amount of change was also statistically significant ($P < .001$). There was no significant correlation between the amount of surgical and postsurgical change. In contrast to Pg, postsurgical vertical changes at Me were minimal and not statistically significant (Table 1).
Table 1. Surgical and Postsurgical Changes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (mm)</th>
<th>SD</th>
<th>Min (mm)</th>
<th>Max (mm)</th>
<th>Mean (mm)</th>
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<tr>
<td>Horizontal hard pogonion</td>
<td>5.7‡</td>
<td>2.33</td>
<td>0.9</td>
<td>11.7</td>
<td>0.04</td>
<td>0.25</td>
<td>-0.8</td>
<td>0.6</td>
<td>5.7‡</td>
<td>2.33</td>
<td>0.8</td>
<td>11.5</td>
</tr>
<tr>
<td>Vertical hard pogonion</td>
<td>-1.9†</td>
<td>1.8</td>
<td>0.4</td>
<td>-6.7</td>
<td>0.89‡</td>
<td>1.1</td>
<td>-0.4</td>
<td>0.3</td>
<td>1.0‡</td>
<td>2.12</td>
<td>3.3</td>
<td>-6.2</td>
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<tr>
<td>Horizontal menton</td>
<td>6.4‡</td>
<td>2.5</td>
<td>1.5</td>
<td>12.3</td>
<td>0.02</td>
<td>0.24</td>
<td>-0.9</td>
<td>0.3</td>
<td>6.3‡</td>
<td>2.5</td>
<td>1.5</td>
<td>12.2</td>
</tr>
<tr>
<td>Vertical menton</td>
<td>-1.3‡</td>
<td>1.7</td>
<td>2.2</td>
<td>-8.0</td>
<td>0.00</td>
<td>1.7</td>
<td>-0.5</td>
<td>0.7</td>
<td>-1.3‡</td>
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Negative numbers for horizontal measures indicate posterior movement. Negative numbers for vertical measures indicate superior movement.

* Significant at P < .05.
† Significant at P < .01.
‡ Significant at P < .001.

SOFT-TISSUE CHANGES

The overall advancement (from presurgery to long term) was 5.4 mm at SPg (±1.62). When compared with the overall changes at Pg (5.7 mm), the ratio of hard- to soft-tissue change was 1:0.9. The overall vertical change of SPg was 0.87 mm superiorly (±2.49). When compared with the overall vertical changes at Pg after bone remodeling (1.01 mm superiorly), the ratio of hard- to soft-tissue change at Pg was 1:0.9.

BONE REMODELING PATTERNS

Qualitative evaluation of bone remodeling showed that there were areas of bone resorption and bone deposition occurring simultaneously in the genioplasty sites. The anterior superior angle of the advanced genial segment was the site where most resorption occurred, which was very slight in a considerable number of cases but considerable in others (Fig 3). This remodeling pattern did not affect the horizontal stability of Pg, as Pg was immediately posterior to the bone plate. No resorption between the anterior vertical limb of the plate and the genial segment was noted. However, because Pg assumed a more superior position after the surgery in the majority of cases, bone remodeling affected the vertical position of the Pg, which showed some inferior positioning.

Extensive bone deposition was observed along the anterior portion of the proximal segment, around and immediately above the osteotomy site at the point B area. In some cases, the superior vertical limb of the bone plate became covered by bone (Fig 4).

Another area of bone deposition was along the posterior edges of the distal segments bilaterally, where the proximal and distal segments interfaced (ie, at the posterior end of the bony wings). Such bone deposition was always observed, leading to a rounding of the sharp
edges resulting from the osteotomy. In addition, in all cases where a gap was present between the two segments of bone, new bone formation bridged this gap completely. This phenomenon has been previously described in the literature.20

CLINICAL FINDINGS

Palpation of the region both intraorally and extraorally did not show any evidence of the hardware. None of the patients complained of pain or discomfort with or without palpation of the region. Most of the patients expressed surprise when informed they had a titanium bone plate in their chin.

Discussion

Like any other maxillofacial osteotomy, OIBM can be adversely affected by two completely different mechanisms. Skeletal instability, where the advanced genial segment changes in position prior to osseous union, can rapidly alter the surgical result. Osseous remodeling, where the advanced genial segment is slowly recontoured during the remodeling process, is a much slower pathway by which the final result may differ from the immediate postsurgical result. Both of these mechanisms are important in advancement genioplasty by OIBM.

SKELETAL STABILITY

Stability of the advanced genial segment is usually reported as very good, irrespective of what method of fixation is used. However, determination of changes in osseous position are difficult because translation of the advanced genial segment and osseous remodeling may occur simultaneously. There are warnings in the literature against the use of pogonion as a reference point when studying stability of genioplasty because bony remodeling would invalidate any conclusion about skeletal stability, since the differentiation between them is impossible.2-13 We are in agreement with this statement. However, analysis of menton helped to determine if the changes in the position of pogonion were caused by bone remodeling or postoperative movements of the osteotomized segment.13 Our results showed menton to be absolutely stable in both horizontal and vertical planes (Table 1). Even with all the controversies over pogonion, it is still the most important point to be assessed in any genioplasty study, as it is the bony landmark of the chin prominence. Bony remodeling indeed affected the vertical position of pogonion in our sample, but horizontal position was retained. Similar findings have been previously described by others.7 There are reports in the literature showing changes in the horizontal position of pogonion due the bone remodeling.5,6,11,25 We did not find postsurgical changes in the horizontal position of pogonion. As remodeling occurred, even though pogonion moved further inferiorly, it remained in the same anteroposterior position. This remodeling pattern is not unusual, but the preservation of the horizontal position of pogonion is probably due to the skeletal stability achieved with the fixation method.

OSSEOUS REMODELING

Years ago it was suggested that because the mandible is dense and a continuous blood flow is maintained by the soft-tissue pedicle pedicle, the advanced genial segment would not undergo significant resorption.26 This concept has changed substantially during the past 20

FIGURE 4. Immediate and 38-month postoperative radiographs of a case where remodeling pattern was very favorable.
years; the pattern of bone remodeling that occurs in the chin after advancement by OIBM is now a very well-known phenomenon. However, the causes are still not known. Theories have been put forth: 1) soft-tissue pedicle size and presence or absence of it; 2) periosteal and soft tissue pressures; and 3) postoperative stretching of the suprahyoid muscles. All of these in some way concern blood supply to the advanced genial segment. However, it has been shown that even with the use of a broad soft-tissue pedicle, bone remodeling always will occur.

In the usual instance, both areas of bone resorption and deposition have been reported following advancement genioplasty by OIBM. The most common locations for bone resorption are the anterior superior angle of the advanced genial segment. The angles and sharp edges become rounded by 6 months. The sites of bone deposition are the anterior surface of the mandible above the osteotomy site. Precious et al warned that placement of rigid fixation hardware in these areas of remodeling could lead to protrusion of the fixation hardware, which would become palpable. However, no data have ever been shown to support this theory. In fact, despite the presence of the bone plate in the areas where remodeling (deposition and apposition) occur following advancement, the remodeling patterns presented in this study are similar to the patterns described for cases of wire fixation (Fig 5). In spite of the fact that the bone plate covered much of the area where bony deposition usually occurs, one case reoperated 23 months following initial surgery showed extensive bony deposition over the plate (Fig 6). These results indicate that the bone plate does not interfere with the normal bone remodeling process of the mandibular symphysis after OIBM. All 39 patients in this study were carefully examined by at least one of the investigators during the last follow-up examination. No evidence of the hardware was found by palpation intraorally or extraorally. Further, no patient reported discomfort with or without palpation of the region.

CLINICAL UTILITY

The results of this study show no greater stability or difference in remodeling pattern than when wire osteosynthesis is used. However, the bone plate used in this study does offer several advantages to the surgeon. This plate is much simpler to place than the nonrigid means of fixation, such as wires. One can readily select the plate corresponding to the amount of advancement.
desired and be assured that this is what will be produced in the patient. After the plate is attached to the advanced genial segment, the pull of the soft tissues holds this segment in position against the mandible, allowing the surgeon to assess the amount of advancement prior to securing the remaining screws on the superior flange of the bone plate. If a different amount of advancement is decided on, this can be promptly performed by removing the plate from the advanced segment and replacing a new plate. Another useful feature is the adjustability of the position of the advanced genial segment after securing the plate. If the posterior extensions of the advanced genial segment are not equally advanced, the entire segment can be readily twisted to one side or the other, straightening the chin. The plate is sufficiently malleable to permit this, yet rigid enough to prevent postsurgical displacement. If one wishes to increase the vertical dimension of the chin during the advancement procedure, a longer plate can be selected and the plate unbent to provide the desired movement. When one knows how much anterior and inferior movement is desired, the appropriate plate can be selected by using the Pythagorean theorem ($a^2 + b^2 = c^2$). For example, if a 6-mm advancement and 5-mm inferior repositioning are desired, the hypotenuse is calculated by the formula $6^2 (36) + 5^2 (25) = 61$, which approximates $8^2 (64)$. Therefore, an 8-mm plate would be selected. The plate is modified so that the angle of the horizontal portions is less than 90°. The bone plate used in this study, although originally designed for advancement genioplasties by OIBM, offers considerable advantages over other methods and lends itself to a number of different applications. The capabilities of this plate do not deleteriously affect the stability of the surgical result, which is as good as with other fixation techniques.

Acknowledgment

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References