Optimizing Esthetic Outcomes and Bone Stability: Chin Advancement Through Inverted V Osteotomy

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Abstract: Traditional horizontal osteotomies for small and short chins often yield suboptimal results due to limited bone advancement, resulting in deep labiomental folds and heightened bone resorption risks. This study investigates the effectiveness of an innovative inverted V-shaped osteotomy technique in enhancing esthetic outcomes for patients with such chin concerns. Thirty-eight patients who underwent inverted V-shaped osteotomy for recessed chins between January 2018 and June 2022 were included. Excluding cases involving simultaneous mandibular contouring surgery, patients were followed up for a median duration of 1.2 ± 0.5 years. Preoperation and postoperation soft tissue pogonion (Pg') and labiomental fold depth (LMF) changes were measured. IBM SPSS (version 27.0) was used for statistical analysis, with significance defined as $P < 0.05$. Patient satisfaction was assessed using a visual analog scale. Successful advancement genioplasty was performed on all patients without any severe complications. The average change in soft tissue pogonion (Pg') measured 6.2 (1.9) mm, and the mean alteration in labiomental depth was 0.42 (0.4) mm. The procedure achieved a bone to soft tissue movement ratio of 1:0.96. Patient satisfaction was notably high, with a mean VAS score of 8.7. An inverted V-shaped osteotomy enables greater bone advancement for small and short chins, leading to improved esthetic outcomes and offering a mechanically advantageous condition for bone segments.

Key Words: Advancement genioplasty, inverted V osteotomy, labiomental fold

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The shape of a chin significantly influences the esthetic proportions of the face. A properly sized, shaped, and positioned chin can enhance facial symmetry and harmony. A long and large chin creates a more masculine and strong appearance, while a small and receding chin is a sign of weakness and submissiveness.

Genioplasty is a valuable procedure in the field of esthetic surgery and can be combined with other techniques to achieve optimal esthetic results. However, addressing chin recession is a challenging task, mainly due to the limited availability of bony substances for an osteotomy. Consequently, there are difficulties in achieving optimal esthetic results for individuals with small chins using conventional genioplasty techniques.[1–3]

One of the most commonly used methods for chin advancement is the horizontal sliding osteotomy of the mandibular symphysis. In this approach, a horizontal osteotomy is performed ~5 to 6 mm below the mental foramen. The inferior segment is then advanced and repositioned according to a newly devised plan, and fixation is achieved using osteosynthesis plates, screws, and/or wires.[4,5]

However, this method has disadvantages when applied to small and short chin advancement surgeries. Advancements made using a horizontal sliding osteotomy in such cases can be cosmetically unfavorable due to an insufficient amount of the inferior segment being cut for advancement.

To minimize potential damage to the inferior alveolar nerve, which typically runs ~4 to 5 mm below the mental foramen, the osteotomy procedure is intentionally conducted ~5 to 6 mm below the mental foramen. This approach ensures that the horizontal osteotomy results in only a small cut segment, reducing any risks to the nerve.

Advancing this small lower segment of the bone can deepen the labiomental fold and increase the risk of bone resorption.[6,7] In addition, due to the narrow angle of the lateral border of the inferior segment in a horizontal sliding osteotomy of the mandibular symphysis, most of the outside bone disappears, even if mild resorption occurs in the inferior segment after surgery, which can lead to an excessively narrow chin or depression below the Marionette's line.

The purpose of this study was to evaluate the effectiveness of an inverted V genioplasty technique in advancing a larger volume of the inferior segment while also assessing the simplicity of the surgical method. We present our findings to provide valuable insights into the outcomes and feasibility of this novel approach.

MATERIALS AND METHODS

Patients

For this study, we selected a cohort of 38 patients who exclusively underwent advancement genioplasty as a primary surgical procedure at our hospital between January 2018 and June 2022.

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To ensure the accuracy of the results and eliminate potential confounding factors, we excluded patients who underwent prior bone-contouring surgeries or genioplasty simultaneously with other facial procedures. In addition, patients younger than 20 years who were still undergoing growth were not included in the analysis. If the surgery was performed during the period of undergoing growth, the effect of the surgery was decreased because the bone could continue to grow after the surgery. Furthermore, patients requiring 2-jaw surgeries due to malocclusion or severe facial asymmetry were excluded from the study.

To assess the final outcomes of the surgery, we scheduled routine hospital visits for all patients 6 months after the surgical procedure. During the visit, we evaluated the patients' postoperative condition. We obtained clinical photographs, radiographs, and facial 3-dimensional computed tomography (CT) images before and at 6 months after the surgery. The clinical photographs encompassed frontal, oblique, and lateral views, resulting in a total of 5 images for each patient. For the radiographic assessments, we utilized frontal, lateral cephalometric, and panoramic views for analysis. These comprehensive imaging modalities allowed us to thoroughly evaluate the patients' preoperative and postoperative conditions. The image evaluation was performed by a single surgeon.

All clinical photographs were captured at consistent distances and camera settings under standardized lighting conditions by a skilled photographer at our hospital. Radiographs were captured by a skilled radiographer with the patients in a relaxed position, ensuring proper alignment of the frontal teeth midline and occlusion during imaging. All the patients provided written informed consent to participate in this study.

Surgical Procedures

Under general anesthesia and orotracheal intubation, a standard intraoral vestibular incision was made in the symphyseal area, followed by subperiosteal dissection. Lateral subperiosteal dissection was extended along the planned osteotomy line, encompassing ~5 mm beyond the mental foramen, both laterally and inferiorly, to visualize the mental nerve. To prevent soft tissue ptosis after bony segment advancement and maintain blood flow to the bony segments, great care was taken to preserve the maximum soft tissue attachment of the chin.

The inverted V-shaped osteotomy was executed considering the following. First, the vertical midline was marked. Next, the planned osteotomy lines were marked. The convergence point formed by the upper osteotomy lines in the submental region was ~5 mm below the root apices of the lower anterior teeth, and the lower lateral parts of the lines were spaced ~5 to 6 mm away from the mental foramen.

To ensure a sufficient angle of the lateral border of the inferior segment, the angle between the inverted V was typically maintained at 145° ± 10. In addition, the directions of the 2 lines of the inverted V-shaped osteotomy were altered based on the patient's chin anatomy. Therefore, the midline deviation and chin asymmetry were reduced (Fig. 1).

A drill was used to mark the midline 1 to 2 mm in depth. The mental nerve and soft tissue flaps were cautiously retracted and protected during lateral and posterior extension of the chin osteotomy using a reciprocating saw. After thorough control of any bleeding points, the osteotomized segment was stabilized by applying a single prebent miniplate (4-hole plate) in the paramedian region using monocortical mini screws to secure it in its new position.

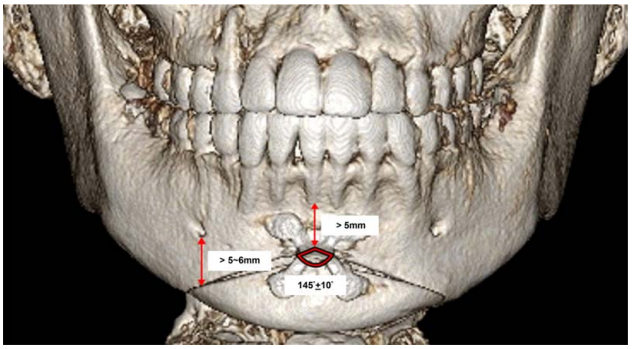

FIGURE 1. Three-dimensional CT image after inverted V osteotomy. The upper osteotomy lines (vertex of inverted V) in the submental region were positioned ~5 mm below the root apices of the lower anterior teeth and maintained a lateral distance of 5 to 6 mm from the mental foramen. The angle of the vertex is usually maintained at 145° ± 10. Because the direction of the 2 lines of the inverted V osteotomy can be altered based on a patient's chin anatomy, the amount of midline deviation and chin asymmetry is reduced.

In cases where instability was noted, additional 2-hole prebent miniplates were placed on both sides of the osteotomy. To obtain a smooth soft tissue contour, resection of the mandibular body margin was performed using a reciprocating saw, and a bur was used to trim the bony edges. After saline irrigation and confirmation of hemostasis, negative drain was applied, and closure of the surgical site was performed in 2 layers. The first layer involved the use of 4-0 rapid Vicryl sutures to reapproximate the mentalis muscles. The second layer involved the closure of the mucosa using 5-0 rapid Vicryl sutures (Supplemental Video 1, Supplemental Digital Content 1, http://links.lww.com/SCS/G235). The total surgical duration was 45 minutes. All surgeries and procedures were performed by a single surgeon with 12 years of experience in genioplasty. A negative pressure drain was applied, followed by the application of a bulky compressive dressing that was kept in place for 1 day. Patients were admitted for 1 day. One day after surgery, the drain was removed and if there were no abnormalities in the patient's condition or wound, the patient would be discharged. For 7 days postsurgery, a facial bandage was applied, and postoperative antibiotics were administered.

Cephalometric Assessment

The Frankfort horizontal (FH) plane was used as the reference line.

The Nasion vertical (NV) is a line drawn perpendicular to the FH plane. The vertical distance between the NV and Pg was calculated preoperatively (T1) and 6 months postoperatively (T2) to measure the amount of bone movement before and after surgery. In addition, the vertical distance between NV and soft tissue Pg' was measured preoperatively (T1) and 6 months postoperatively (T2) to assess the amount of soft tissue movement before and after surgery.

The measurement of the labrale inferius (Li) involved a line perpendicular to the esthetic line. The lower labial mental fold (LMF) was assessed for each cephalogram by drawing a line from the LMF perpendicular to the line connecting the Pg and Li (Fig. 2).[8,9] We used a program called EzDent to view the radiographs and 3-dimensional CT images, allowing us to measure the changes before and after surgery. Measurements were recorded in millimeters (mm) and statistical analysis was conducted using IBM SPSS (version 27.0; SPSS Inc., Chicago, IL), and the level of significance was set at $P < 0.05$. Descriptive statistics included the frequencies and proportions of categorical

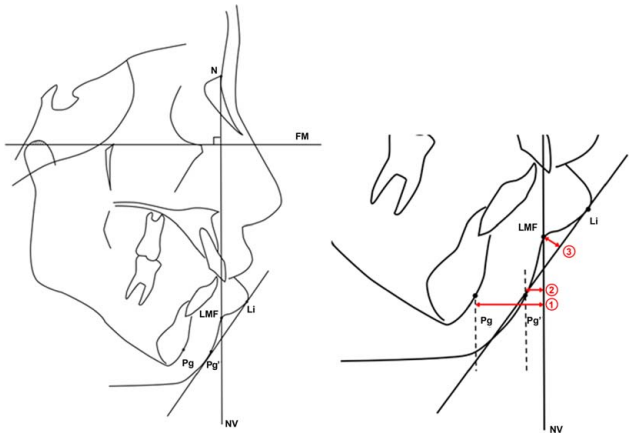

FIGURE 2. Measurement that the change in soft tissue and bone before and after surgery. ① Bone position. ② Soft tissue position. ③ LMF depth.

variables. Continuous variables are presented as mean ± SD for normally distributed data and were assessed using the Student *t* test.

RESULTS

This study included 38 participants, comprising 23 women and 15 men, with their ages ranging from 21 to 45 years and an average age of 26.8 years. To assess the final surgery outcomes, we scheduled routine hospital visits for all patients every 6 months after the surgical procedure. The average follow-up period for the study was 1.2 ± 0.5 years.

Clinical Findings

The median follow-up duration was 1.2 ± 0.5 years. In 2 patients (5.3%), transient sensory changes were observed in the skin surrounding the mental nerve area. However, both patients fully recovered from these changes within 3 months. In addition, 1 patient had a wound infection (2.6%), which was successfully treated with wound irrigation and intravenous antibiotics. Throughout the follow-up period, there were no instances of hematoma or wound dehiscence (as shown in Supplemental Table 1, Supplemental Digital Content 2, http://links.lww.com/SCS/G236). Moreover, there were no reports of postoperative functional issues, including temporomandibular joint dysfunction, malocclusion, mastication difficulties, or tooth root injury.

To assess the changes in the patients' facial features, we compared preoperative and postoperative photographs. The postoperative photographs were taken at various intervals ranging from 6 to 29 months after the surgery. Bone resorption was not observed on follow-up CT scans, and there were no instances of smaller chins or soft tissue depressions, which may clinically manifest as bone resorption. In all cases, the recessed chin was effectively advanced. There was minimal change in the LMF before and after surgery. All the patients who underwent surgery were satisfied with the results of the study. Patient satisfaction was assessed using a VAS, and the scale ranged from 0 (most dissatisfied response) to 10 (highest level of satisfaction). Patients were surveyed using this scale, with the average VAS score being 8.7.

Radiographic

The cephalometric tracing analysis yielded the following results: (1) the mean (SD) change in the bony Pg was 6.4 (1.5) mm, (2) the SD change in soft tissue Pg' was 6.2 (1.9) mm, and (3) the SD change in labiomental depth within the group was 0.42 (0.4) mm. However, no significant differences were observed. The *P*-value was >0.05 (as shown in Supplemental Table 2, Supplemental Digital Content 3, http://links.lww.com/SCS/G237). On average, the ratio of horizontal changes in the osseous to soft tissues was 1:0.96.

Cases

The following cases were randomly selected to exemplify the study.

Case 1

A 45-year-old female with severe hypoplasia of the chin underwent an inverted V-shaped osteotomy with 6 mm advancement. The postoperative facial profile revealed an improvement in lower facial shape and youthful neck contour (Fig. 3).

FIGURE 3. Case 1: (A) preoperative clinical photo and (B) 6-month postoperative clinical photo. (C) Preoperative 3-dimensional computed tomography and (D) 6-month postoperative 3-dimensional computed tomography.

Case 2

An 18-year-old male with a retruded and short chin underwent an inverted V-shaped osteotomy with 4 mm advancement. Postoperatively, an improved facial profile and more balanced lower proportions were obtained. There was only a minimal change in the labiomental folds (Fig. 4).

DISCUSSION

The horizontal sliding osteotomy is one of the most commonly used genioplasty methods for increasing chin projection and has the advantage of creating an appropriately shaped chin by moving the bone in 3 dimensions.[6,7,10]

However, it is essential to perform a horizontal osteotomy ~5 to 6 mm below the mental foramen to safeguard the integrity of the neurovascular bundle.[11] Therefore, it is often difficult to advance a sufficient amount of bone in patients with small and short chins.[10–12] However, this approach yields suboptimal results because an insufficient volume of bone is advanced. In addition, because the angle of the lateral border of the inferior segment is narrow in the conventional horizontal sliding osteotomy method, most of the outer side of the bone disappears even if mild bone resorption occurs. This creates a narrow chin or depression below Marionette's line.

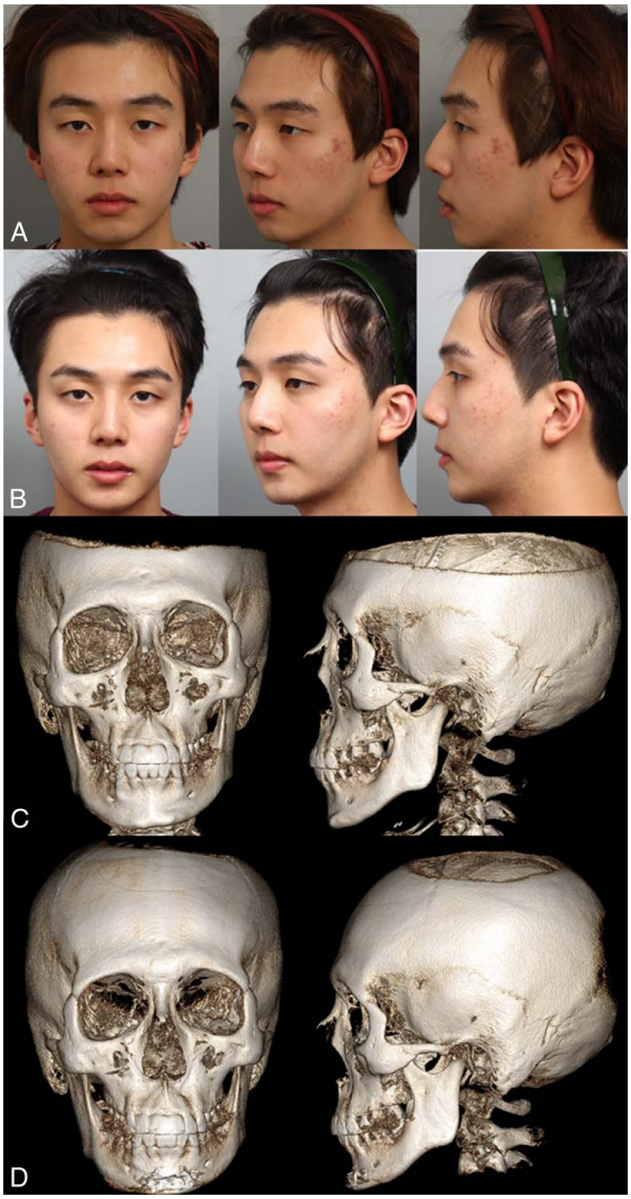

FIGURE 4. Case 2: (A) Preoperative clinical photo and (B) 6-month postoperative clinical photo. (C) Preoperative 3-dimensional computed tomography and (D) 6-month postoperative 3-dimensional computed tomography.

In addition, during surgery, it is difficult to expose the bone sufficiently from the cephalic side to the lateral side; therefore, the vertical length of the inferior segment is inevitably shortened in many cases when performing a horizontal sliding osteotomy. If an osteotomy is performed with an inverted V-shape, the possibility of midline deviation during the fixation process can be reduced. Consequently, the operation time can be reduced, and the chances of left-protruding and right-protruding asymmetry during fixation can be reduced.

In cases where there is a small chin with midline deviation or significant asymmetry, the approach involves removing the bone on the deviated contralateral side in a wedge shape. Subsequently, a method is used to rotate the remaining bone fragment and then fix it in place. By utilizing this technique, it is possible to achieve a midline shift of 2 to 3 mm for the chin. However, if a larger midline shift is required, alternative osteotomy techniques such as T-shaped osteotomy should be considered.[13]

The inverted V-shaped osteotomy was designed to incorporate a larger segment of the mandible. There are 3 advantages to moving a larger inferior volume forward in the shape of an inverted V. First, it curtails the deepening of the labiomental fold. Nonetheless, our study findings revealed no statistically significant disparity in LMF depth before and after surgery (Fig. 5C).

Second, maintaining a broader angle for the lateral border of the inferior segment, compared with horizontal sliding osteotomy, enhances its resistance to bone resorption. Therefore, it did not cause a decrease in chin width owing to bone resorption or depression at the bottom of the marionette line (Fig. 5B).

Third, because a large amount of the inferior segment is advanced, the ratio of horizontal changes for osseous to soft tissues is improved compared with horizontal genioplasty. The advanced area was calculated by measuring the average value of the 38 patients who underwent surgery. When using inverted V osteotomy, the area of the inferior segment could be advanced by an average of 1.74 times compared with horizontal sliding genioplasty (Fig. 5A). The soft tissue profile change resulting from the advancement of the inferior segment has been investigated by various authors, and the ratio of horizontal changes in bone to soft tissues varies from 1:0.6 to 1:1 in the existing literature. In our genioplasty technique, the ratio of bone to soft tissue movement was 1:0.96, which is consistent with findings reported in the literature.[14]

Excessive bone resorption often ensues postsliding genioplasty due to concentrated focal tension on the bone. Excessive advancements have been made to produce noticeable changes in patients with small and short chains. Unfortunately, this can increase the chance of bone resorption and deepen the LMF. In addition, the chance of labial incompetence increases because of increased soft tissue tension[6,7,15] (Fig. 5). In our study, no instances of chin narrowing or marionette depression were observed, and follow-up CT scans indicated no bone resorption. Postoperatively, all patients exhibited improved facial profiles with increased harmony in their lip profiles and softer lower labial mental folds, as evidenced by postoperative photographs.

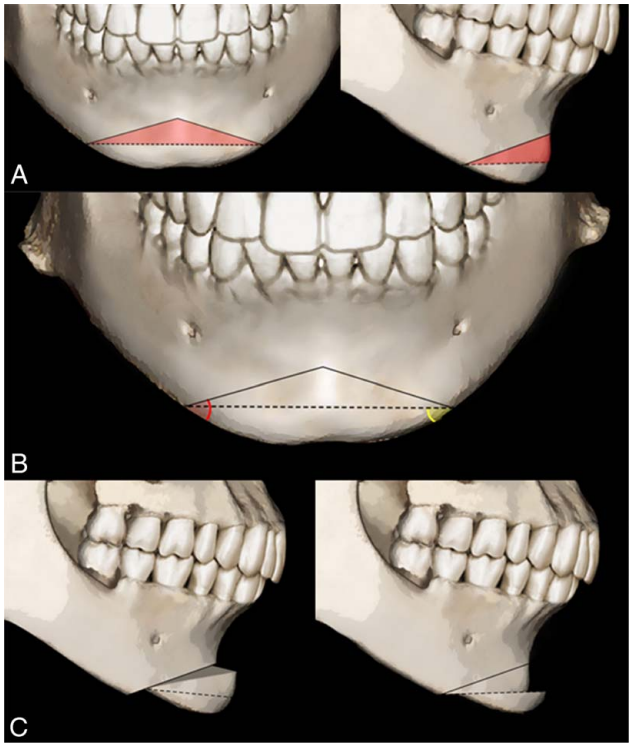

FIGURE 5. Comparison inverted V osteotomy and horizontal sliding ostetomy. (A) Red highlights the amount of additional bone segment incorporated in inverted V osteotomy compared with horizontal sliding osteotomy. The average values were measured in 38 patients. When inverted V osteotomy was performed, the inferior segment could be advanced ~1.74 times larger than that in horizontal sliding osteotomy. To improve aesthetics, larger volumetric bone movement allows for less bone advancement compared with smaller volumetric bone movement. (B) The volume of the lateral border of the inferior segment from the inverted V ostomy was greater than that from the horizontal sliding osteotomy. A larger bone mass and surface area are more resistant to bone resorption. Therefore, the narrowing of the chin and depression at the bottom of the marionette line due to bone resorption can be mitigated. (C) Lateral view: an inverted V osteotomy incorporates more vertical components of the moving segment of the chin than a horizontal sliding osteotomy. Therefore, the unwanted excessive deepening of the labiomental fold can be reduced.

The gap between the advanced inferior segment and remaining bone is called the secondary angle. When resolving the secondary angle, it was necessary to cutoff only the part that touched the skin. Excessive cutting to completely match the margin can extend the osteotomy too far back, making the chin smaller. It can also cause depression below Marionette's line.

In severe hypoplasia of the chin, which requires advancement > 10 mm, the labiomental fold may be deepened, in which case, an auxiliary implant may be considered.[16]

In 2014, Seifeldin et al[8] reported chin genioplasty using a shield shape. Technically, performing an osteotomy in the shape of a shield using a reciprocating or oscillating saw is difficult. It is much easier to cut in a straight line, and the operation time can be reduced using the proposed method.

If the vertical length is to be increased, the cut piece can be rotated downward while the lateral cut ends remain attached. This maneuver allows a 2 to 3 mm increase in vertical length, and the bony gap is healed through the bone remodeling process.

In 2014, Kim et al[17] reported inverted V-shape osteotomy with central strip resection; however, it is about narrowing and vertical reduction genioplasty, not advancement genioplasty.

Microgenia with a bimaxillary protrusion is common in Asian patients. In this situation, the surgeon should determine whether the patient has difficulty in mouth closure or dimpling of the chin skin. These patients also had exposed upper teeth during a relaxed state and awkward lip closure.[18] Following surgery, these conditions improved, especially with lip closure observed photographically. However, in cases where the skin of the upper lip is deficient, surgery on the chin will not improve the upper lip; this should be discussed with the patient preoperatively. If these conditions are not discussed preoperatively, the patient may claim that the above-mentioned issues (such as chin skin dimpling) occurred after surgery.

Some patients with small and short chains may have insoluble fillers or foreign substances placed preoperatively. In these cases, there is a higher risk of wound dehiscence and infection. Therefore, a preoperative discussion with patients should be conducted before surgery.

Our study has several limitations. First, although the sample size of 38 patients who underwent advancement genioplasty was relatively large compared with that of previous studies, it may still be considered relatively small, which could potentially affect the ability to detect significance. Second, the follow-up period of 1.2 ± 0.5 years is relatively short, which limits our ability to predict long-term soft tissue and bone changes. Third, this single-center study may restrict the generalizability of the findings to other patient populations. Future studies with larger sample sizes and longer follow-up durations are required to further investigate these aspects.

CONCLUSION

It is crucial to secure a large volume of the inferior segment during advancement genioplasty. By achieving a significant volume in the inferior segment, favorable esthetic results can be achieved, and potential complications such as deepening of the labiomental fold or bone resorption, which may occur following excessive advancement, can be prevented. Inverted V osteotomy represents an effective approach to ensuring an ample inferior segment volume, with the added advantage of a straightforward and simple surgical procedure. Future studies with larger sample sizes and longer follow-up durations are required.

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