Vertical Distraction Osteogenesis Combined With Bilateral 2-Step Osteotomy for Preprosthetic Rehabilitation of Edentulous Mandible

Tito M. Marianetti, MD, SD, Fabrizio Leuzzi, DMD, Enrico Foresta, MD, SD, Giulio Gasparini, MD, SD, Daniele Cervelli, MD, SD, Pier Fracesco Amoroso, DMD, and Sandro Pelo, MD, SD

Abstract: The aim of the current study was to appraise the effectiveness of distraction osteogenesis combined with bilateral 2-step osteotomy for the vertical augmentation of atrophic edentulous mandibles.

To verify the predictability of this technique, we evaluated bone density and vertical bone gain of a cohort of 27 patients. The intraoral alveolar distractor was placed in the symphyseal area; then, it was left in situ for 2 months after surgery to consolidate the newly formed bone. A total of 189 implants were inserted. The main complications’ issue was tied up to the neurosensory disturbances of the inferior alveolar nerve, which disappeared few months after the surgery.

At the end of the distraction osteogenesis, a mean vertical bone gain of 10.5 mm evaluated by comparing preoperative and postoperative computed tomography was reached. Three months after the surgery, the radiologic data indicated that the difference in the mean bone density, recorded in Hounsfield units (HU), between the distracted bone and the preexisting mandibular bone was not statistically significant ($P > 0.05$). The last measurements done showed that the osseous density in the distraction chamber was higher than the original medullary bone density: the regenerated bones were more dense ($876.8 \ [205.9] \text{HU}$) than the preexisting medullary bone ($312.1 \ [142.3] \text{HU}$) and less dense than the preexisting cortical bone ($1721.1 \ [170.4] \text{HU}$) at the ninth month.

In conclusion, this approach appeared to be a viable solution for the improvement of vertical volume in atrophic mandibles.

Key Words: Distraction osteogenesis, vertical bone regeneration, atrophy, bilateral 2-step osteotomy

(J Craniofac Surg 2013;24: 1175–1178)

Postoperative results after treatment of severe maxillary and mandibular atrophy of Cawood class 5 or 6 are often aesthetically and functionally unsatisfactory.

Such kind of bone resorption is usually tied up with an increased interarch space; when this arrangement is not correctly treated with preprosthetic regenerative surgery, it leads to an improper implant rehabilitation in which the crowns will be much too long.

Severely resorbed edentulous mandibles require extensive bone reconstruction to achieve an efficient rehabilitation with implants and fixed prosthesis. Harvesting autogenous bone grafts from the calvarial or iliac crest is a well-established procedure but may not be accepted by all patients.

Onlay bone grafts that are placed to gain vertical height may suffer extensive resorption because of postoperative infection, exposure into the oral cavity, or a lack of a sufficient broad vascular supply. Sandwich osteotomy with inlay grafts has been proposed to recreate the morphology of the alveolar crest for vertical deficiencies. The visor osteotomy or the bone-hydroxyapatite onlay augmentation posterior to the mental foramina pursued the same aim: to recreate the original anatomy of the mandible. However, the first technique has a high risk for nerve injury and the second technique cannot guarantee a full-arch implant-supported fixed prosthesis.

Vertical bone-guided regeneration with membrane may present drawbacks such as unpredictable bone gain and membrane exposure.

Short dental implants used in the posterior part of the mandible are a reliable option, but a considerable mandibular atrophy (Cawood classes 5 and 6) is a major drawback because of the proximity of the inferior alveolar nerve.

Distraction osteogenesis has been successfully applied to the maxillofacial region for the correction of hemifacial microsomia, craniosynostosis, and Franceschetti syndrome. Distraction osteogenesis is a technique of gradual bone lengthening that allows the body’s natural mechanisms to generate a new bone. The same distraction osteogenesis principles have been used for the maxillary arches. These medical devices eliminate the need for harvesting bone from a donor site; therefore, morbidity and the time needed for surgery are dramatically reduced.

This study was focused on the possibility of combining the bilateral 2-step horizontal osteotomy of the mandible involving the crestal bone above the inferior alveolar nerve and the symphyseal area by using the intraoral distraction. We would like to present the results of vertical bone gain and the density variation of the distracted area during a follow-up of 2 years.
MATERIALS AND METHODS

From January 2005 to February 2009, a total of 87 patients with severe mandibular atrophy (Cawood and Howell classes 5 and 6) were observed. They were referred to our clinics by their dentists to undergo preprosthetic surgery.

It was proposed that bilateral 2-step osteotomy combined with vertical distraction osteogenesis be used to restore a sufficient dimension wherein fixed implant-supported prostheses can be placed. Among the patients who accepted our treatment plan, a total of 27 patients (16 women, 11 men) were judged suitable according to the following criteria.

The inclusion criteria to participate in the study were as follows:

• Inclusive age between 18 and 75 years.
• Good general conditions, without some contraindication to the surgical treatment in general anesthesia.
• Presence of severe mandibular atrophy of Cawood class 5 or 6.
• Alveolar crest height above the inferior alveolar nerve ranging from 3 to 7 mm.
• Necessity of implant-prosthetic rehabilitation.
• Refusal to graft procedure.

The exclusion criteria were as follows:

• Previous or present diagnosis of pathologies affecting the healing processes of bone.
• Previous or present diagnosis of neurologic or metabolic diseases, including diabetes mellitus.
• Currently receiving cortisone or bisphosphonates therapy.
• Currently receiving chemotherapy or radiotherapy.
• Currently receiving cortisone or bisphosphonates therapy.
• Less than 3 mm of bone above the inferior alveolar nerve in the mandible.

All patients were unsatisfied with their mandibular denture, and they desired a full-arch implant-supported fixed prosthesis that could include at least the first molars.

Distraction was begun 6 days after surgery and continued up to the attainment of a satisfactory vertical dimension of the alveolar crest. The screw was rotated twice a day for the resultant of 0.8 mm per day. Two months after the last day of enlarging, the distractor device was removed, and 6 months after the end of the bone distraction, a total of 189 implants were inserted among a cohort of 27 patients. Because of the fear of collapsing of the transported segment, the patients were not allowed to wear a mandibular denture and they were demanded to maintain a liquid diet until the distraction device was set in place.

Once the surgical phase was completed, we observed the patients with a 2-year follow-up focused on clinical and radiologic evidences.

To assess bone density and vertical gain of bone, a three-dimensional quantitative computed tomography (CT) was used. The same scanning conditions (tube voltage, 130 kV; tube current, 83 mA; slice thickness, 1 mm; and slice intervals, 1 mm) were provided for each CT scan. The cross-sectional, coronal, and axial images for each slice thickness, 1 mm; and slice intervals, 1 mm) were provided for each same scanning conditions (tube voltage, 130 kV; tube current, 83 mA; slice thickness, 1 mm; and slice intervals, 1 mm) were provided for each.

The HUs determined by the softwares in the CT machines were taken before the surgery (Fig. 1).

The quantitative CT allowed us to evaluate the proposed parameters (vertical gain of bone at the canine region and the density variation of the distracted areas) at the end of the distraction (3 mo), then at the implant insertion (6 mo after the end of the bone distraction), and finally during the last years of follow-up (18 mo).

General anesthetics were administered via nasotracheal intubation. The mean length of time from intubation to reawakening was 2 hours.

A mucoperiosteal incision was made extending from the retromolar area buccal to the crest of the ridge to the opposite site. The mucoperiosteum was elevated, and the mental nerves were identified. Great care was taken to not expose the lingual side. A broad vascular pedicle was maintained to ensure the nutrition from the lingual side. The distraction device Martin (Martin GmbH & Co, KG Tüttlingen, Germany) was placed in the ideal position on the vestibular aspect of the mandible, and it was fixed using screws. The osteotomy had to pass parallel to the long axis of the device between the 2 lines of fixation screws. Therefore, small holes were made wherein the osteotomy had to be done. The device was temporarily removed.

A horizontal intraforamina osteotomy was performed, maintaining a safe margin from the mental nerves. The small holes oriented the bone cut. A further 2 bone cuts were made parallel to the cranial border of the mandibular canal, and their length was related to the implant plan. The 3 bone cuts were then jointed by other 2 vertical bone cuts just mesially to the mental foramen giving the shape of bilateral 2-step osteotomy.

The cranial fragment became free to move because of 2 vertical or slightly distally angulated bone cuts in the molar region. All bone cuts were made using an oscillating bur to minimize the width of the cut and, therefore, the quantity of bone loss during the operation.

The last part of the osteotomy was made using a chisel and a hammer to preserve the integrity of the vascular pedicle on the lingual side.

The distraction device was placed again and fixed using screws (Fig. 2). It was activated to test the mobility of the cranial segment (transported segment) and the caudal fragment. Attention was given to the major friction points or even to the obstacles for the lifting of the transported segment. The 2 segments were left separated by 1 mm to prevent unwanted bone knitting.

The mucoperiosteal flaps was repositioned, and it was closed with 3.0 Vicryl mattress sutures. A small cut into the mucosa was made for the distractor activation screw, which was visible in the oral cavity. Intravenous antibiotic therapy was given 1 hour before the operation (2 g of piperacillin and 0.25 g of tazobactam), and it was continued twice a day for 5 days.

RESULTS

The use of the vertical distraction osteogenesis combined with bilateral 2-step osteotomy allowed us to successfully rehabilitate...
all the edentulous mandibles included in the study. The augmented ridges appeared to be firm and stable in all cases (100%).

A total of 189 implants were placed (minimum torque of insertion, 30 N/cm), and survival rate at the end of the observation period was 95.2%. Nine implant failures happened within 1 year of loading. All the other implants did not suffer with persistent pain, infection, or mobility.

We found an overall complication rate of approximately 40%; this high rate was caused by the complications that resulted from the subjective evaluation of sensory disturbance, which revealed that 6 of the 27 patients experienced neurosensory disturbances (hypoesthesia). These problems disappeared between 2 and 7 months after the surgery, and a permanent paresthesia in only 1 case was reported.

This way, the complication rate became smaller after a few months, which was up to the percentage of approximately 22%.

Among the 27 patients, one of them had an infection, which was later resolved with antibiotic therapy; furthermore, in 2 patients, there was an alteration of the distraction vector and, in 2 more patients, a fracture in the posterior portion of the osteotomized bone segment occurred. These 2 patients ignored the medical prescriptions because they weared the old prosthesis and they did not follow a liquid diet. Nevertheless, all patients were healed by themselves, and then, they were successfully rehabilitated by inserting the fixtures in the interforaminal area.

At the end of the distraction osteogenesis, a mean vertical bone gain of 10.5 mm (range, 7–17 mm) evaluated by comparing preoperative and postoperative CT was reached; the measurement's site was the canine region.

The resorptive process at the observed area was active during the first year, where a mean of 1.2 mm (range, 0.5–1.7 mm) of bony height was lost, but thereafter, it continued at a slower pace.

The distractor device was more efficient in the symphyseal area than in the distal part. As a result, the bone gain was not uniform for the whole mandible. While the osteotomized section was being lifted vertically, its 2 extremities followed the symphyseal part with a delay of 2 mm. This led to a difference of bony gain between the distal part of the mandible and the midline (Fig. 3).

The study included 11 male and 16 female participants. The mean (SD) bone density (725.7 [174.7] HU), which resulted from the preoperative CT, in males was significantly higher than that (546.9 [209.7] HU) in females (P < 0.01).

Three months after the surgery, the radiologic data indicated that the difference in the mean (SD) bone density among the distracted bone and the preexisting mandibular bone (652.0 [164.9] HU) was not statistically significant (P > 0.05).

The last measurements done during the ninth and 18th months after the surgical intervention showed that the osseous density in the distraction chamber was higher than the original medullary bone density: the regenerated bones were more dense (876.8 [205.9] HU) than the preexisting medullary bone (312.1 [142.3] HU) and less dense than the preexisting cortical bone (1721.1 [170.4] HU) at the ninth month; then, the bone density increased until the 18th month.

Despite the presence of a thin radiolucent area at the final evaluation in 35% of the patients, the new generated bone withstood the functional demands of a full-arch implant-supported fixed prosthesis (Fig. 4).

Furthermore, all patients presented a sufficient bony consolidation, observed radiologically, 3 months after the distraction. There was no bone necrosis.

The width of the crestal keratinized tissue was assessed by using intraoral photos taken before and after the surgical intervention. The mean gain was 5.5 mm.

**DISCUSSION**

The distraction osteogenesis is a biologic process that leads to new bone formation between 2 bone surfaces, which are gradually separated by incremental traction.

The results of this study showed that the distraction of the osteotomized mandibles was a reliable surgical solution to recreate a satisfactory vertical dimension of the symphyseal area and of the alveolar crest above the inferior alveolar nerve. The bone density was measured with a standardized CT; this method has been used with the same purpose in several studies because it is objective and reliable for the morphologic and qualitative analysis of the bone.17–19
Higher mean bone density value was found in males than in females in the current study, and this finding may be related to the hormonal peculiarities in females and generally higher bone mass in males.19

The bone density recordings in the current study are comparable with those in previous reports.18,20 The study, regarding 27 distracted areas, disclosed that the mean bone density, 3 months after an intervention of bilateral 2-step osteotomy combined with vertical distraction osteogenesis, was the same with the preexisting mandibular bone.

Nevertheless, 9 months after the surgery, the mean distracted bone density appeared to be higher than the original medullary bone density. Obviously, it was lower if compared with the density of the preexisting cortical bone.

At the time of implant insertion, the tissue between the lingual and buccal cortex, generated during the distraction period, appeared to be a healthy bone and the ridge was covered with healthy-looking soft tissue.

The survival of the osteotomized bone segment depended on the preservation of the lingual mucoperiosteal flap13; furthermore, the start of the ossification process at the distracted site was caused by the lingual periosteal action. The maintained broad vascular pedicle on the lingual side ensured a nutritional supply for the cranial segment. By assessing the callus formation with CT sagittal scans, we can put in evidence that the new bone formation started on the lingual side of the alveolar crest, where the periosteam was intact, and, moreover, that the efficiency of ossification processes strictly depends on a good management of the soft tissues during the intervention.21

The ideal rate of distraction must allow the lengthening of the alveolar crest with healthy bone formation and a proper soft tissue response.22 In our patients, we waited 5 days before starting the distraction with a rate of 0.8 mm/d as also proposed by many publications; in our experience, this rate worked well as shown by the results.

The high complication rate found is mainly caused by the high rate of hypoesthesia, self-solved in all patients but 1. The fractures that occurred to the posterior part of the distracted bone fragment affected only 2 patients. They ignored the medical prescriptions regarding the need for a liquid diet and the prohibition for the use of the old prosthesis before the bone healing. This supports our convictions on the importance of a careful selection of patients.

In our experience, the vertical distraction osteogenesis appears to be a viable augmentation technique. Raising the bone level of the lower jaw to the ideal position means that the implant-prosthetic rehabilitation will be aesthetically and functionally better.

The use of the distraction osteogenesis as an alternative to the traditional bone grafts allow to eliminate the need of harvesting bone with the shortening of the surgical times and the reduction of the morbidity.

An important advantage derived from the use of distraction osteogenesis is the possibility of increasing the quantity of bone and soft tissue simultaneously, whereas the main disadvantage is that it is represented by the high risk for damaging the inferior alveolar nerve.

Although it is a risky procedure for the safety of the nerve and although it requires collaboration with the patient, because of the need for a liquid diet and the need to avoid cigarette smoke, the results are very encouraging and the technique can be considered an efficient solution for treating severe atrophies (class 5 or 6) in edentulous mandibles with at least 3 mm of bone height above the inferior alveolar nerve.

REFERENCES


1178 © 2013 Mutaz B. Habal, MD

Copyright © 2013 Mutaz B. Habal, MD. Unauthorized reproduction of this article is prohibited.