# Double-Step Transport Osteogenesis in the Reconstruction of Mandibular Segmental Defects: A New Surgical Technique

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Distraction osteogenesis was first introduced by Ilizarov in 1957.[1–3] Since then, it has been used in the gradual lengthening of endochondral bones of the extremities. In relation to craniofacial skeleton, the first case of mandibular lengthening was reported by McCarthy et al. in 1992.[4] Constantino et al.[5] demonstrated the effectiveness of bifocal distraction osteogenesis in the reconstruction of mandibular defects in dogs.

Excellent results have been obtained by means of the use of microvascularized free flaps in the reconstruction of large mandibular segmental defects.[6–8] However, its morbidity and costs suggest the use of an alternative technique in selected patients with increased surgical risks. Moreover, because of the composite nature of most mandibular defects, the reconstruction of both bone and soft tissue becomes a desirable objective. In relation to it, distraction osteogenesis has been referred to as a successful treatment modality in mandibular segmental defects.[9–11] By means of bifocal distraction osteogenesis, new bone is obtained after osteotomy and gradual separation of bony fragments.

Initial experimental studies used external devices in the restoration of mandibular defects.[5,12–14] However, cutaneous scarring and compliance of the patient may play an important role. When compared with the extraoral technique, intraoral distraction has improved stability, aesthetics, and patient motivation. In this article, we report the clinical case of a patient with a right mandibular segmental defect secondary to postablative oncologic surgery. The patient was treated by means of bifocal distraction osteogenesis with a semiburied device and transcutaneous activator. We describe a new technique of osteogenic transport in the reconstruction of large mandibular segmental defects.

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## CASE REPORT

A 69-year-old man presented with a right mandibular mass histologically diagnosed as mucoepidermoid carcinoma of the right retromolar trigone, pathologic stage pT4. The patient was treated in another center by means of surgical resection and reconstruction with bone grafting and a reconstruction plate. The soft-tissue defect was reconstructed by means of a radial forearm free flap. After 2 months, total necrosis of the bone was observed and the reconstruction plate was removed. Necrotic bone was also resected. The postsurgical defect was 45 mm long in the right hemimandibular body (Fig. 1) when the patient consulted us. No important soft-tissue defect was observed. Distraction osteogenesis was chosen as the reconstructive procedure. An osteotomy in the basilar region of the mandible was performed to obtain a 12-mm transport disk in the right parasymphyseal region, and the distraction device (AO Synthes, Oberdorf, Switzerland) was placed by means of a right submandibular approach. After verifying the mobility of the distractor, the device was returned to its original position, with the distraction activator placed percutaneously. Adequate contact between bony fragments and good hemostasis were obtained. Direct closure of the submandibular approach was performed, and after the latency period (10 days), distraction was initiated at a rate of 0.5 mm per day. In the panoramic radiographs obtained monthly after the surgical procedure, distraction of the transport disk and new bone generation were observed. At the end of the consolidation period, adequate new bone was generated (Fig. 2). A 30-mm new basilar bone was obtained.

Then, a new surgical procedure was performed. The distraction device was removed and a new osteotomy of the entire mandibular body was performed. A titanium miniplate and screws were used to obtain adequate stabilization of the entire newly generated bone. The distraction device was placed again, but the transport vector was 20 degrees above that of the previous one, to direct the transport disk to the residual fragment of the mandibular ramus. The latency period and distraction rate were similar to those performed during the initial procedure. A total of 45 mm of newly generated bone was obtained at the end of the distraction. Panoramic radiographs were also obtained (Fig. 3). The consolidation period lasted 12 weeks, and the distractor device was not removed during this period. After this time, the device was removed through the previous submandibular approach, and a 1-cm iliac crest bone graft was placed between the transport disk and the mandibular ramus by means of a plate and screws (Fig. 4). No complications were observed. The quality of the new bone was verified macroscopically, and it was regarded as excellent. No microscopic study of the new bone was performed. The patient remains alive 47 months after surgery, without signs of tumoral recurrence. Function and aesthetics were satisfactory for both patient and surgeon.

## SURGICAL TECHNIQUE

A submandibular approach was used to provide good access, with ablation of both hard and soft tissues around the lesion. This approach was also used to design the transport disk and to place the semiburied distraction device. During surgery, special attention was paid to preserve the periosteum and muscular attachments over the transport disk, to ensure its vascularity. At this point, an osteotomy was performed proximal to the defect to create the transport disk. The unidirectional distraction device (AO Synthes) used in this case allowed a maximal lengthening of 40 mm. The transport bone fragment was fixed to the movable part of the distraction device by means of two bicortical 10- to 14-mm-long screws, whereas two other bicortical screws fixed the device to the rest of the mandible. After verifying the mobility of the distractor, the device was returned to its original position, with the distraction activator placed percutaneously.

During the latency period (first 10 days), no device activation was carried out. After this time, distraction was initiated at a rate of 0.5 mm per day. The consolidation phase took place for 12 weeks. After this time, a new distraction procedure was performed, with an osteotomy of the entire mandibular body, from the newly generated basilar to the alveolar region. Both structures were fixated by means of titanium miniplates and screws to ensure stability of the new transport disk. This trapezium-like transport disk was distracted, as it was the initial transport disk, and the activation period was complete when the total lengthening of the bone transport segment reached the distal stump. Another consolidation period took place for 12 weeks. Finally, an iliac crest cortical bone graft was used to complete the bone union once the distraction device was removed. The

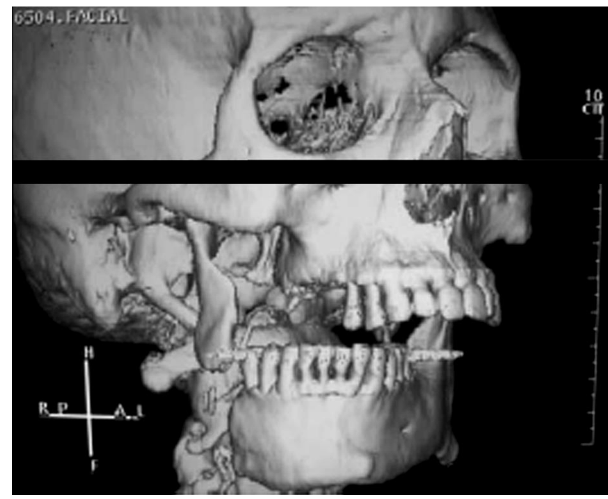

**Fig. 1.** Three-dimensional computed tomographic scan of a right mandibular segmental defect alter ablative surgery.

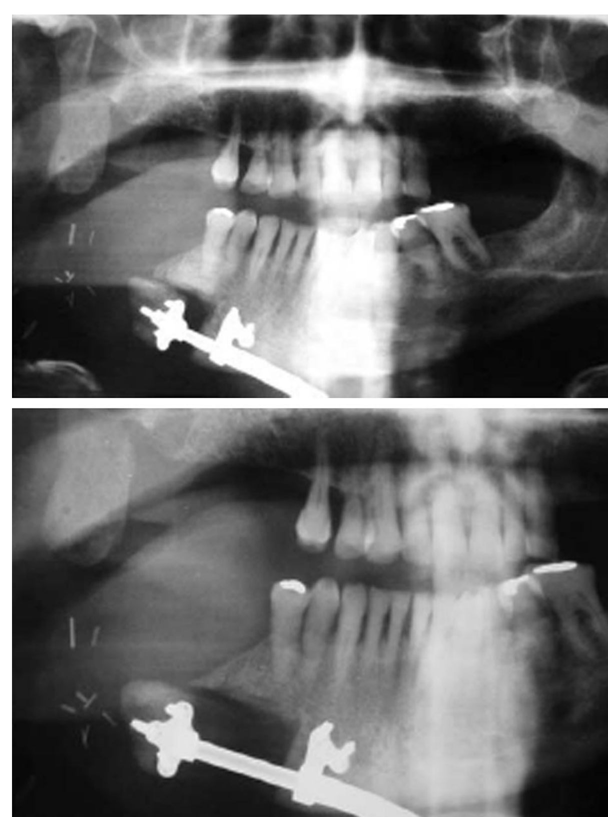

**Fig. 2.** Panoramic radiography. First distraction osteogenesis: distraction of the basilar region of the mandible. (*Above*) At the beginning of distraction. (*Below*) At the end of distraction.

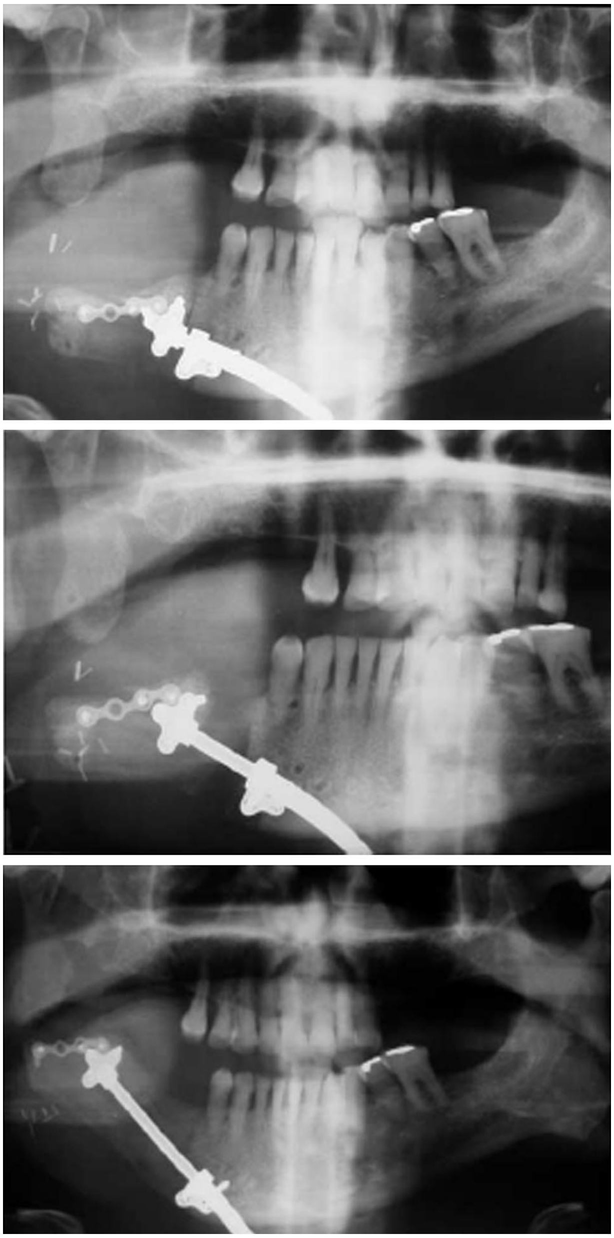

**Fig. 3.** Panoramic radiography. Second distraction osteogenesis: distraction of the entire mandibular body. (*Above*) At the beginning of distraction. (*Center*) Midpoint of distraction. (*Below*) At the end of distraction.

overall time for treatment was approximately 5 months.

## DISCUSSION

Many surgical techniques are currently available for reconstructing mandibular defects. Microvascular procedures have been widely used, although donor-site morbidity, difficulty of the technique, and contraindications in high-risk risk patients may advocate for the use of distraction

**Fig. 4.** Panoramic radiograph obtained after the placement of iliac crest bone graft and plate with screws. Adequate newly generated bone is obtained.

osteogenesis. By means of distraction, new bone is formed in the mandibular gap. Two foci of bone formation are present in bifocal distraction osteogenesis, and a transport disk is moved along the mandibular defect to generate new bone. As previously observed by Constantino et al.,[5] the diameter of the newly formed bone is similar to that of the mandible and transport disk. Moreover, the inferior alveolar nerve and artery are recannulated in most cases,[15,16] with clear benefits for the patients. All of these conditions may improve the subsequent placement of osseointegrated implants.

Preservation of a well-vascularized transport disk is essential to ensure its viability. In relation to it, special care must be taken when performing the osteotomies, and the periosteal envelope and muscular attachments must be preserved as much as possible. During the operation, special attention must be paid to avoid soft-tissue prolapse in the bony gap. The appearance of granulation tissue may obstruct advancement of the bony edges during the distraction period. This condition has been considered to be a limiting factor for bone regeneration in large mandibular defects. The insertion of a resorbable shield to protect the bony defect as an additional measure to prevent soft-tissue relapse has been recently proposed.[17] No obstruction of the device was observed in our patient, and no additional procedures were needed.

It is essential to predict an adequate vector during the operation to generate new bone in the desired direction. Furthermore, the distraction device must apply compression forces at the docking sites, to achieve fusion with the residual distal skeleton stump. This ideal condition was not obtained in our case because of the small residual condylar fragment. An anterior iliac crest bone graft was placed between the transport disk and the proximal stump. Final results in these patients were also good at the end of the follow-up period. The requirement for bone grafts to complete bone union is not an argument against distraction osteogenesis. The graft is always much smaller than that required if distraction osteogenesis is not performed. Moreover, soft tissue is expanded according to the bone transport.[18]

As previously reported by our group, and because of its reliability, we used internal semiburied distraction devices in all of our cases. In fact, this is the only method currently used in our department. It offers some advantages in comparison with external distraction devices, such as the following: (1) better stability, (2) a lower incidence of infection and dehiscence, (3) a lower incidence of unaesthetic scars and trauma, and (4) greater comfort and subsequent tolerance.[19] Although external devices have been used widely for reconstructing mandibular segmental defects, there are no clinical series regarding mandibular reconstruction by means of submerged distraction devices. The use of this type of distraction has been previously applied for mandibular regeneration in a canine model, with good results.[20] Moreover, in comparison with other internal devices such as the intraoral or the transmucosal activator, the external activator allows easier access for activation. With this type of activator, extraoral access is needed and complications derived from intraoral exposure are avoided. This is the reason why risks of infection and dehiscence decrease.

The technical limitation of the distractor used in this study is derived from the total length achieved after distraction. A total segment of 40 mm of generated bone is the maximum lengthening obtained by means of the use of one device. This limitation may be overcome by the use of two consecutive distraction devices in patients whose defects are much greater than 40 mm. Another limitation may be the one derived from the direction followed by the transport disk after osteotomy. It tends to move parallel to the transcutaneous activator of the distractor; thus, it is sometimes necessary to perform a greenstick fracture osteotomy after distractor removal, to reproduce mandibular curvatures, such as in the symphyseal region and the angle of the mandible. The use of a plate-guided distraction device, as reported by Herford,[18] could obviate this condition, although distraction technology still has to be refined to develop newer and more adapted devices.

In the present article, we describe a modification of the standard technique. Initially, the basilar region of the mandible is distracted and, at a second operation, the entire body of the mandible is distracted en bloc. The generation of a cylinder of new bone in the basilar region of the mandible allows the mandibular alveolar mucosa or soft tissue over the bone to be free of any stretching. The conventional distraction process could damage the mucosa in patients with gingiva of low quality who require precise, large distractions. New bone is generated in the external mandibular curvature, which is the longer border. Once the initial osseous cylinder is obtained and the basal mandible generated, the second surgical procedure consists of designing an entire mandibular transport disk. The transport disk is a trapezium with the newly generated basal mandible as the major base. The innovation of designing the segment along the inferior border allows maximization of the bone stock. This could be useful in cases in which large osseous defects must be repaired and more than one distraction device must be used. By means of this new technique, the necessity of alveolar region lengthening decreases substantially, as much as the stress generated in the gingiva over the alveolar bone.

In our experience, distraction osteogenesis in mandibular segmental defects is a reliable method for reconstruction in those patients who are not candidates for more aggressive surgical procedures. Our results advocate for the use of bone transport by means of internal distraction devices with a transcutaneous activator as an optimum alternative in this type of patient. We describe a new technique by means of which osteotomies and subsequent distraction procedures are performed in two or more steps. We propose the use of this technique as an alternative for mandibular segmental defects that exceed the capacity of the distractor device, even in the presence of a fragile and low-quality gingiva.

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