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Curvilinear Segmental Mandibular Reconstruction Utilizing Distraction Osteogenesis and Early Open Callus Manipulation

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Summary: The authors present a new technique for reconstruction of large curvilinear mandibular defects with distraction osteogenesis and early open callus manipulation. In phase 1, transport disks are created from mandibular bone and distracted across the entire length of the defect, without the restriction from a mandible plate fixation. This allows for full-length distraction until enough regenerate is obtained to reconstruct the defect without the need for additional bone grafts. Taking advantage of the soft moldable regenerate, the second and final operative procedure allows for the manipulation, repositioning, and fixation of the transported segments in the ideal position creating perfect tridimensional form and symmetry of the mandible arch. In addition, the consolidation phase is shortened by the early removal of distractors, substantially reducing the total length of treatment. This article describes 2 clinical cases treated according to this technique, one with a 6-cm mandibular defect where a sagittal plane manipulation was performed, and the other with a 7-cm defect and axial plane manipulation. Five years postsurgery, both patients had achieved full stable reconstruction without the need for bone grafting, and had obtained good facial symmetry, with no recorded complications. This technique serves to establish bone transport as a valuable alternative to bone free flaps in the reconstruction of large curvilinear segmental mandibular defects. *(Plast Reconstr Surg Glob Open 2017;5:e1229; doi: 10.1097/GOX.0000000000001229; Published online 24 January 2017.)*

Segmental mandibular defects represent one of the most challenging reconstructive problems, particularly when curvilinear parts are involved. Microvascular bone free flaps remain the gold standard in large defect reconstruction.[1–3] However, the morbidity associated with long operating and hospitalization times suggests the need for less invasive reconstructive techniques in selected patients with increased surgical anesthetic risks.[3,4] Additionally, donor-site morbidity remains a concern particularly in young active patients, especially when limbs or iliac crest are selected. In such cases, distraction osteogenesis (DO) has been proposed as a valuable treatment option, despite the extended treatment time, the need for multistage procedures and bone grafting for bone union at the compression focus and vector control difficulties.[5–7] These disadvantages could be obviated, by the technique developed by the first author, used to treat 2 patients with large curvilinear defects.

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CASE REPORTS

Case 1

A 20-year-old man, presented with severe facial asymmetry (Fig. 1) consequent to the treatment of a right tem-

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Fig. 1. Case 1. Facial asymmetry, conditioned by right orbital zygomatic and maxillomandibular hypoplasia with occlusal cant and deviated nose. Pre- and 2 years postreconstructive facial appearance.

poral fossa malignancy at age 1, with surgical excision and radiotherapy (40 rad).

A stereolithographic model was constructed for preoperative planning (Fig. 2).

The buccal cortex of the parasymphyseal area was subperiosteally dissected through a submandibular approach,

Fig. 2. Case 1. Stereolithographic model used for preoperative planning: measurement of real bone deficits (6 cm length defect in the right mandible body and 2.5 cm in the right maxilla); distractor devices premolding (6 cm distractor device KLS-Martin, Tuttlingen, Germany, and maxillary internal 3 cm distractor device Depuy-Synthes, Oberdorf, Switzerland), osteotomies and distraction process essay; premolding of a locking reconstruction plate for second operation.

and a vertical osteotomy was performed immediately distal to the canine, creating a 5-cm transport disk. The premolded distractor device was fixed.

Distraction protocol was followed reaching 6 cm (Table 1).

The second procedure was performed 1 week after the end of the distraction phase. The distractor device was approached trough the previous scar. Dissection over the body and footplates allowed for safe removal of the device avoiding damage of the regenerate identified between the bone stumps. The premolded reconstruction plate was fixed first at the symphysis. A nonlocking screw was placed at the most mesial stump of the transported segment, to act as a rotating axis, and manipulation with bone forceps was applied distally, to rotate the entire transported segment through 45° in a clockwise direction. Another nonlocking screw was tightened at the distal end of the transport segment, completing adaption to the plate in the ideal position. Additional locking screws were placed to reinforce the fixation.

No complications occurred, facial symmetry was achieved (Fig. 1), and good consolidation was confirmed by computed tomography allowing for dental implant placement 3 months after the second procedure (**See figures, Supplemental Digital Content 1**, ***http://links.lww.com/PRSGO/A365***; **Supplemental Digital Content 2**, ***http://links.lww.com/PRSGO/A366***; **Supplemental Digital Content 3**, ***http://links.lww.com/PRSGO/A367***; and **Supplemental Digital Content 4**, ***http://links.lww.com/PRSGO/A368***).

Case 2

A 52-year-old man, presented with a tridimensional mandible defect resulting from the excision of intraoral squamous cell carcinoma 6 years before. The buccal aspects of the remaining ascending ramus and symphysis

Table 1. Distraction Protocol Details

Case	Latency Period	Length of DO	Rate of DO (mm/d)	Additional Procedures	Treatment Time (Total)	Hospitalization Time (Total)
1	7 days	6 cm	1 (during 45 d) 0.5 (next 30 d)	Le Fort I DO of 26mm Orbitozygomatic PSI* Rhinoplasty*	3 months	7 days
2	7 days	7 cm	1		2 months	5 days

*At second intervention.

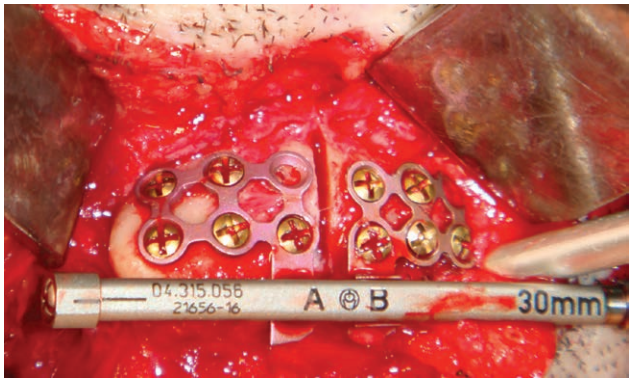

Fig. 3. Case 2. Transport disk of 2 cm created by an osteotomy at the symphysis and fixation of a 3-cm AB-CMF distractor device; another transport disk of 2 cm was created at the angle with fixation of a 4-cm BC-CMF distractor device (both Depuy-Synthes, Oberdorf, Switzerland).

were subperiosteal dissected using a submandibular approach. Two transport disks of 2 cm were created and were fixed with distractor devices (Fig. 3). Distraction protocol was followed reaching 7 cm (Table 1).

The second operative procedure was performed 1 week after the end of the longest posterior distraction phase and 17 days after the end of the shorter anterior distraction phase. Distractor devices and the regenerated segments were approached as described in *Case 1*. The devices were removed and a premolded reconstruction plate was fixed to the mandibular stumps. After axial manipulation, the transport disks were brought together to close contact and were fixed in the ideal position, utilizing nonlocking screws for perfect adaptation to the plate.

No complications were recorded, and good consolidation with bone continuity of the mandible arch was observed on computed tomography 1 year after the second procedure (**See figures**, **Supplemental Digital Content 5**, ***http://links.lww.com/PRSGO/A369***; **Supplemental Digital Content 6**, ***http://links.lww.com/PRSGO/A370***).

DISCUSSION

Microvascular bone flaps remain the gold standard technique for the reconstruction of segmental mandibular defects, although donor-site morbidity, difficult adaptation to the defect, technical requirements, and contraindications in high-risk patients argue in favor of alternatives such as DO.

Internal distractors offer important advantages, including better stability, a lower incidence of infection, a lower incidence of unaesthetic scars, and greater patient comfort.[8–11] Both patients described in this article were treated with internal devices and were able to pursue normal lives during the distraction phase.

Problems attributed to bone transport include difficult distraction vector planning and control, the need for bone grafting, and long treatment times. Additional difficulties arise when curvilinear segments need to be reconstructed. In such cases, curvilinear distraction represents an alternative, but requires even longer treatment times and/or additional operations.[4,8,12]

In this article, we describe a new technique that obviates most of these problems. In the initial phase, without the restriction imposed by previous reconstruction plate fixation, a regenerate is created that is larger than the defect. This eliminates the need for additional bone grafting. The second stage, performed before consolidation, allows for ideal tridimensional repositioning of segments guided by premolded plates. These support the new regenerate in position even in curvilinear segments, avoiding soft-tissue compression and regenerate retraction. The total length of treatment is shortened because the consolidation phase with distractors in place is eliminated, and only 2 surgeries are required.

At the 5-year follow-up, both patients had achieved stable curvilinear reconstructed segments, one in the region of the mandibular angle, and the other in the parasymphyseal region, demonstrating that early open callus manipulation can be safely performed in both sagittal and axial planes. Full reconstruction was obtained with DO alone with no requirement for additional bone grafting. Each patient underwent only 2 operations, and the duration of treatment and hospitalization was reasonable compared with alternative procedures (Table 1).

Closed callus molding was reported, using external distraction devices or orthodontic elastics to prevent problems related to vector planning or control.[13–15] Experimental studies performed by *Kunz* show that molding can be performed immediately after the end of the distraction phase.[16,17] Additionally, Wei et al[18] have shown that molding could be successfully performed 8 weeks into the consolidation phase. Pereira[19] was the first to report about open callus manipulation in bone transport for maxillary reconstruction. As far as we know, this article represents the first report of this technique in mandibular reconstruction.

Because these are the first and only 2 reported cases, further clinical experience is needed to evaluate the predictability of this technique. Experimental studies are needed to establish the safety of the procedure regarding consolidation and to determine the optimal timing of open callus manipulation.

We describe a new technique wherein DO reconstruction of large curvilinear segmental mandibular defects is effective and stable, requiring only 2 surgical procedures, eliminating the consolidation phase and using the second surgical procedure for distraction device removal, open manipulation and fixation of segments in the ideal position without the need for additional bone grafting.

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PATIENT CONSENT

The patient provided written consent for the use of his image.

REFERENCES

1. Muñoz Guerra MF, Naval Gías L, Campo FR, et al. Marginal and segmental mandibulectomy in patients with oral cancer: a statistical analysis of 106 cases. *J Oral Maxillofac Surg.* 2003;61:1289–1296.
2. Chang E, Jenkins M, Patel S, et al. Long-term operative outcomes of preoperative computed tomography-guided virtual surgical planning for osteocutaneous free flap mandible reconstruction. *Plast Reconstr Surg.* 2016;137(2):619.
3. Torroni A, Marianetti TM, Romandini M, et al. Mandibular reconstruction with different techniques. *J Craniofac Surg.* 2015;26:885–890.
4. González-Garcia R, Rubio-Bueno P, Naval-Gías L, et al. Internal DO in mandibular reconstruction: clinical experience in 10 cases. *Plast Reconstr Surg.* 2008;121:563–575.
5. Block MS, Otten J, McLaurin D, et al. Bifocal distraction osteogenesis for mandibular defect healing: case reports. *J Oral Maxillofac Surg.* 1996;54:1365–1370.
6. Sawaki Y, Hagino H, Yamamoto H, et al. Trifocal distraction osteogenesis for segmental mandibular defect: a technical innovation. *J Craniomaxillofac Surg.* 1997;25:310–315.
7. Shvyrkov MB, Shamsudinov AKh, Sumarokov DD, et al. Non-free osteoplasty of the mandible in maxillofacial gunshot wounds: mandibular reconstruction by compression-osteodistraction. *Br J Oral Maxillofac Surg.* 1999;37:261–267.
8. Whitesides LM, Wunderle RC, Guerrero C. Mandible reconstruction using a 2-phase transport disc distraction osteogenesis: a case report. *J Oral Maxillofac Surg.* 2005;63:261–266.
9. Takenobu T, Nagano M, Taniike N, et al. Mandibular reconstruction using intraoral trifocal bone transport: report of case. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;103:630.
10. Kashiwa K, Kobayashi S, Nohara T, et al. Efficacy of distraction osteogenesis for mandibular reconstruction in previously irradiated areas: clinical experiences. *J Craniofac Surg.* 2008;19:1571–1576.
11. Rubio-Bueno P, Naval-Gías L, Rodríguez-Campo F, et al. Internal DO for reconstruction of MSD: preliminary clinical experience in five cases. *J Oral MaxillofacSurg.* 2005;63:528.
12. Herford AS. Use of a plate-guided distraction device for transport distraction osteogenesis of the mandible. *J Oral Maxillofac Surg.* 2004;62:412.
13. Hoffmeister B, Wolff K. The floating bone concept in intraoral mandibular distraction. *J Craniomaxillofac Surg.* 26(Suppl. 1):76.
14. McCarthy JG, Hopper RA, Hollier LH Jr, et al. Molding of the regenerate in mandibular distraction: clinical experience. *Plast Reconstr Surg.* 2003;112:1239–1246.
15. Kunz C, Hammer B, Prein J. Manipulation of callus after linear distraction: a "lifeboat" or an alternative to multivectorial distraction osteogenesis of the mandible? *Plast Reconstr Surg.* 2000;105:674–679.
16. Kunz C, Adolphs N, Buescher P, et al. Possible problems of moulding the regenerate in mandibular distraction osteogenesis – experimental aspects in a canine model. *J Craniomaxillofac Surg.* 2005;33:377–385.
17. Kunz C, Adolphs N, Buescher P, et al. Distraction osteogenesis of the canine mandible: the impact of acute callus manipulation on vascularization and early bone formation. *J Oral Maxillofac Surg.* 2005;63:93–102.
18. Wei S, Scadeng M, Yamashita DD, et al. Manipulating the mandibular distraction site at different stages of consolidation. *J Oral Maxillofac Surg.* 2007;65:840–846.
19. Pereira AR, Montezuma N, Oliveira L, et al. Immediate reconstruction of large full-thickness segmental anterior maxillary defect with bone transport. *Craniomaxillofac Trauma Reconstr.* 2016;9:305–312.