Osteosynthesis and simultaneous irregular trifocal distraction osteogenesis for segmental mandibular defect after tumor ablative surgery: a case report

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Objective. This paper describes a case of secondary mandibular bone reconstruction performed to place dental implants. Osteosynthesis and simultaneous irregular trifocal distraction osteogenesis were documented.

Patient. The patient was a 51-year-old man with recurrent ameloblastoma of the mandible. Segmental mandibulectomy for tumor ablation and immediate mandibular reconstruction were performed. Because the volume of reconstructed bone was insufficient to place dental implants, trifocal distraction osteogenesis (vertical and horizontal distraction osteogenesis) was performed. Because the mandible had lost its continuity, osteosynthesis was performed simultaneously.

Results. Through this procedure, the bone was well augmented. Absorption of the distracted bone was not seen. Adequate-length implants were placed.

Conclusion. Irregular trifocal distraction osteogenesis synchronized with osteosynthesis shortened the treatment period and produced stable bone augmentation for placement of dental implants. Therefore, this procedure could be indicated for complicated segmental mandibular bone defects. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:651-5)

Dental implant is a powerful tool for oral rehabilitation after tumor ablative surgery, but it requires bone with sufficient height and length. Therefore, many methods of bone reconstruction have been developed. But, if the recipient bone is poorly formed, it is necessary to perform secondary surgical bone augmentation procedures, such as additional bone grafting, application of a bone substitute, or guided bone regenerative.

Distraction osteogenesis has been developed to gain sufficient alveolar bone length, height, and width for placing dental implants.1-5 Although distraction osteogenesis requires a long treatment period, the procedure can enable clinicians to avoid bone harvesting which might cause morbidity of the donor site. Many studies have reported vertical distraction osteogenesis as an effective way to gain sufficient bone height to place dental implants after marginal mandibulectomy,6 reconstruction with vascularized fibular bone flaps,7,8 or free iliac bone graft.9,10 Bifocal or trifocal distraction osteogenesis has been used after such procedures to close the segmental mandibular defect.11-14 Because the segmental mandibular bone defect is often complicated, multifocal distraction osteogenesis that enables reconstruction of both soft and hard tissue could be an effective procedure in such a condition. Currently, with the development of procedures and devices for bone transport, trifocal distraction osteogenesis is becoming an established method for treating large mandibular bone defects.11,13

This report describes a case of distraction osteogenesis performed for secondary bone augmentation after mandibular bone reconstruction using a reconstruction plate and composite graft of particulate cancellous bone marrow (PCBM) and β-tricalcium phosphate (β-TCP). In the present case, the newly formed bone was poor, the plate fractured after the first reconstruction, and a complicated bone defect remained with loss of mandibular continuity. To reconstruct this defect, short multibone transport was performed as secondary bone augmentation. Each of the 2 distraction devices transported its bone disk in a different directional axis, and the devices were docked at the intersection of the 2 directions to induce compression osteosynthesis. The
pathologic mandibular bone fracture was simultaneously treated by intramaxillary fixation. The distraction protocol, clinical course including implant therapy, and efficacy of the external fixation device are discussed.

CASE REPORT

A 51-year-old man had been diagnosed with recurrence of ameloblastoma in the middle to right mandible. The patient had first developed ameloblastoma 20 years previously and had undergone marginal mandibulectomy and free bone graft at another hospital. Orthopantomography revealed a radiolucent lesion with a well defined border in the central part of the mandible.

A segmental mandibulectomy extending from the left canine to the posterior part of the right mandible excluding the mental foramen was performed to excise the recurrent ameloblastoma. The residual segment of mandibular bone was fixed with a titanium bone reconstruction plate (Stryker Japan, Tokyo, Japan), and a free iliac bone plate and PCBM mixed with β-TCP granules at equivalent volume were grafted into the bone defect.

However, the majority of the grafted tissue was absorbed without sufficient bone formation, and the reconstruction plate fractured one year after the operation (Fig. 1, B; Fig. 2, A and B). The miniplate and fractured reconstruction plate were removed and mandibular bone reconstruction was performed under general anesthesia. Because the mandible had lost its continuity, both margins of the bone segment were contacted and fixed with an external fixation device (Pennig wrist fixator, Orthofix, Verona, Italy) for ostesynthesis. Simultaneously, trifocal distraction osteogenesis was performed for secondary bone augmentation. The major bone segment was distracted vertically, and the upper part of the minor bone segment was distracted horizontally (Fig. 1, C). Two box-shape osteotomies were performed, and 2 extraosseous distraction devices (KLS Martin, Jacksonville, FL) were placed on the vestibular surface of each mandibular segment. The directions of these distractions were decided carefully in consideration of the contact of both bone segments and the ideal dental implant site. The devices were fixed with unicortical microscrews and were temporarily activated to ensure correct function. Primary closure of the surgical wound was achieved in 1 layer, and the tip of the activating cylinder was displayed on the oral incision line. An antibiotic was administered intravenously for 4 days and then continued orally for 3 days. The device was activated at a rate of 0.5 mm per day from the seventh postoperative day. Increases in bone height of 10 mm (vertical distraction) and bone length of 7 mm (horizontal distraction) were detected on orthopantomography and computerized tomography (CT), respectively (Fig. 1, C; Fig. 2, C and D). Horizontal distraction was stopped at this point, because the segment made contact with the other bone segment and there was strong resistance to further distraction (Fig. 1, C; Fig. 2, C and D). The distraction devices and external fixation instruments were removed 5 weeks after the setting operation, and the bone segments were fixed with a titanium miniplate (Fig. 2, C and D). Four months after completing distraction, with newly formed bone and bone connection of the mandibular fragments confirmed on CT (Fig. 2, E and F), dental implant surgery was performed under general anesthesia. Six implants (Brånemark System; Nobel Biocare, Göteborg, Sweden) were placed: 2 13-mm-long 3.75-mm-diameter implants at the left side of the bone and 4 10-mm-long 3.75-mm-diameter implants at
the right side of the bone (Fig. 3, A). The initial stability of these implants was acceptable. Six months after the first implant surgery, the implants were exposed. Sequentially, an implant-supported fixed prosthesis was fabricated 2 months after exposure of the implants (Fig. 3, B). The final prosthesis was followed-up for 2 years and appeared stable on orthopantomography (Fig. 3, C).

DISCUSSION

Absorption of grafted bone is a common occurrence. Micro movements of the bone graft following transplantation increase the absorption rate of the graft.\textsuperscript{15,16} It is possible that the mechanical strength of the graft materials was insufficient in the present case, so that masticatory forces after the initial reconstruction operation were too strong to maintain fixation of the mandible. Consequently, micro movement of the titanium plate and graft material could occur. This could be why the graft absorbed considerably and the titanium plate fractured.

Distraction osteogenesis has been categorized into monofocal, bifocal, and trifocal distraction, depending on the number of bone regenerative sites at which osteogenesis occurs.\textsuperscript{17} Trifocal distraction is defined as that in which two bone segments from opposite ends of the defect are distracted so that they contact in the middle position.\textsuperscript{14,18} When successful, the contact area of both bone segments shows bony union with numerous osteoblasts.\textsuperscript{19} In the present case, distraction osteogenesis was performed in 2 different directions, and both distracted bone segments were brought into contact for bone connection. Therefore, although both bone segments were not in opposite positions, the procedure was considered to be a trifocal distraction. In this irregular trifocal distraction, it is necessary to note the following points. Because the directions of both bone segments were not on the same line, one distraction...
would not obstruct the other. And because bone height was absolutely insufficient in the middle mandible, the vertical distraction was given priority. Finally, when both segments came into contact, horizontal distraction was stopped to avoid excessive pressure on the vertically distracted bone segment. Consequently, increases in bone height of 10 mm (vertical distraction) and bone length of 7 mm (horizontal distraction) were achieved.

Because the mandibular bone had a pathologic fracture, bone needed to be fixed for bone connection. Because the vertical distraction device was attached to the margin of the mandible, it was difficult to use a titanium reconstruction plate to fix the mandibular bone segment to simultaneously perform the distraction osteogenesis. Therefore, an external fixation device was used to fix the fractured mandibular bone segment. The external fixation device needed only 2 points for its pins to be inserted to rigidly fix and maintain the continuity of the mandibular bone. Thus, by using the external fixation device it was possible to perform osteosynthesis and distraction osteogenesis in 1 stage. The external fixation device in the present study is usually used in hand surgery, sometimes in combination with soft tissue and bone distraction. This device was useful to shorten the treatment period in the present case.

In distraction osteogenesis, distraction rate and retention period are critical in ensuring bone consolidation. In the present case, after a 7-day latency period, the distraction device was activated with a 0.5 mm application once a day, and approximately 10 mm bone height was gained. Chiapasco et al. recommended a 0.5 mm daily distraction rate on a vertically deficient edentulous ridge for uneventful recovery of the surgical wound. Distraction rate and retention period have also been addressed by earlier studies on the vertical distraction of grafted bone. Klesper et al. performed vertical distraction of vascularized fibular bone flaps in the mandible at 1.0 mm per day, followed by a 12-week retention period, and gained 9-12 mm bone height. Kunkel et al. performed vertical distraction of free iliac bone grafts in the mandible at 0.5 mm per day, followed by a 4–6-month retention period, and gained 6-9 mm bone height. Earlier reports describing trifocal distraction for mandibular reconstruction indicated that the 2 transport bone segments were moved 1.0 mm per day (twice per day at 0.5 mm each time) followed by 3- or 6-month retention period. In the present study, the necessary distance was short, and because the distraction was the secondary operation after poor bone augmentation, the bone segments were distracted at 0.5 mm per day. Then it was considered better to have a much longer retention period in the present case. However, because the distraction device injured the soft tissue, 2 devices were removed and the original bone segments were fixed with a titanium miniplate to maintain bone distraction. Consequently, CT demonstrated matured bone in the distraction area that was favorable for placement of the dental implant.

Fig. 3. A, Orthopantomograph after 6 implants placed in the reconstructed mandibular bone. B, Eight months after implant insertion, the implant-supported fixed prosthesis is completed. C, Two years after the final prosthesis, the bone condition is stable.
ported distraction osteogenesis of only the upper part segment of mandible. Kondoh et al.\textsuperscript{22} reported the distraction of an alveolar bone segment including the second molar and named this procedure sliding transport distraction osteogenesis.

In the present case, osteosynthesis and simultaneous trifocal distraction were accomplished, and subsequently dental implant therapy has succeeded to date. Although long-term follow up and more detailed investigation are necessary, the procedure could be useful in shortening the treatment period of dental implant therapy and may be indicated for complicated segmental mandibular bone defects.

REFERENCES


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