Mandibular Reconstruction Using Autologous Iliac Bone and Titanium Mesh Reinforced by Laser Welding for Implant Placement

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Segmental mandibulectomy is a treatment option for benign and malignant neoplasms of the mandible. Although reconstructing the mandible of a patient with a missing segment is difficult, it is essential to improve the postoperative course of the patient. Mandibular reconstruction using titanium mesh is a useful technique for dental implant placement because the morphology of the mandible can be easily reproduced. However, fitting titanium mesh to the remaining mandible is not an easy task during surgery. The present report introduces a method in which a 3-dimensional skull model fabricated by means of stereolithography is prepared, based on computerized tomography (CT) scans, to construct a titanium mesh cage matching the shape of the mandible, preoperatively. Furthermore, the load-bearing area of the titanium mesh cage is reinforced by laser welding another layer of titanium mesh to reduce the incidence of metal fatigue during jaw movement. Int J Oral Maxillofac Implants 2008;23:1143–1146

Key words: *dental implant, iliac bone graft, laser welding, mandibular reconstruction, titanium mesh*

Repair of large discontinuity defects of the mandible is a major challenge to reconstructive surgeons. Occlusal reconstruction is also an important issue and, in relation to the opposing teeth and maxilla, the mandible needs to be reconstructed to match its preoperative shape for final prosthodontic treatment. Many methods have been reported to reconstruct the mandible,[1–4] and one such method is to implant an autologous bone graft using titanium mesh.[5] Mandibular reconstruction using titanium mesh is suitable for recovering the physiological shape of the mandible, and either a cortical bone block or particulate cancellous bone and marrow can be used[6–8] to facilitate prosthodontic treatment with dental implants. However, it is difficult and timepconsuming to fit and shape titanium mesh during reconstructive surgery.

To resolve the aforementioned problems, the following method was employed: The craniofacial skull model was fabricated with stereolithography on the basis of CT data. Stereolithography creates a physical model of the craniofacial skull by steering a laser, guided by data from a conventional CT scan, onto selectively solidifying liquid resin, creating a model layer by layer, as an integrated solid counterpart of the CT slices (1 mm).[9] After trimming the model to simu-

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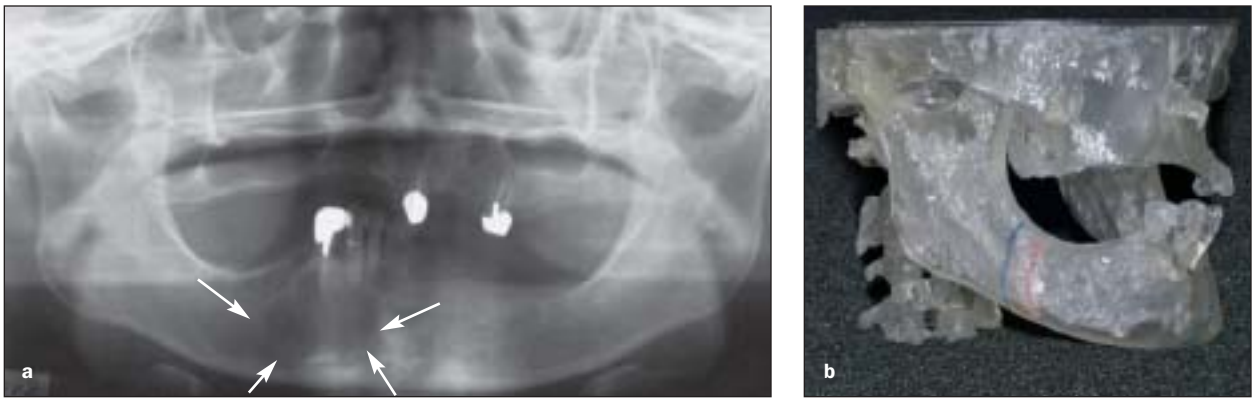

Fig 1 *(a)* A panoramic radiograph taken on the initial visit. (*Arrows*, tumor interface.) *(b)* A 3-dimensional model fabricated with stereolithography based on CT scans (*blue line*, area of planned excision).

Fig 2 Reinforced titanium mesh shaped to match the model with a segmental defect. (*Arrows*, areas reinforced by laser welding.)

late segmental resection, titanium mesh was shaped to match the defect preoperatively. This made it easier to fit the titanium mesh following segmental resection while maintaining the shape of the mandible and shortening the operation time. Furthermore, the amount of bone to be grafted can be determined by measurements obtained using this model before surgery; an appropriate resin stent can be produced beforehand.[9]

Even if the mandible is reconstructed using titanium mesh, the mesh can fracture or break during jaw movement before the grafted bone ossifies.[10] Load-bearing areas of the mesh are susceptible to metal fatigue. In case of a severe fracture, reoperation is sometimes required. To prevent such fractures, after bending the titanium mesh to simulate the shape of the target mandible, another layer of titanium mesh is placed and laser-welded.

For occlusal reconstruction, dental implants were ideal.[11] Favorable masticatory and occlusal function can be restored by placing dental implants in a bone graft postoperatively. This case illustrates that mandibular reconstruction can be performed using titanium mesh and occlusions with implants can be restored without delay.

CASE REPORT

A 59-year-old woman was referred to our department by her dentist. Her panoramic radiograph showed a multilocular radiolucent lesion in the mandible (Fig 1a). The patient underwent detailed examination. The preoperative CT showed a 46 × 11-mm tumor extending from the midline of the mandible to the right mandibular angle. The absorbance of the internal structure of the lesion was low and relatively even, and the lesion was divided into several sections by osseous septal walls. The lesion was biopsied under local anesthesia and histopathologically diagnosed as a myxoma. Based on imaging findings, a 3-dimensional model was fabricated by means of stereolithography (Fig 1b). Using the model, the extent of segmental mandibulectomy was determined, and the area corresponding to the tumor was removed. Titanium mesh (Dumbach, Leibinger, Germany) was shaped to simulate the resulting model (Fig 2). Another layer of titanium mesh was laser welded to cover the load-bearing area (Neolaser L, Girrbach Dental Systems, Germany). Under general anesthesia, a right segmental mandibulectomy was performed, and the mandible was reconstructed using the titanium mesh and can-

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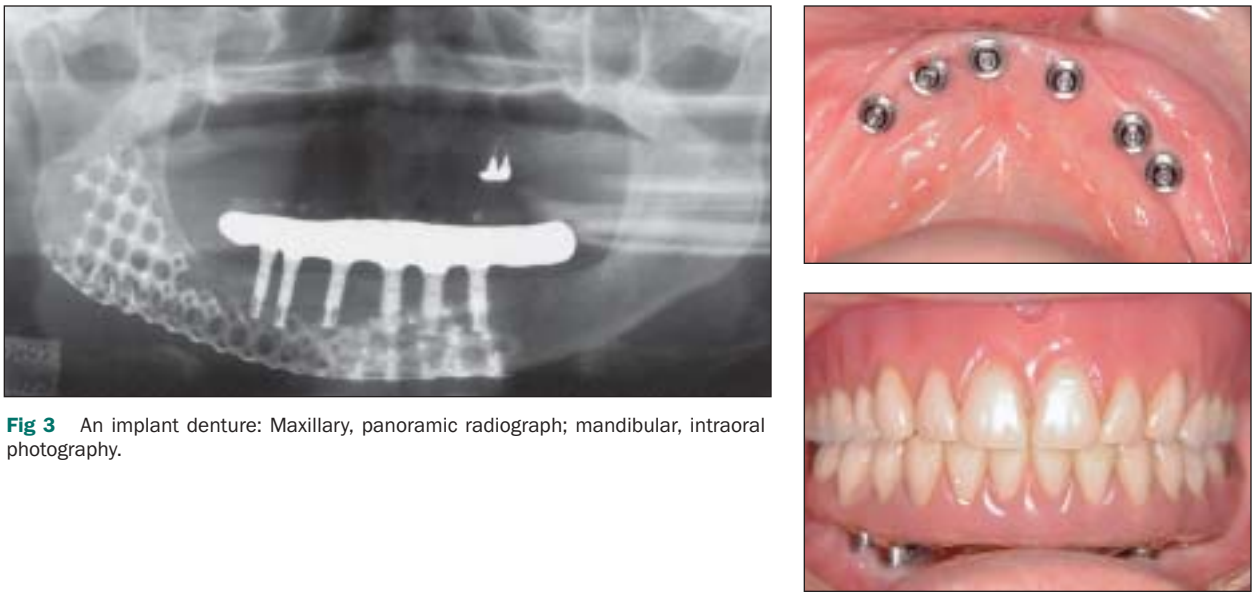

Fig 3 An implant denture: Maxillary, panoramic radiograph; mandibular, intraoral photography.

cellous bone harvested from the ilium. Four months later, 6 Brånemark implants (Ø3.75 mm, length 15 mm, and Ti-unite surface, Nobel Biocare, Sweden) were placed. One month later, a second surgery was performed to prepare and attach superstructures. Three years later, the maxilla is edentulous, but the occlusion and facial appearance is favorable (Fig 3).

DISCUSSION

Vascularized bone grafts made from fibula, ilium, or scapula have been utilized for mandibular reconstruction, and dental implants have been placed in bone grafts.[12] Although high success rates have been achieved with such bone grafts,[13,14] flap preparation and vascular anastomosis take time, and complications such as postoperative thrombogenesis may occur.[15,16] Also, bone grafts are not suitable for elderly patients, smokers, alcoholics, or patients with diseases such as diabetes because of vascular complications.[15] Furthermore, it is difficult to shape a straight bone graft to conform to the curvature and buccolingual morphology of the mandible during surgery.[17] As dislocation of the residual mandible and joint can cause failure of occlusion and implant treatment, proper reproduction of the shape of the mandible is essential for restoring or creating proper occlusion and is an important element in the preparation of dentures and implant-retained prostheses.

The biggest advantage using titanium mesh is that the anatomical shape of the mandible can be easily reproduced for final prosthodontic treatment with dental implants.[18] However, it was not easy to shape the titanium mesh to match the residual bone during surgery. This problem can be resolved by preoperatively preparing a skull model fabricated by stereolithography based on the CT scans.[9] This makes it easier to fit the titanium mesh during surgery and shortens the operation time. Because titanium mesh does not need to be bent more than necessary, metal fatigue can also be minimized. Furthermore, it is possible to estimate the necessary amount of bone graft to facilitate prosthodontic treatment before surgery. This also contributes significantly to preoperative planning, including implant placement and final prosthesis. This technique can be applied to both primary and secondary reconstruction of a patient with a missing segment of the mandible. Also, cosmetic problems and displacement of the residual mandible and joint have been improved by this method in secondary reconstruction cases (Fig 4).

In the past, titanium mesh that was shaped to simulate the morphology of the mandible cracked or fractured once occlusion was restored in some patients. To avoid mesh failure before ossification of the mandible and repeat surgery, we have been reinforcing the titanium mesh by laser-welding another layer of titanium mesh to the load-bearing areas. However, laser welding can oxidize treated surfaces. We conducted a composition analysis of the laser-welded areas (energy dispersive X-ray analyzer: MAS7/550MT, EDAX Japan), and the results showed no contamination with impurity (Yamaguchi, in preparation), suggesting high biocompatibility. The results of bending and tensile strength tests have also shown that laser welding increases strength. When internal structures are laser-irradiated, the strength increases by more than 20% (Yamaguchi, in preparation). Hence, laser welding is not harmful to the human body and is a technically convenient method to reliably increase strength.

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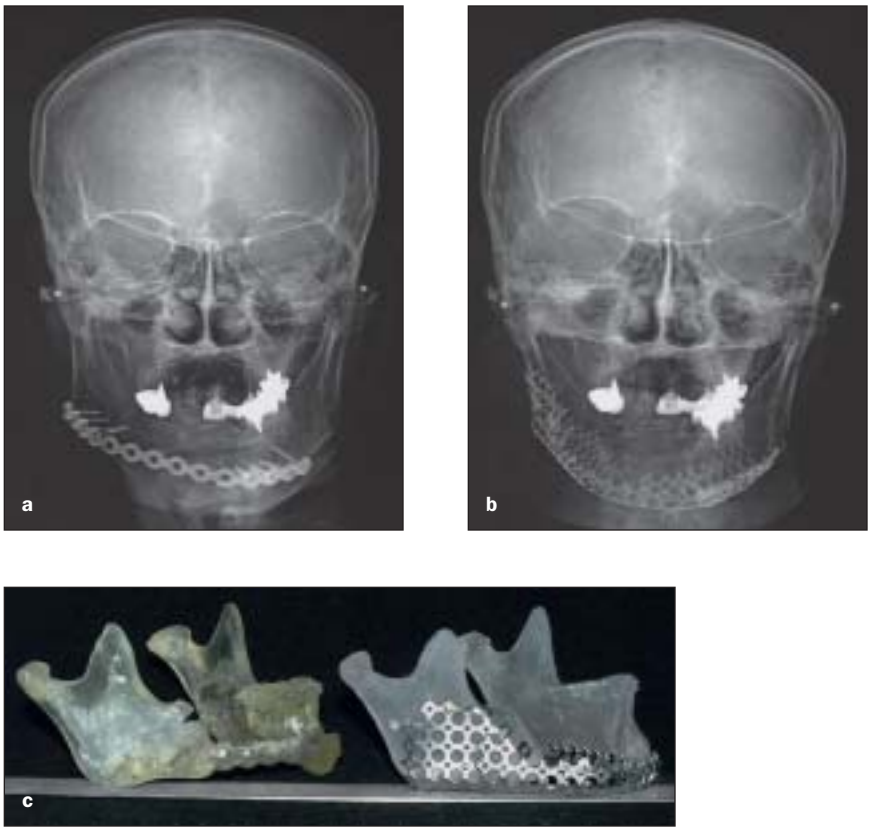

Fig 4 Postoperative radiograph *(a)* after primary reconstruction with reconstruction plate and *(b)* after secondary reconstruction by this technique. *(c) Left*, displacement of the residual mandible bone by reconstruction plate. *Right*, a mandibular model after proper reproduction of the shape by this technique.

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