A Revised Approach for Mandibular Reconstruction With the Vascularized Iliac Crest Flap Using Virtual Surgical Planning and Surgical Navigation

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Purpose: The purpose of this study was to describe a revised approach for mandibular reconstruction with vascularized iliac crest flap using virtual surgical planning and surgical navigation.

Patients and Methods: Preoperative maxillofacial and iliac non–contrast-enhanced computed tomography (CT) scans were acquired, and CT data were imported into ProPlan CMF software (Materialise, Leuven, Belgium). We performed virtual mandibulectomy and superimposed the 3-dimensional iliac image on the mandibular defect. The surgeon shaped the iliac flap according to virtual parameters and the stereomodel. Surgical navigation was used to check and correct the shaped segments. The position of the osteotomy lines and relevant parameters regarding the shape of the iliac flap also were provided to the surgeon. After computer simulation, a reconstructed mandibular stereomodel was manufactured. A reconstruction plate was prebent and fixed on this model using titanium screws. The model was scanned, data were imported into ProPlan CMF, the mandible was segmented, and data were imported into the intraoperative navigation system. Then, the model was registered with the original CT data, and the reconstruction plate was eliminated. Navigation data were exported into a universal serial bus drive, which was connected to the terminal working station during surgery. Intraoperative navigation was used to implement the virtual plan for patients. The sagittal, coronal, axial, and 3-dimensional reconstruction images displayed by the navigation system were used to accurately determine the osteotomy sites and osteotomy trajectory during surgery. Surgical probe guidance was used to mark the osteotomy line and transfer the virtual procedure to real-time surgery.

Results: Using our method, we precisely recovered the original configuration of the mandible. The shift in the reconstructed mandible and plate was less than 5 mm.

Conclusions: We provided a new method for mandibular reconstruction with vascularized iliac crest flap and an individual reconstruction plate using computer-assisted techniques involving surgical navigation, which have the potential to improve the clinical outcomes of this procedure.

J Oral Maxillofac Surg ■*:1.e1-1.e11, 2016*

Received from Department of Oral and Maxillofacial Surgery, Peking University School and Hospital of Stomatology, Beijing, China.

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This work was supported by grants from the National Supporting Program for Science and Technology (No. 2014BAI04B06) and Science Foundation of Peking University School of Stomatology for Young Scholars (No. PKUSS20150206).

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Received October 29 2015

Accepted February 22 2016

0278-2391/16/00239-1

http://dx.doi.org/10.1016/j.joms.2016.02.021

Mandibular reconstruction is a challenging procedure in the field of head and neck reconstructive surgery, which aims to achieve the best possible functional and esthetic outcomes. Q4 The iliac crest bone graft was used for mandibular reconstruction in the early 20th century.[1] With the development of microvascular surgery, bony reconstruction has been revolutionized because of the application of vascularized bone grafts. The possibility of using vascularized bone flaps led to higher graft survival rates and improved functional outcomes.[2-4] Several different bone flaps have been established over time. Graft selection depends on the defect size and location, requirement for soft tissue, and status of recipient vessels. The microsurgically revascularized iliac crest bone graft has some advantages over other bone grafts, such as the large amount of bone, rich cancellous blood supply, and compact cortex, which make this graft an ideal choice for plate fixation and endosseous implant placement during dental rehabilitation.[5]

Currently, the use of computer-assisted techniques for mandibular reconstruction has increased, leading to a decrease in the surgical duration and complication rate and improved esthetic and functional outcomes.[6-8] These techniques include the use of 3-dimensional (3D) stereolithographic models, cutting guides, prebent plates, and preshaped titanium mesh implants, among others.[9-11] The essential basic step in computer-assisted reconstruction is transfer from the virtual preoperative plan to real-time surgery. It has now become possible to import virtual data into a navigation system, which is used to provide guidance for the accurate and safe placement of hardware or bone grafts, movement of bone segments, tumor resection, and osteotomy designs. Finally, newly designed, mobile, intraoperative computed tomography (CT) scanners have become available and can be used to confirm the accuracy of reconstruction before patients leave the operating room.[12] Several appliances and studies regarding navigation surgery have focused on the midfacial region.[12,13] Previously, computer-aided navigation was rarely used for mandibular reconstruction because of the mobility of this bone. The purpose of this study was to introduce a revised approach for mandibular reconstruction with the vascularized iliac crest flap using virtual surgical planning and surgical navigation.

Patients and Methods

A 23-year-old female patient came to our institution with visible swelling on the right side of the mandible. A panoramic radiograph showed an extensive, radiolucent, multilocular, expansile lesion (Fig 1). A soft tissue biopsy of the lesion yielded a diagnosis of ameloblastoma.

VIRTUAL PLANNING

Preoperative maxillofacial and iliac non–contrast-enhanced CT scans with a 1-mm slice thickness were acquired, with the former acquired in a stable occlusion position (field of view, 20 cm; pitch, 1.0; slice, 0.75 mm; 120Y280 mA). A lead-rubber suit Q5 was used to decrease abdominal radiation exposure. CT data in the Digital Imaging and Communications in Medicine file format were imported into ProPlan CMF software (Materialise, Leuven, Belgium). First, the mandible and maxilla were segmented. Then, we performed virtual mandibulectomy with ProPlan CMF according to clinical and 3D radiologic findings, after which we superimposed the 3D iliac image onto the mandibular defect in its desired orientation according to the ideal mandibular contour (Fig 2). If the contour of the mandible was destroyed by the tumor, mirroring tools were used to form the ideal mandibular contour.[14] The length of every iliac segment was measured and provided to the surgeon to facilitate intraoperative positioning and placement. The surgeon shaped the iliac flap according to these parameters, cross-checking with a protractor and ruler. Surgical navigation was used to check and correct the shaped iliac segments. The position of the osteotomy lines and relevant parameters regarding the shape of the iliac flap also were provided to the surgeon.

After computer simulation was completed by the surgeon and a bioengineer, a reconstructed mandibular and iliac stereomodel was manufactured by the bioengineer using 3D printing technology. A reconstruction plate was prebent and fixed on the reconstructed mandibular model using 2 titanium screws (Fig 3). The iliac crest cutting template was made with silicone rubber to guide the harvest of the iliac crest.

Next, the mandibular model with the reconstruction plate was subjected to CT (field of view, 20 cm; pitch, 1.0; slice, 0.75 mm; 120Y280 mA), and CT data in Digital Imaging and Communications in Medicine file format were imported into ProPlan CMF software. The model was segmented, and Q6 data were imported into the intraoperative navigation system (iPlan 3.0; Brainlab, Feldkirchen, Germany). Then, the model was registered with the original CT imaging data, and the image of the reconstruction plate was separated from that of the model using Brainlab software. Six points indicating the positions of the titanium screws were marked to adjust the position of the remaining mandible during surgery (Fig 4). The navigation data were exported into a universal serial bus drive, which was then connected to the terminal working station during surgery.