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Use of a three-dimensional custom-made porous titanium prosthesis for mandibular body reconstruction

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Abstract. The progress made in recent years in the field of head and neck bone reconstruction is directly related to technological advancements made in computer-aided design and manufacturing (CAD/CAM) and three-dimensional printing in particular. Today these technologies are mainly used in mandibular reconstruction to manufacture aids for harvesting and shaping bone flaps. However problems remain when addressing patients with a contraindication to microsurgery who need extensive bone reconstruction. For these patients who cannot benefit from vascularized bone grafts, surgeons have to find alternative solutions aimed at maintaining best function and aesthetics. The goal of this article is to present an original method for mandibular body replacement with custom-made porous titanium prostheses in patients ineligible for a bone free flap. This solution has been used for two patients with an intraoral approach, resulting in no visible scars, with simple postoperative care of a short duration. This innovative solution represents an additional option for the treatment of complex mandibular reconstructions.

Key words: porous titanium; mandibular reconstruction; mandible prosthesis; 3D prosthesis; facial reconstruction.

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The gold standard in the restoration of extensive mandibular defects remains the use of bone free flaps. The main flaps used are the iliac crest, scapula, and/or fibula flap, depending on the indication, habits, and patient[1]. This fibula donor site is commonly preferred for the quality and quantity of available bone, but the pedicle may more frequently be affected by atherosclerosis, which can limit its use[2,3].

Various techniques are proposed in the literature for patients showing contraindications to mandibular reconstruction by free flap. Such contraindications include stenosis or a lack of good quality cervical vessels, stenosis of the fibula flap pedicle, lupus anticoagulants, the patient's general condition incompatible with extended surgery, etc. Among the techniques proposed, the reference method remains the pedicled flap together with a titanium megaplate[4]. This solution provides the filling tissue needed and some support, although minimal, from the megaplate. However, it presents various limitations, with complications in postoperative care from both a functional and aesthetic standpoint[5]. Indeed, megaplate breakages or exposure, problems with articulation, and major aesthetic sequelae are some of the difficulties encountered in such patients postoperatively.

To address this problem, which is common in all departments performing maxillofacial reconstruction, it was decided to restore the defects in two patients present-

ing contraindications to mandibular reconstruction by bone free flap with a porous titanium custom-made prosthesis (Materialise, Châtillon, France). The design principles for this type of prosthesis, the surgical technique used, and the postoperative follow-up of these two patients are presented here. The specifications of this method and possible uses of porous titanium prostheses are discussed.

Materials and methods

Patients

Patients offered this treatment option were examined by a multidisciplinary team, who approved their medical management. Two patients needing a reconstruction of the mandibular body, but for whom a bone free flap was contraindicated, were treated.

Patient 1 was an 82-year-old female patient with painful and disabling mandibular corpus ameloblastoma. In the face of cervical vascular contraindications, as well as a heart condition ruling out extended bone free flap surgery, the multidisciplinary committee rejected the use of a bone free flap in this patient.

Patient 2 was a 56-year-old male patient with a history of a squamous cell carcinoma of the right floor of the mouth who was treated surgically with a local flap and postoperative radiotherapy. The patient developed a pathological fracture of the mandible secondary to osteoradionecrosis (Fig. 1). With 2 years remaining before the completion of radiation therapy, it was still painful and the patient was unable to feed himself. This patient presented major stenosis of the carotid axis and atherosclerosis of the lower limbs. The multidisciplinary committee rejected the use of a bone free flap in this patient.

Planning

The acquisition of a three-dimensional (3D) model of the facial bones requires a series of thin axial computed tomography sections, with a slice thickness of 0.4 mm to 0.7 mm. Images of these axial sections in DICOM format are imported into Mimics Medical 18.0 software (Materialise, Leuven, Belgium).

The segmentation phase involves defining and isolating the 3D objects of interest in the scan data (bone tissues, soft tissues, teeth, nerves, osteosynthesis materials, etc.). In this way, 3D objects corresponding to the reconstruction area of interest are obtained. The planning phase is then conducted: the surgeon and the engineer define the possible resection and the overall shape and characteristics of the custom-made implant. During this stage, many clinical and technical parameters are discussed, including the surgical access, position of the implant fixation screws, and the global shape of the implant and its projection, depending on the elasticity of the soft tissues. The prosthesis and possible cutting guides are then designed using the 3-matic software (Materialise, Leuven, Belgium) according to the surgeon recommendations and the technical specifications determined previously (Fig. 1).

Once the design has been validated by the surgeon, the implant is manufactured based on a technique known as 'selective laser melting', which is the selective fusion of titanium powder by a laser beam (Materialise, Châtillon, France). This is an additive 3D printing process (layer-by-layer printing) that allows the implants to be produced from the associated design files. The prostheses used in this work were made of porous grade 2 titanium; they had a 3D internal structure, with pores of typical dimensions varying between 860 μm and 1500 μm and a porosity rate of 53%. The typical thickness of the fixation wings was 1 mm.

In view of the condition of patient 2, it was decided to make an implant with a height lower than the native mandible so that there would be sufficient soft tissue to cover the implant without the need for a local flap. For this patient, the implant was designed to allow the possible placement of dental implants at the same time.

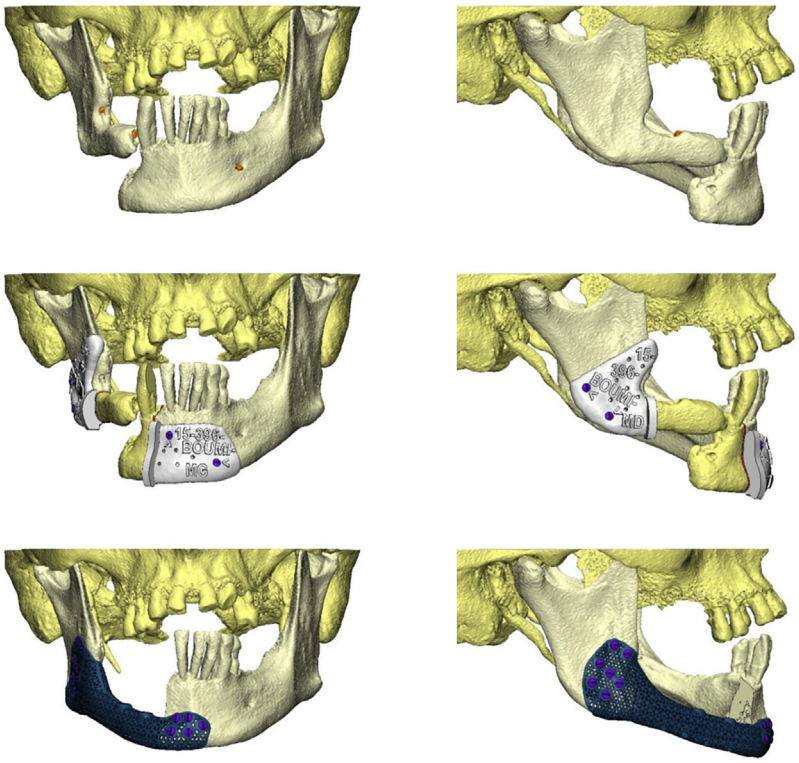

Fig. 1. 3D simulation for the design of the cutting guides and the custom implant in porous titanium.

Surgical technique

The surgical technique was the same for both patients and was performed under general anaesthesia and nasotracheal intubation. The surgical approach was intraoral with a vestibular surgical access (Fig. 2). There was no need to resect the soft tissues in either case. The cutting guides were positioned and fixed in the correct place with screws. The osteotomies and the pre-drilling holes were performed at the same time. Thus, the implant was positioned using the same intraoral access, and the fixation was simple by screwing through the pre-drilled holes. The surgical access was closed directly, without a local flap and with the placement of two drains (one below and one above the implant) to avoid the formation of a postoperative collection. For patient 1, antibiotic prophylaxis was provided for 48 h. For patient 2, who had