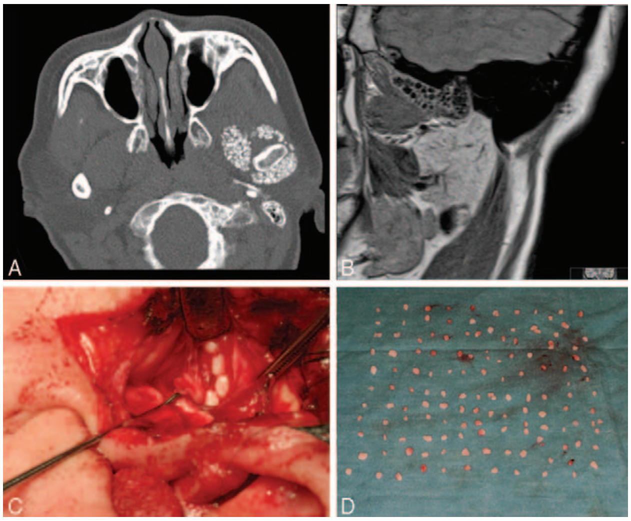

FIGURE 1. (A) Computed tomography of the TMJ revealed multiple small calcified structures around the neck of the left mandibule. (B) Magnetic resonance imaging slide of the left TMJ revealed an expanded joint with multiple calcified lesions. (C) Open surgery was carried out in which the superior joint space was opened. (D) Multiple calcified round structures ranging between 1 and 5 mm in diameter were evacuated from the left TMJ. TMJ, temporomandibular joint.

(Fig. 1A). Magnetic resonance imaging was performed and showed an expanded joint with multiple calcified lesions within (Fig. 1B).

Open surgery was carried out in which the superior joint space was opened (Fig. 1C). Multiple calcified round structures ranging between 1 and 5 mm in diameter were evacuated (Fig. 1D).

One day after surgery, the patient was discharged from hospital. Two weeks postsurgery, the patient remained symptom free. Computed tomography examination revealed a small residue of chondromatosis medial of the TMJ.

Synovial chondromatosis of the TMJ is a rare disease, women are more affected than men (2.5:1). It mainly occurs on the right site. Despite the benign nature of the disease, it may become a chronic progressive condition that normally does not undergo spontaneous regression, in which patients' quality of life can be markedly impaired. In some patients, no radiographic changes are evident in OPG images so when a chondromatosis is suspected computer tomography or magnetic resonance imaging are the diagnostic tools of preference. Despite the recently described interventional radiology and arthroscopy techniques to treat a synovial chondromatosis,[4] open TMJ surgery remains the therapy of choice in which removal of all involved synovium, and loose bodies are required for adequate treatment.[5]

Although rare, incomplete surgical removal of the loose bodies can lead to recurrence and even malign transformation can occur.[2]

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Virtual Surgery Planning and Three-Dimensional Printing Template to Customize Bone Graft Toward Implant Insertion

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Abstract: Premaxillary tooth loss and bone deficiency or atrophy often occur in facial trauma. Onlay bone graft and implants have so far been the best means of restoring function and esthetic appearance. Void space between the graft and the jaw bone, over projection and mucosal trauma can cause mucosal dehiscence, bone exposure, or resorption and can compromise implant survival. Virtual surgical planning using 3-dimensional printing technology has improved the efficiency of craniofacial surgery. The drawbacks of this technology are its cost and time-consuming preparation. However, the democratization of high-performance 3-dimensional printing and open-source software have enabled surgeons to master the procedure. The authors applied this innovative technology to customize bone graft for insertion of a premaxillary implant. It enabled us to custom-make the bone graft on the template and to perfectly embed the graft in the gap with a reduce operating time and a good osteointegration.

Key Words: 3-Dimensional printing, bone graft, implant, surgical model

Premaxillary tooth loss and bone deficiency or atrophy are often experienced in facial trauma. This area is complex to rebuild owing to the direct pressures from the tongue, upper lip, and inextensive mucosa.[1] To date, onlay bone graft and implants have proved to be the best means of restoring function and esthetic appearance with an implant survival rate higher than 96%.[2] Two conditions must be met to achieve the best osteointegration. First, congruence and immobilization between the graft and the receiving

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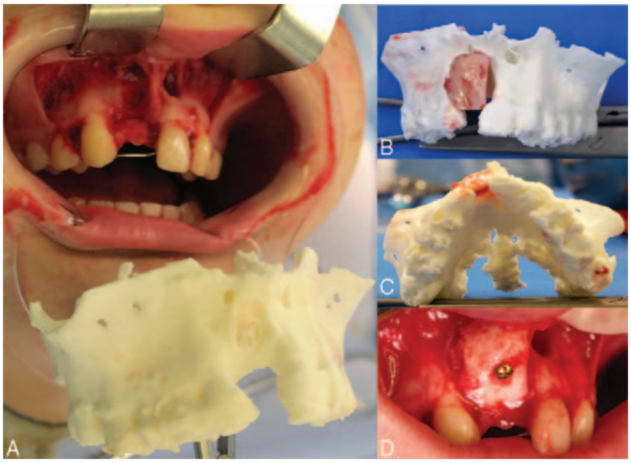

FIGURE 1. (A) During surgery, after exposure of the gap to be filled in the premaxillary bone, comparison of the patient's anatomy and the 3-dimensional printing template shows an exact match. (B) The bone piece just after harvesting in the symphysis is progressively drilled until it perfectly matches the 3-dimensional printing template (frontal view). (C) The position of the bone graft from an axial view can also be controlled to ensure there is no over projection and that the bone defect is perfectly filled. (D) At the end of surgery, the bone graft is perfectly embedded in the gap with no over projection providing good stability and a tight but-low tension suture.

site must be as perfect as possible.[3–5] Second, scars on the mucosa must be limited and sutured tight. To optimize bone graft congruence, limit scars, and reduce time-consuming during surgery, we developed a model in which the bone graft is shaped during surgery directly on a 3-dimensional printed template.

CLINICAL REPORT

A 18-year-old girl, who had lost teeth 11 and 12 secondary to an alveolar bone fracture 1 year before after a horse's hoof kick, presented to our department for implants. The upper lip and the mucous membrane had many scar tissue. To ensure the best possible outcomes for the patient, it was decided to use virtual surgical planning with 3-dimensional printing technology. The Digital Imaging and Communications in Medicine images of the patient were imported into 3D Slicer (3D Slicer 4.0; Surgical Planning Laboratory, Harvard University, Boston, MA) for the segmentation and 3-dimensional modeling. A stereolithographic (STL) file was generated and imported into the Autodesk Meshmixer software (Autodesk Inc, Mill Valley, CA), where the imperfections mesh were removed and support added. Then the STL model was sent to our "in office" 3-dimensional printer a MakerBot Replicator (MakerBot Industries, Brooklyn, NY), which created the model using a bioplastic filament composed of polylactic acid (PLA). Once manufactured, the model was sterilized with a low-temperature (18–35°C) sterilization technology called Sterrad (Advanced Sterilization Products, Irvine, CA) to be taken to operation room. Between the reality and the model, there was an exact match (Fig. 1A). During surgery, the bone defect was measured on the model and the smallest piece of bone was harvest on the donor site (Fig. 1B). At the same time, the premaxillary bone was exposed and the graft customized until it perfectly fills the gap in the 3-dimensional model (Fig. 1C). Once the bone graft was adapted, it was embedded in the patient's jawbone and stabilized by screws (Fig. 1D). Finally, the soft tissues are folded down and sutured tightly without tension. At 7 and 15 days healing was satisfying, any mucosa dehiscence or bone infection or exposure was recorded.

DISCUSSION

Bone with membranous origin, such as from the mandible and calvaria, is preferentially used because it produces a higher bone density and resorbs less.[2,3] For small volume harvesting, intraoral bone is recommended.[6,7] For small volume harvesting, intraoral bone is recommended.[7] There have been reports of postsurgical complications, such as chin sensitivity and numbness of the lower teeth or vestibular area at the symphysis harvesting site.[8] Mucosal dehiscence, exposure of bone graft, complete failure of block graft, and neurosensory impairment at the grafted site have been documented but with an implant survival rate higher than 96%, similar to that of implants in native bone.[2] To obtain osteointegration and bone formation, some build a framework, fill it with shaved bone and secure everything with multiple mini screws to obtain the best congruence between bone graft and maxillary.[3] Others used autogenous bone graft by using human recombinant growth factor as platelet-derived growth factor or as bone morphogenetic protein (BMP 2 and BMP 7) to enhance bone formation; however, the high cost of this approach and the lack of large studies currently limit its application.[9,10] To date, bone graft stability in the maxillary seems to be the key point to obtain the highest rate of implant survival. To meet this challenge, we believe that virtual surgical planning with 3-dimensional printing technology seems to be a valuable option. The main drawbacks of this technology are the cost and long assembly time because the preparation is outsourced to partner companies. However, the democratization of high-performance 3-dimensional printing and open-source software has enabled surgeons to become proficient in the technique.[11] The cost of the bioplastic filament coil as acrylonitrile butadiene styrene or PLA to perform the model is <2 euros. Production time, including modeling and printing, is on average 10 to 14 hours. During surgery, the bone defect is measured on the model to enable the surgeon to harvest the smallest piece of bone. Consequently, the mandibular incision is smaller and the risk of stretching or traumatizing the inferior alveolar nerve at emergence is reduced. At the same time, the premaxillary bone is exposed and the piece of bone customized until it perfectly fills the gap in the 3-dimensional model. Consequently, time consuming is less and the maxillary incision is reduced because the 3-dimensional model was used to shape the bone graft exactly to the required size. Once the bone graft is adapted, it is embedded in the patient's jawbone and owing to its good fit fewer screws are needed to stabilize it. Finally, when the soft tissues are folded down as they were less traumatize and the incision shorter, it is easier to obtain tight suture but with few tension. The ultimate goal would be the use of a subperiosteal tunnel approach to slide the bone graft in the maxillary defect and have the smallest suture. In light of this result, a clinical study is now in progress.

Independently planned virtual surgery using a self-made 3-dimensional printing template was a successful risk-free procedure. This approach reduces costs and surgical delay. It improves surgical precision, reduces operating time and the number of screws to fix the graft. In addition, using 3-dimensional surgical models and planning surgery with students is a valuable educational experience.

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Coronal Split Corpus Osteotomy of the Mandible: A Modified Visor Osteotomy Technique for Bone Volume Enhancement

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Abstract: The bony augmentation of severely atrophied mandible is generally required for the purposes of prosthetic rehabilitations. The treatment strategies have been well defined in the literature ranging from osteotomy techniques to distraction osteogenesis. Visor osteotomy is the milestone of the reconstructive surgery for the atrophied mandible which has received some modifications. In the present study, the authors describe a new modification of visor osteotomy in which a complete coronal split osteotomy down to the inferior border at the mental region has been performed. The main advantage of this modification is to preserve the lingual cortex from the inferior border of the mandible up to the alveolar region without disturbance of the suprahyoid muscle attachments. The procedure is thought to be a "highly sensitive" one and undesired fractures may occur during splitting of the bony segments.

Key Words: Mandibular augmentation, preprosthetic rehabilitation, visor osteotomy

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A favorable 3-dimensional bone volume of mandibular ridge must exist for implant placement to fullfill the prosthodontic and esthetic criteria of rehabilitation. Several surgical procedures have been advocated for bone augmentation of the atrophic mandible.[1,2] Current techniques include onlay bone grafts, ridge splitting, subperiosteal membrane-guided regeneration, alveolar osteotomies/sandwich grafts, interpositional grafts, mandibular inferior border grafting, distraction osteogenesis, and the use of growth factors.[3,4]

One important alternative in the reconstruction of atrophic mandible is preprosthetic reconstructive surgery using autogenous bone graft prior to the placement of osseointegrated dental implants.[5]

The visor osteotomy, first described in 1975 by Harle, was initially performed for the reconstruction of severely resorbed edentulous mandibles.[6] The procedure involved a parasagittal osteotomy of the mandible from body to body, with the lingual plate of bone raised superiorly and pedicled to the lingual soft tissue.[7] The classic osteotomy was further modified by Stoelinga et al[8,9] to include a horizontal osteotomy in the anterior mandible with autogenous bone placed within the interpositional gap. Peterson[10] described a similar technique to the anterior mandible and suggested a horizontal osteotomy extending between mental foramens, allowing the insertion of autogenous bone blocks between segments.

In the present article, the authors propose a combination of previously described techniques of Harle and Stoelinga in the mental region. The authors have focused on 3-dimensional mandibular osseous volume enhancement for preprosthetic purposes prior to dental implant installations and for denture applications as well.

METHODS

Ten patients (7 women, 3 men) with severely atrophied mandibles underwent augmentation surgery with autogenous bone harvested from anterior ilium. Panoramic radiographs and cone beam computed tomography scans were used preoperatively to assess bone height and shape. The age of the patients ranged from 30 to 56-year old. Informed consent was obtained from all patients prior to surgery. All operations were performed under general anesthesia via nasotracheal intubation. Cephazoline sodium was administered before surgery. The patients were treated with the modified osteotomy technique as follows.

A mucosal incision at the cheek and labial sides of vestibular fornix was performed from 1 retromolar region to contralateral side (Fig. 1A). After elevation of the mucosal flap an incision on the periosteum over the alveolar crest was initiated and periosteal flap was raised to reach to the bone (Fig. 1B). Mucosal and periosteal dissections were continued in all directions to identify the mental nerves. The crestal osteotomy was initiated close to the lingual side at the premolar and molar region beginning from the alveolar crest to the mylohyoid ridge (Fig. 2A and B). Further at the anterior aspect of the mandibular body, 2 parallel vertical osteotomies just mesial to the mental foramen were performed at the lateral cortex without touching the lingual cortex and these vertical osteotomies