The Minimally Invasive-Guided Genioplasty Technique using Piezosurgery and 3D printed surgical guide: An innovative technique

Olivier Oth, Maria Fernanda Orellana, Régine Glineur
Department of Oral and Maxillofacial Surgery, Hospital Erasme, Université Libre de Bruxelles, 1070 Brussels, Belgium

Abstract

Introduction: Mental nerve injuries with neurosensory deficits, asymmetries, and intra-operative bleeding are the main immediate complications of genioplasty. Following a recent systematic review, three-dimensional (3D)-printed cutting guide could improve the predictability and accuracy of this surgical technique avoiding postoperative asymmetries. Furthermore, anatomical structures in the surgical area (mental nerve and teeth roots) are better protected, reducing the morbidity and providing safer results. Ultrasonic piezoelectric osteotomy allows by its intrinsic characteristics, a selective cut of mineralized structure with a lower risk of vascular and nervous damage (microvibrations), intra-operative precision (thin cutting scalpel and no macro-vibrations), and blood-free site (cavitation effect). The aim of this article is to present a new minimally invasive technique: the minimally invasive-guided genioplasty technique (aka MIGG technique). This technique combines the advantages of piezosurgery and of a space-saving 3D-printed cutting guide, requiring open-source programs and an affordable 3D printing technology. **Materials and Methods:** All the steps of this technique are described: preoperative surgical planning (CT scanner, segmentation with 3D slicer®, and design of the cutting guide with Blender®) and 3D printing of the guide and sterilization of it. The surgical procedure is presented in detail as well as the postoperative care. **Conclusion:** The MIGG technique offers, according to the authors, a better postoperative recuperation, a reduction in operating time, less complications, and protection of the anatomical structures (mental nerve, teeth, lingual soft tissue and vessels). This minimally invasive technique for genioplasty is a promising approach to perform a chin osteotomy.

Keywords: Computer-assisted, genioplasty, printing, three-dimensional, surgery

Introduction

Genioplasty is a surgical technique to correct a chin deformity. It consists of an osteotomy of the inferior border of the mandible, allowing movement of the chin in three dimensions, and positioning it in its new desired position.[1] To obtain the best results in genioplasty, it is essential to make an optimal surgical plan. The osteotomy location and the movement of the bony segment directly impact the surgical outcome. Conventionally, genioplasty is performed based on surgeon's intraoperative assessment only.[2] The technique was first described by Trauner and Obwegeser,[3] and several adjustments have been described, all with the aim to improve esthetical outcome, reduce complications and recovery time, and simplify the surgical procedure.

Mental nerve injuries with neurosensory deficits, asymmetries, and intra-operative bleeding are the main immediate complications of genioplasty.[4]

A recent systematic review showed that three-dimensional (3D)-printed cutting guide could improve the predictability and accuracy of this surgical technique, which helps to avoid

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Address for correspondence: Dr. Olivier Oth, Department of Oral and Maxillofacial Surgery, Hospital Erasme, Université Libre de Bruxelles, Route de Lennik 808, 1070 Brussels, Belgium. E-mail: oth.olivier@gmail.com

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postoperative asymmetries.[5] It also protects anatomical structures in the environment of the surgery (mental nerve and teeth roots) reducing the morbidity and providing safer results.

Ultrasonic piezoelectric osteotomy allows by its intrinsic characteristics, a selective cut of mineralized structure with a lower risk of vascular and nervous damage (microvibrations), intraoperative precision (thin cutting scalpel and no macrovibrations), and blood-free site (cavitation effect).[6]

There were three main goals with this work:

1. To develop a minimally invasive technique thanks to the advantages of piezosurgery and to a design of a space-saving 3D-printed cutting guide. To reduce the postoperative complications, the operating time, and the postoperative recovery period
2. To increase the precision of the surgical procedure by a precise preoperative simulation and the use of a 3D-printed cutting guide
3. To develop a technique using the latest technology, but using open-source programs and affordable 3D printing technology.

Technique

Preoperative surgical planning

A computed tomography (CT) scanner of the maxillo-facial area is done preoperatively using a high-resolution protocol with the following acquisition settings; system: SOMATOM Emotion 16, tube current: 130 mAs, grayscale: 16 bits, potential: 130 kV, scan time 35 s, and voxel size: 0.01 mm^3 (0.24 mm × 0.24 mm × 0.20 mm). DICOM images from these scanners are extracted.

Segmentation of those DICOM images is then done with an open-source software: 3D Slicer®. Segmentation consists of the selection of the area of interest and the creation of different STL files (the file extension used in 3D printing) for each anatomical structure [Figure 1]. The mandible and the inferior alveolar nerve are thus segmented, and two STL files are created [Figures 2 and 3].

We then used the open-source software Blender® to create the 3D printing cutting guide. Blender® software is used in 3D animation to modeling, rigging, simulating, rendering, compositing, and motion tracking, even video editing and game creation. With this software, you can easily create different 3D volumes and adapt to the osseous relief of the mandible with a Boolean function. Following our experiment protocol, the cutting guide should be created with a minimum height of 8 mm to find a perfect fitting on the mandibular osseous surface and with a maximal length of 25 mm to prevent large incision to place the guide. Two holes of 2.4 mm are made for the future fixation screws.

Three-dimensional printing of the cutting guide

The guide is printed with a Replicator+® 3D printer (from MakerBot Industries®, New York, USA) operating on the principle of additive technology Fused Deposit Modeling. The parameters selected for the 3D printing are layer thickness (mm): 0.3 mm; nozzle diameter (mm): 0.5 mm; part bed temperature (°C): no bed thus heated room temperature: (15–25); extruder head speed: 150 mm/s; and temperature of extruder (°C): 215.

The biomaterial used is polyethylene terephthalate glycol aka PETG (Taulman® 3D guideline® filament 1.75 mm). PETG is the best material because of its proven biocompatibility in accordance with industrial standard, its European ISO10993 certification and its American Food and Drug Administration-approval.

To sterilize our guides, we used a STERRAD® 100S (Johnson and Johnson® company), a low-temperature hydrogen peroxide sterilizer, with one cycle of 50 min using a temperature lower than 55°C. This low-temperature sterilization technique prevents any deformation of the guide during sterilization. Indeed, PETG is sensitive to conventional thermal steam sterilization techniques, aka autoclave (temperature of 121 or 134°C thus above the melting point of this material and with high rate of humidity). A recent study was done in our department and concluded that the morphological deformations induced by the hydrogen peroxide sterilization are infra-millimetric and totally compatible with a surgical use.

Surgical intervention

The intervention is done under general anesthesia with nasotracheal intubation and the patient in a supine position. The facial skin is disinfected using cutaneous iso-betadine® (polyvidone iodine 10% solution). The patient is draped, and the oral cavity is disinfected and rinsed with buccal iso-betadine® (polyvidone iodine 1% solution). Local anesthetic is injected in the mental region through the vestibulum (xylocaine® 1% lidocaine HCl injection solution 10 mg/ml + adrenaline 1/100,000). The lower lip mucosa is exposed by the assistants using two small retractors. A short "V" incision is made inferior to the mucogingival junction (with the tip of the V directed forward). The superficial layer of the muscle orbicularis oris is dissected in the direction of the teeth. Orbicularis Oris is then incised 3 cm long approximately 10 mm lower than the gingival sulcus with direct contact to the bone through the periosteum. Bilateral subperiosteal dissection is performed under the mental muscles on a sufficient area to place the 3D-printed cutting guide. The guide with the recommended measurements (minimal height of 8 mm and maximum length of 25 mm) find manually a perfect fit with the mandibular external osseous surface avoiding the necessity of making an occlusal landmark. The guide is stabilized with 2 osteosynthesis screws [Figure 4]. The lower border of the guide corresponds to the osteotomy line. The subperiosteal dissection is continued laterally to lower border of the guide [Figure 5]. Visualization of the mental foramen and nerve is unnecessary because the information about the position of those anatomical structures is contained in the guide. Indeed, the guide is designed preoperatively to pass inferiorly from its two anatomical structures with a safety

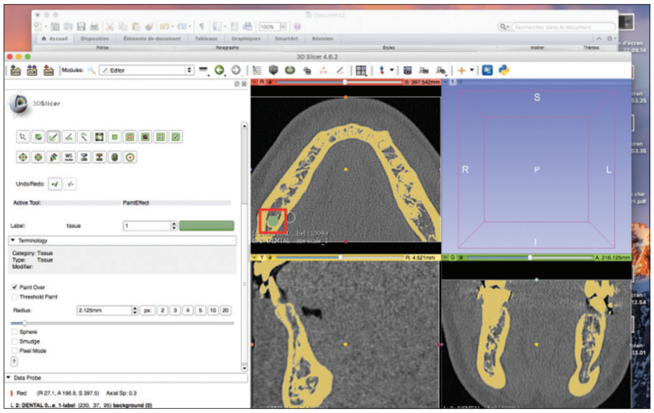

Figure 1: Segmentation of the inferior alveolar nerve and mandibular bone

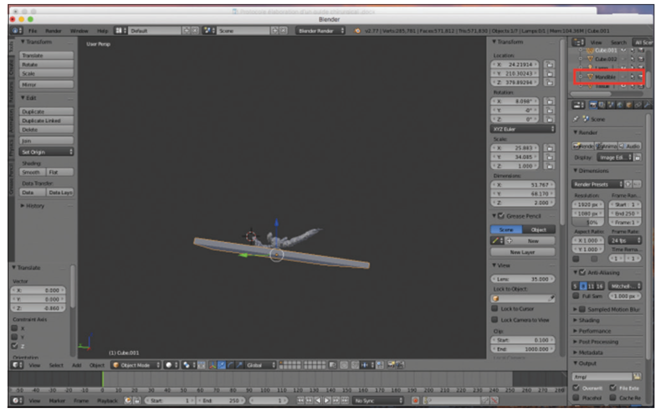

Figure 2: Creation of an STL-file of the nerve and evaluation of the cutting plane

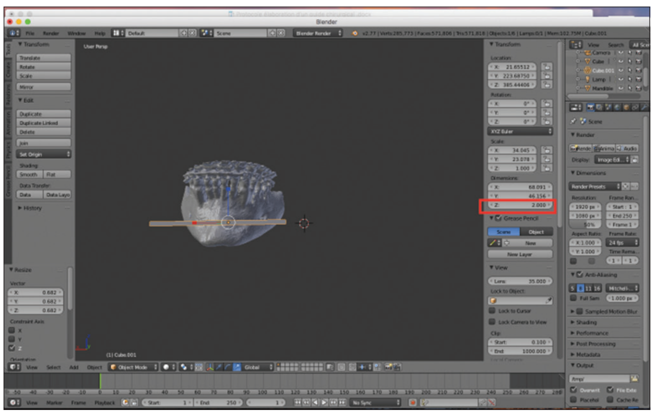

Figure 3: Creation of an STL-file of the mandible and evaluation of the cutting plane

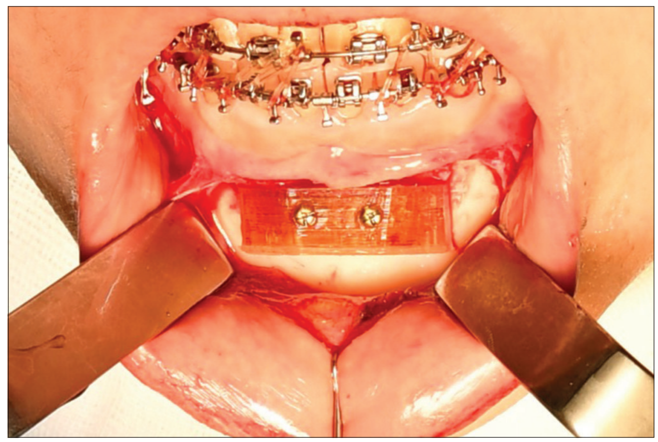

Figure 4: Cutting guide in place and fixed with two monocortical screws. The inferior border of it represents the cutting plane. The superior border is parallel to the inferior border at a minimum distance of 8 mm

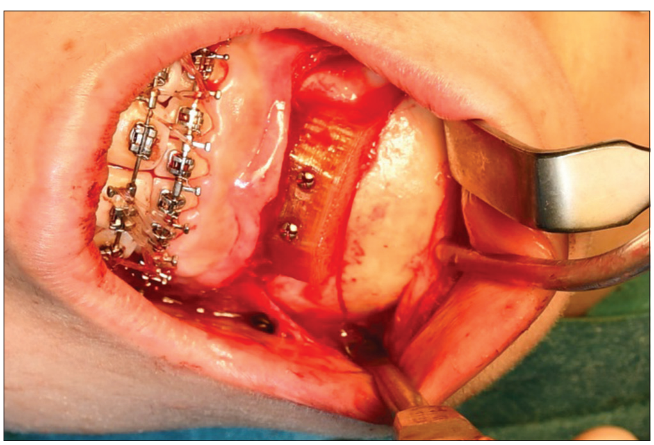

Figure 5: Osteotomy line. Dissection of the mental nerve is not needed

Figure 6: Fixation of the genial segment is performed using a chin plate and self-taping screws

distance and particularly under the intraosseous curve that makes the inferior alveolar nerve before exiting the mandible through the mental foramen [Figure 2].

The osteotomy starts by making two marks in the sagittal plan above and below the osteotomy line with a Lindemann drill. The osteotomy is done using piezoelectric surgery (Piezosurgery® Mectron® with inserts MT1-10 and MT1-20), allowing less damaged to the lingual soft tissues. A second osteotomy line under and parallel to the first one is done when an impaction is needed. Osteotomy can be finalized, if necessary, with a chisel. The guide and its two fixation screws are removed. The mobility of the chin segment is checked and positioned according to the functional, esthetical, and physiologic parameters. Fixation of the genioglossus muscle is performed when necessary with nonabsorbable sutures ethilon® 2-0 (Ethicon®). Fixation of the genial segment is performed using a STRYKER® chin plate and self-taping screws [Figure 6]. After intraoperative evaluation of the chin shape, the wound is closed into two layers: reapproximation of the periosteal incision is performed with 3-0 Vicryl® suture (Ethicon®), and the mucosa is closed using a 4-0 Vicryl Rapide® absorbable suture (Ethicon®).

Postoperative procedure

Postoperative medication consists of painkillers, anti-inflammatory medications, and an antiseptic mouthwash. The patient is discharged after one night in the hospital.

Discussion

Richard *et al*. distinguished peroperative complications (atypical osteotomy, hemorrhage, soft-tissue damage, and injury to the mental nerve) and postoperative complications (neurosensory deficits, hematoma, infection, secondary displacement, bone necrosis, mental ptosis, defective ossification, dental lesions, periodontal lesions, and irregular mandibular contours).[4]

Little has been published over minimally invasive techniques in genioplasty. One technical note by Nadjmi *et al*. uses a vertical incision to minimize the functional recovery time.[7] 3D printing technology is being used more often in orthognathic surgery, and a recent systematic review studied its impact on genioplasty. Following Bertossi, piezoelectric cutting device, compared with traditional rotating instruments, enables to reduce or avoid many complications (especially immediate and early ones) associated with this surgical procedure. Combining 3D printing and piezosurgery is therefore obvious to further reduce complications and constitutes the main advantage of this technique. We believe that many complications can be diminished with this technique, excluding infection and secondary bone issues which are inherent risks in genioplasty.

From January 2016 on, we started to perform genioplasties (with or without a combination of Le Fort I and/or BSSO) according to this minimally invasive-guided genioplasty technique (MIGG technique). We have improved the protocol and the design of the cutting guides to achieving the results that we have today: those ones showed better postoperative recuperation, reduction in operating time, less complications, and better confidence in this technique by the surgeon to protect the anatomical structures (mental nerve, teeth, lingual soft tissue, and vessels). We think that this minimally invasive technique for genioplasty is a promising approach to perform a chin osteotomy. A retrospective study has been started in our department to objectify and quantify these results.

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Conflicts of interest

There are no conflicts of interest.

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