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In-and-out Technique: An In-house Efficient Predictive Hole Fabrication Workflow

Javier Asensio-Salazar, MD, MSc*
Alvaro Rivero Calle, MD*
Eduardo Olavarría Montes, MD*
Alejandro Delgado Fernández, MD†
Ignacio Zubillaga Rodríguez, MD, PhD*
Ramon Gutiérrez Díaz, MD*
Gregorio Sánchez Aniceto, MD, PhD*

Summary: Virtual surgical planning (VSP) and three-dimensional (3D) printing can increase precision and reduce surgical time in craniofacial reconstruction. However, the elevated cost and manufacturing time of outsourced workflows is increasing the development of in-house solutions. One of the main challenges in in-house workflows is to create cutting guides that hold plate position information. This is due to the fact that hospitals usually lack the infrastructure required to design and 3D print custom-made plates. Including plate-positioning information in resection guides is especially relevant in complex reconstructions and when tumor extension limits plate placement before resection. Current in-house workflows revolve around the idea of 3D scanning the bent plate's shape and to fuse it with the VSP. The goal of this article is to share our technique to transfer plate position information to resection guides. Our protocol uses a 3D model of the reconstruction as an intermediate step to transfer the plate position of a bent stock reconstruction plate to cutting guides. Two patients who required mandibular reconstruction with fibula flap are presented to illustrate the technique. This workflow requires a 3D-printed model of the desired outcome, cutting guides, and a stock plate. Results were satisfactory in terms of cutting location and angulation, plate adaptation and condylar position. This technique allows for a simple, safe, cheap, and quick alternative to add reconstruction plate information to cutting guides. *(Plast Reconstr Surg Glob Open 2024; 12:e5702; doi: 10.1097/GOX.0000000000005702; Published online 5 April 2024.)*

INTRODUCTION

One of the main challenges in in-house workflows is to create cutting guides that hold plate position information.[1] The aim of this article is to describe an easy and novel technique to include drilling information in resection guides for stock plates.

METHODS

To illustrate this process, we present two patients diagnosed with oral cancer who underwent segmental mandibulectomy and fibula-flap mandibular reconstruction.

Our in-house protocol is performed in collaboration with the biomedical department of our institution (IQNET ES-GS-0011/2023). It requires a model of the reconstructed mandible, cutting guides, and a 2.6-mm stock reconstruction plate. Anatomical data were obtained from a lower extremity angio-computed tomography (CT), cervical-CT, and positron emission tomography-CT. Surgical resection was planned with iPlan Brainlab software, segmentation was performed with 3D-Slicer, and virtual surgical planning (VSP) with Meshmixer.

VSP and Three-dimensional Printing

VSP protocol requires the design of a three-dimensional (3D) model of the reconstructed mandible and mandible and fibula cutting guides (Fig. 1). (**See figure, Supplemental Digital Content 1**, which displays patient B VSP, **http://links.lww.com/PRSGO/D136**.) They are 3D-printed in Surgical Guide Resin (Formlabs, ISO-13485).

Resection guides are designed to work as drilling and cutting guides. To reduce the degrees of freedom and improve stability, a gonial basal extension and a joining

*From the *Department of Oral and Maxillofacial Surgery, Hospital Universitario 12 de Octubre, Madrid, Spain; and †Department of Oral and Maxillofacial Surgery, Hospital Universitario Joan XIII, Tarragona, Spain.*

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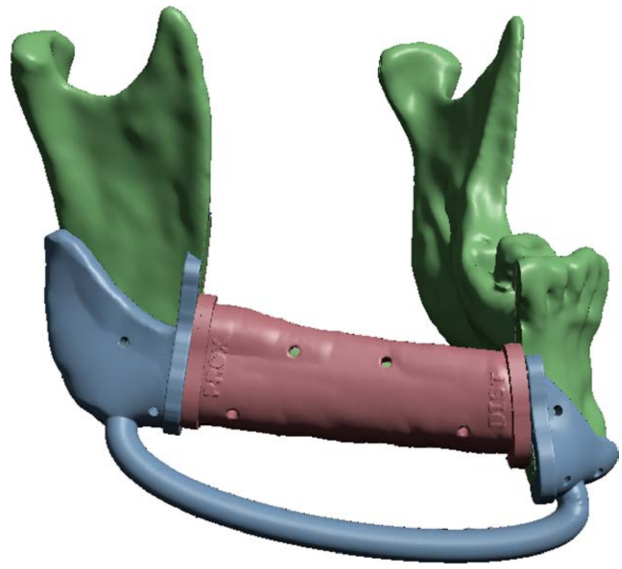

Fig. 1. VSP: Patient A: Surgical guides were designed for mandibular resection and reconstruction with a fibula free flap in both patients. Cutting guide design is shown for each patient. Mandibular cutting guides are painted blue, and fibula cutting guides are red.

tube are added. Resection limits are based on tumor extension and surgical plan.

The reconstruction plate is usually fixated with four screws. To increase plate position predictability, each side of the resection guide was extended laterally to include two to three plate holes.

General thickness of the guide was 3 mm. However, an extra 2 mm of thickness (5 mm in total) is added to the areas anticipated to include the reconstruction plate. This is intended to increase angular precision and to act as a longer drilling guide. Finally, the holes to fix the guide are

Takeaways

Question: To find a simple technique to create in-house cutting guides that include predictive holes for plate alignment.

Findings: The technique only requires a three-dimensional model, surgical guides, and a prebent plate. It only takes a few minutes without any additional cost and can deliver accurate results in complex resections and reconstructions

Meaning: This technique reduces the need to rely on biomedical companies for three-dimensional planning, speeding up the process and reducing costs. Moreover, it has the potential to be used in multiple craniofacial and orthopedic areas.

placed in the areas that were not expected to overlap with the reconstruction plate.

Plate Bending and Generation of Drilling Holes

The reconstruction plate is bent to fit the 3D model of the reconstructed mandible and locked to the mandibular model with plate-holding forceps (Fig. 2). [**See Video (online)**, which details the steps required to perform this technique successfully.]

Concentric perpendicular drills are performed in each plate hole over the mandibular model. These drills need to cross the mandibular model from buccal to lingual. The reconstruction plate is then released, and the resection guide is fixated to the mandibular model.

The drilled holes in the model are used to transfer plate position information to the resection guide. They act as a drilling guide from lingual to buccal. It is sometimes required to cut the 3D model to access these holes from the lingual area of the model. Finally, the holes for the reconstruction plate are marked in the cutting guide

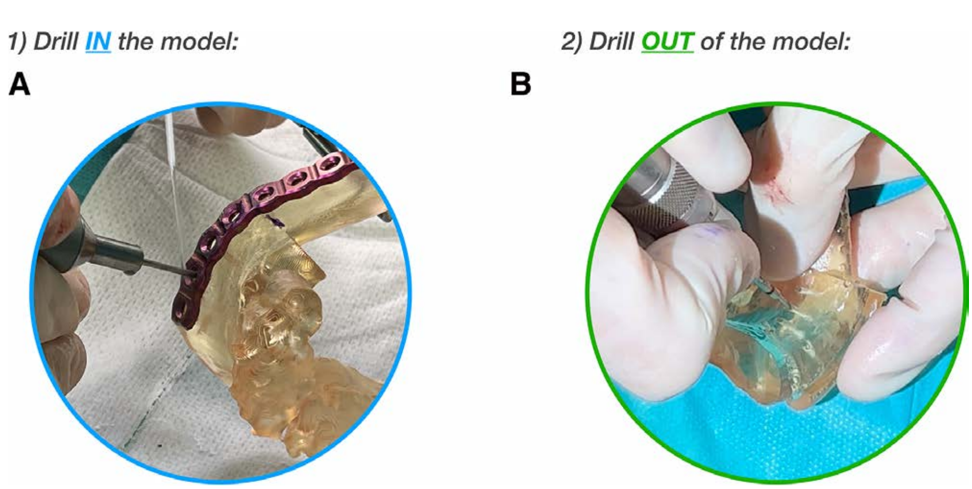

Fig. 2. In-and-out technique. A, A manually bent stock plate is securely locked in the desired position. Orthogonal concentric holes are drilled in the 3D model until reaching the other side of the phantom. B, Then, the plate is loosened, and the resection guide is locked in position. Plate position holes are drilled in the guide using the holes created in the phantom as a guide from the other side of the model.

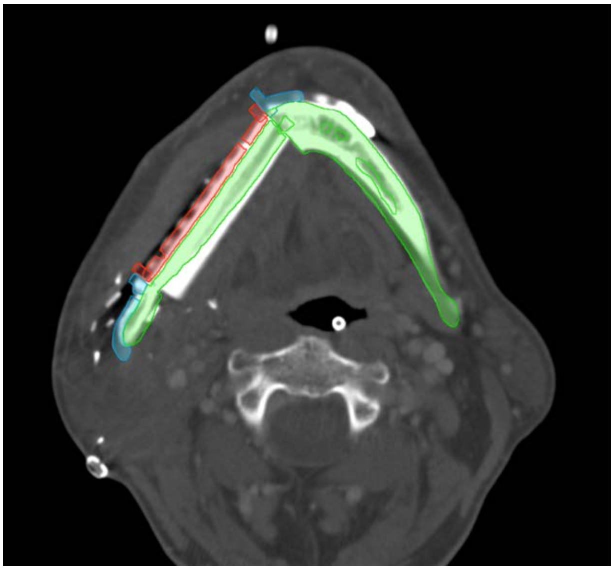

Fig. 3. Patient A postoperative control was performed with postoperative CT and preoperative planning fusion. Mandibular reconstruction is highlighted in green, mandibular resection guide in blue, and fibula guide in red. A satisfactory overlay is achieved between the reconstruction and the preoperative objective.

with a surgical pen to separate them from the holding holes. This process is repeated for the fibula guide.

RESULTS

Resection guides were transferred to the patient and secured with screws. Hole drilling and bone resection were performed.

Postoperative CT was fused with preoperative CT using the iPlan Brainlab Software. Surgical guides and reconstruction models of STL were imported for visualization. Preoperative plan STLs were positioned over the postoperative CT to compare preoperative plan and postoperative results. A high level of surgical precision was achieved with this technique regarding cutting location and angulation, plate adaptation and condylar position (Fig. 3). (**See figure, Supplemental Digital Content 2**, which displays patient B postoperative control, **http://links.lww.com/PRSGO/D137**.)

DISCUSSION AND CONCLUSIONS

Three-dimensional printing in craniofacial surgery has been traditionally outsourced to biomedical companies.[2–4] However, there is an increasing trend to create in-house protocols to reduce cost and turnover time.[5,6]

Three-dimensional-printed reconstruction plates are a good solution for complex reconstruction because (1) the plate can achieve high levels of anatomical conformation and (2) the resection guides can include information regarding plate placement.[7] Nevertheless, this requires extensive 3D planning and metal 3D printing can become quite expensive.[8]

In in-house workflows, plate adaptation can be achieved with advanced experience in plate bending. Then, the plate is usually placed over the surgical area before the osteotomies for hole drilling. However, this is a suboptimal approach because there is usually a mismatch between the original mandibular shape and the reconstructed anatomy, and sometimes, the plate cannot be properly placed before the osteotomy due to tumor extension to the buccal mandibular side. Thus, dissecting the area may compromise oncological margins. Bone fragments may need to be repositioned after the osteotomy.

To solve this problem, one of the most used in-house methods is to 3D scan a bent plate over the anatomical model and to transfer hole information to the VSP. This process requires two rounds of digital and printing work. Lengthening the workaround time and, consequently, increasing the cost.[1]

Our solution offers satisfactory results at a fraction of the cost and time of other solutions. Virtual planning is often performed by residents in 2–3 hours and STLs are printed in less than 24 hours. However, this process can also be outsourced to a biomedical engineer (working in-house or for an external company). At our institution, 1 L of Surgical Guide Resin (Formlabs, ISO-13485) can be used for at least five cases and has an official cost of around €300. Hence, this printing process is cheaper not only because it reduces the need for 3D printing titanium plates but also because it can be performed in-house. Consequently, regardless if an institution has in-house 3D printing facilities, they can benefit from the implementation of this technique because it reduces the need to print custom-made reconstruction plates.

Finally, more studies are being designed to assess its accuracy in further detail. So far, it seems to be a consistent technique once mastered. To achieve satisfactory results, surgical guides must be designed to include at least three holes of the reconstruction plate and anchors should be added to restrict its degrees of freedom. Finally, intraoperative changes in surgical plan will have similar consequences to other custom planning techniques.

Last but not least, this technique can potentially be applied in other 3D craniofacial and general orthopedic surgery workflows.

In conclusion, this technique allows for a simple, safe, cheap, and quick alternative to add reconstruction plate information to cutting guides.

Javier Asensio-Salazar, MD, MSc
Department of Oral and Maxillofacial Surgery
Hospital Universitario 12 de Octubre
Av. de Córdoba, s/n
28041 Comunidad de Madrid, Madrid, Spain
E-mail: jasensio21@gmail.com

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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Treated patients gave written consent to perform mandibular reconstruction following our 3D workflow. The development of this protocol has followed the current European and Spanish legal framework and the principles of the Declaration of Helsinki and has been monitored by our institution's direction and ethics committee.

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