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Mandible Reconstruction with 3D Printed Models

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Abstract

Background: When surgeons operate under general anesthesia, length of surgery, not only its outcome, matters. In maxillofacial surgery we can reduce the time in reconstructive surgery by using presurgical bended plates in presurgically designed 3D models.

Materials and Methods: The study measured the mean time to bend the plates preoperatively on a printed three-dimensional model and the capability of the plates to adapt well on the mandible intraoperatively in cases of mandibular reconstruction after partial resection of the mandible due to pathology, such as benign aggressive tumors.

Results and conclusion: The mean time to bend the plates preoperatively was 17 minutes, with rapid adaptation during surgery. This is important in minimizing the time that the wound is exposed to the environment and minimizes the trauma to the surrounding soft tissues. Multiple checks of the plate if bended at time of surgery can increase trauma to the surrounding soft tissues. The study supports the recommendation of the use of the preoperatively corrected and printed 3D models to prebend the plates pre-operatively. This step should be included as a routine workflow in elective cases, since it is not be possible in cases of emergency or urgency.

Keywords: 3D printed model, maxillofacial reconstruction, reconstruction plates, ameloblastoma, juvenile fibromatosis, keratocyst, osteosarcoma, vascular malformation.

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Introduction

Preoperative virtual planning is considered now essential for good practice in maxillofacial surgery. The reproducible relationship between the part that the surgeons operate on and the surrounding structures makes the treatment plan easier to achieve intraoperatively, reducing the time of operation.[1-3]

In maxillofacial surgery, a lot of time can be wasted in bending the reconstruction plate during surgery to obtain good adaptation to the resected mandible. Printed preoperative three-dimensional (3D) models aim to solve this problem by mirroring the unaffected side to replace the affected side.[4]

The aim of this study was to answer the question of whether the preoperative bending of the plate on a 3D printed model decreases surgical time.

Materials and Methods

Ten adult patients treated at the maxillofacial unit from January to July 2022 with asymmetry in the mandible by different causes, managed by

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resection and reconstruction by iliac bone graft, were studied.

Preoperative Assessment

On clinical examination, all the patients had swelling of the mandible. Preoperative screening panoramic radiograph was used for initial assessment and computed tomography (CT) scans were examined to define the nature and extent of the masses.

Preoperative Virtual Planning

The images obtained from the CT scans were analyzed and processed by the 3D Slicer software[5] for three-dimensional visualization, as an image-guided therapy. Three-dimensional models were printed to represent the mandible in diseased and disease-free forms to facilitate the preoperative bending of the reconstruction plate (Figure 1).

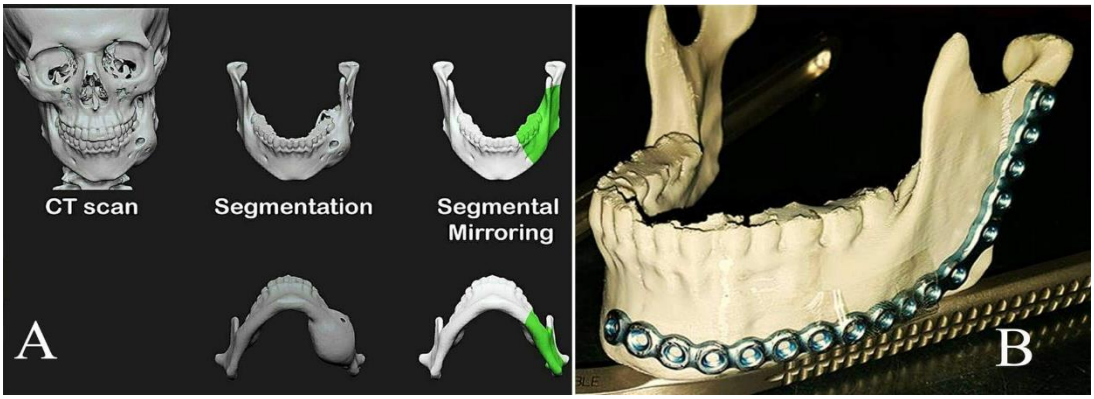

Figure 1: Preoperative virtual planning. A: CT scans analysis by software for segmental mirroring. B: Plate bending on the printed 3D model.

Surgical Procedure

Under general anesthesia, after skin preparation and draping, the preauricular with neck extension incision was performed to expose the tumor (Figure 2A). After en bloc resection of the tumor, a surgical bed was prepared to receive a bone graft from the iliac bone. The well adapted to the recipient site bone graft was then fixed with a pre-bended reconstruction plate (Figure 2B). The surgical field was then checked for any bleeding points and when needed to control them, cauterization or ligation was done, and the flap closed by layers.

Postoperative Care and Follow-Up

If there were no complications, the patients were discharged on the first postoperative day, keeping them on regular follow-up visits.

Results

The first patient (male, 13 years old) presented with facial asymmetry; left side painless swelling of the mandible, with chronic limitation of the mouth opening of six months duration. The histopathological diagnosis of the excised tumor suggested a juvenile fibromatosis.

The second patient (female, 17 years old) presented with left side painless swelling of the mandible of a one-year duration with normal mouth opening. The histopathological

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assessment diagnosed it as an ameloblastoma.

The third patient (female, 14 years old) presented with an aneurysmal bone cyst affecting the left side of the mandible. The histological examination revealed multiloculated blood-filled cystic spaces separated by cellular septae containing fibroblasts, numerous giant cells, woven bone and calcified basophilic material.

The fourth patient (male, 34 years old) presented with facial asymmetry and right side mandibular swelling, and normal mouth opening. The histological diagnosis was ameloblastoma.

The fifth patient (male, 65 years old) presented with facial asymmetry and mandibular swelling of 1-year history with limited moth opening. The histopathological examination revealed keratocyst.

The sixth patient (male, 24 years old) presented with mandibular mass at left side. The pathology revealed an osteosarcoma. In this case, bone graft was postponed, and the reconstruction plate was fixed just to support soft tissues and preserve the facial symmetry.

The seventh patient (female, 30 years old) presented with vascular malformation at the left side of the mandible involving body of mandible and part of ramus.

The eighth patient (female, 35 years old) presented with mandibular swelling at right side of mandible with facial asymmetry. The histopathological exam result was ameloblastoma.

The ninth patient (male, 45 years old) presented with left side keratocyst at right side of body of mandible extending up to ramus.

The tenth patient (male, 40 years old) presented with large mass at right side of mandible with limitation of mouth opening. The histopathology revealed an ameloblastoma.

The mean time required to bend and adapt the reconstruction plate on the presurgical model was 17 minutes. Intraoperatively, all the reconstruction plates adapted well to the mandible without any further need for bending (Figure 2B).

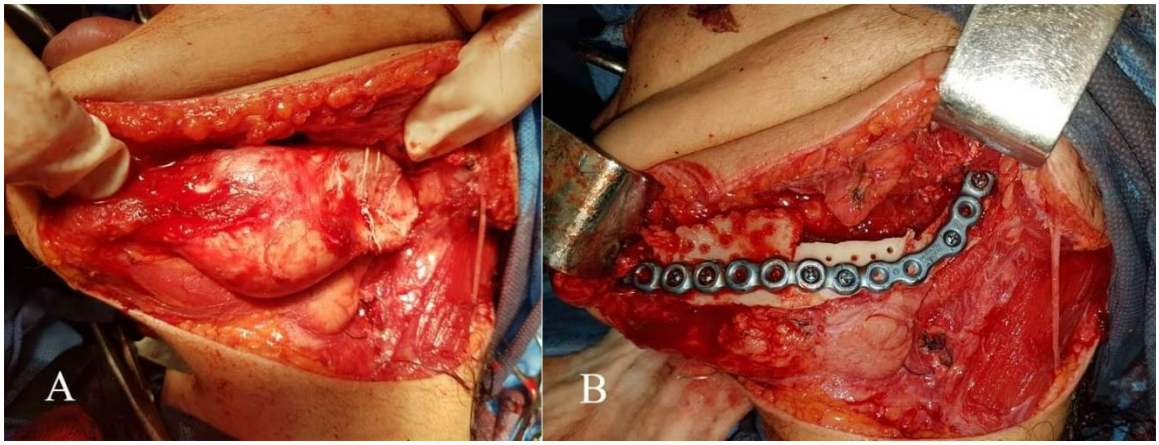

Figure 2: Intraoperative view. A: Before tumor resection. B: After plate adaptation.

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Discussion

During traditional surgery, the surgeons try to adapt the plate on the mandible with multiple slippages, inaccuracy or bulging, which may result in weakening of the plate, increased operation time and further injury to the surrounding structures. Sometimes the surgeon needs to increase the access to work comfortably, at the expense of increasing the surgical trauma.[6, 7]

Strong et al. (2013) concluded that patient-specific preformed titanium mesh was expensive and required more preoperative time[8]. Although our study reached the same results, it is important to remember that in the case of chronic benign tumors, the time before an operation can be extended a little bit for the best interest of the patients, especially those with concurrent systemic diseases who required less time under general anesthesia.

The study concluded that the 3D printed model was preferable in cases of elective surgeries when the operation could be delayed for one week at least, which is the average time to complete the production of the models. The procedure was contraindicated in cases of advanced malignancy, in which the time to start treatment is of essence. The advantages of preoperative plate bending on 3D printed models were reducing the time of the surgery, surgical access, and trauma intraoperatively. Disadvantages included that the model production accuracy depended on the efficiency of the programmer, the step is expensive, and the procedure increased the preoperative preparation time.

Acknowledgment

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Disclosure of interest

The authors declare that they have no competing interests.

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