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Case Report

Bilateral Comminuted Mandibular Fracture Caused by Gunshot Wound: Case Report Using Prototyping to Assist Surgical Planning

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Abstract: The mandible is one of the facial bones most frequently affected in maxillofacial trauma, and firearm projectiles have shown an increase in incidence among the etiological factors of these fractures. Choosing the optimal timing for surgical intervention is challenging, given the degree of bone comminution and the potential complications that these fractures can present. This paper reports the case of a 36-year-old male patient, with poorly controlled diabetes, admitted to an intensive care unit in a municipal tertiary hospital of the public network in Fortaleza, Ceará, Brazil, as a victim of multiple gunshot wounds. Facial computed tomography showed a comminuted bilateral mandibular body fracture with the presence of metallic structures compatible with projectile fragments. The treatment plan was staged in two surgical phases, beginning with surgical debridement and maxillomandibular fixation. Next, pre-molded 2.4 mm reconstruction plates were installed on a 3D-printed prototype. The patient progressed without complications or clinical complaints and remained under clinical and radiographic follow-up during the postoperative period. Thus, it can be concluded that the use of three-dimensional prototypes for pre-molding reconstruction plates is an excellent tool for achieving proper plate adaptability to the bone profile and for reducing intraoperative time.

Keywords: Mandibular fracture; Three-dimensional printing; Gunshot wound.

1. Introduction

Gunshot injuries inflicted on the maxillofacial region often affect adjacent structures of the skull and neck [1, 2]. The treatment of fractures caused by firearm projectiles (FP) is controversial. While some authors advocate closed techniques, others prefer open approaches that involve sequential steps, starting with wound debridement and maxillomandibular fixation, followed by fracture reduction and subsequent fixation. Another option is to perform all these approaches in a single surgical stage, using 2.0 mm or 2.4 mm systems or external fixators for stabilization [3, 4].

The stereolithographic process is a rapid prototyping method that allows the production of accurate three-dimensional models with acrylic resin [5]. These precise models provide a detailed view of the bone structure [6, 7], aiding in surgical planning, particularly for pre-surgical molding of 2.4 mm system plates, which reduces surgical time and consequently decreases patient exposure to general anesthesia, minimizes blood loss, and reduces wound exposure time. All of these are significant trans-surgical benefits for the patient [8, 9].

This study aims to detail the management of a patient with bilateral comminuted mandibular fracture caused by a gunshot wound and the corresponding treatment through virtual planning and three-dimensional (3D) prototyping, aiming for better patient rehabilitation and facilitating surgical management.

2. Case Report

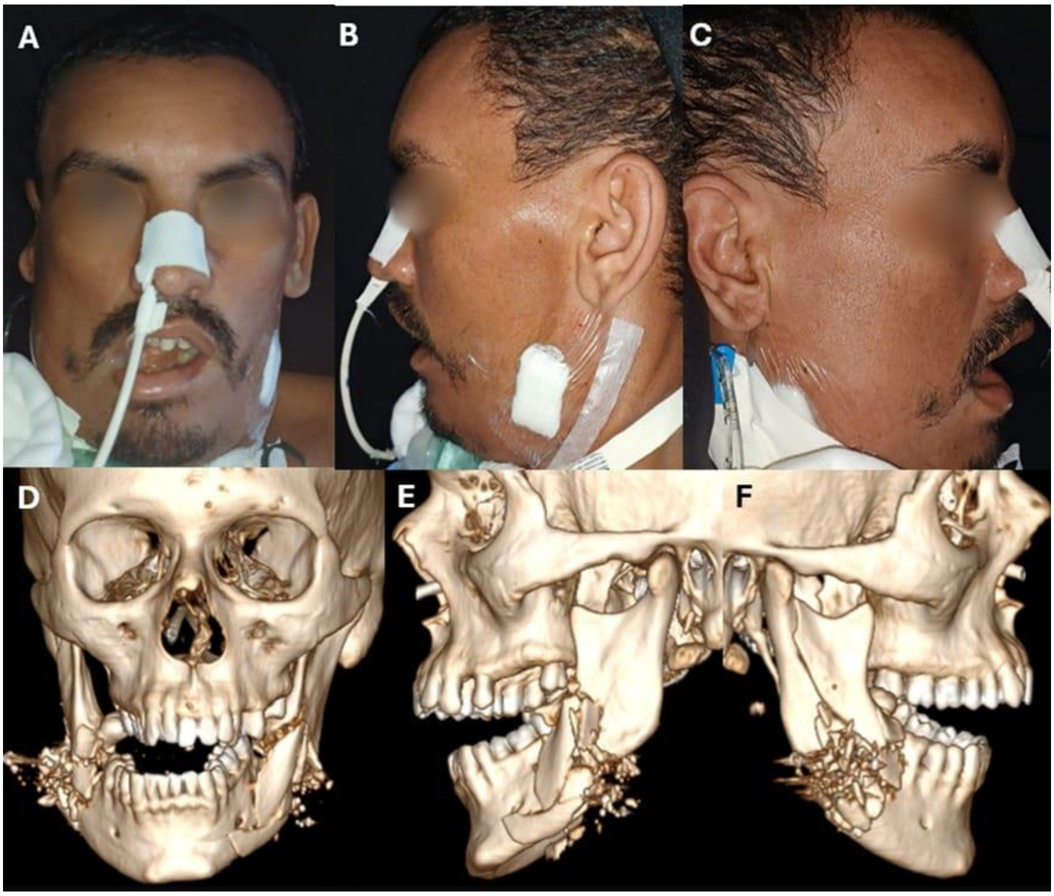
A 36-year-old male patient with poorly controlled diabetes arrived at the emergency department of the Dr. José Frota Institute Hospital, a tertiary municipal hospital in Fortaleza, Ceará, Brazil, with a history of multiple gunshot wounds (GSWs) to the face, thoraco-abdominal region, scrotum, and upper and lower limbs on the right side. The patient was assessed in the emergency department by the General Surgery, Oral and Maxillofacial Surgery, and Trauma teams. From the Oral and Maxillofacial Surgery specialty, the patient was initially monitored without immediate intervention, although he underwent emergency exploratory laparotomy, tracheostomy, and surgical debridement of the right upper limb in the operating room with the General Surgery team. After these procedures, he was transported to the intensive care unit (ICU) for stabilization of his general condition, initially remaining tracheostomized, sedated, under mechanical ventilation, and fed by nasoenteral tube.

Once stabilized in the ICU, the patient underwent intestinal transit reconstruction with colostomy performed by the General Surgery team. Subsequently, he was reassessed by the Oral and Maxillofacial Surgery team, and a physical examination of the face revealed seropurulent discharge from the gunshot wound entry points in the mandibular fracture area. Intraoral examination showed marked mobility in the mandible, mobile teeth in the anterior mandibular region, and tongue laceration from the projectile path, with purulent discharge and necrotic tissue in the ventral and dorsal aspects of the tongue. Facial computed tomography (CT) imaging demonstrated the GSW trajectory crossing the mandibular region laterally, with metallic fragments, resulting in multifragmented fractures of both mandibular angles and bodies as well as the right mandibular ramus (Figure 1). The patient remained on antibiotic therapy for the infection, with Ciprofloxacin and Clindamycin, for 17 days.

The patient's treatment was divided into two stages, the first being surgical debridement and maxillomandibular fixation and the second being osteosynthesis of the complex mandibular fractures. During the first surgical phase, the patient underwent surgery under general anesthesia, where necrotic tissue in the tongue was debrided and sutured, exposed bone fragments and metallic fragments in the oral cavity area of the mandibular fractures were removed, and intraoral wounds were sutured. Occlusion was reestablished by intermaxillary fixation with the placement of six maxillomandibular fixation screws and 0-gauge stainless steel wire (Figure 2).

Following the surgical procedure, a new facial CT scan was performed to view the mandible in the position achieved after maxillomandibular fixation. The CT images in DICOM (Digital Imaging and Communications in Medicine) format were exported to Meshmixer® software (Version 3.5, 2018), which allowed for a 3D visualization of the mandible and conversion of this file to STL (Standard Triangle Language) format, a standard file format for stereolithography used for 3D printer processing. The mandibular model was then printed using the Ender S1 Pro® printer (Creality®, Shenzhen, China) with polylactic acid (PLA) composition. The printed mandible model was used for preoperative molding of the two 2.4 mm fixation plates to be used in the second surgical procedure (Figure 3).

Figure 1. A. Frontal view of the patient in the preoperative stage, showing the absence of dental occlusion and active purulent secretion drainage. B. Right-side profile view. C. Left-side profile view. D. 3D frontal view showing significant bone reduction on both sides of the posterior portions of the mandible. E. 3D left-side view. F. 3D right-side view.

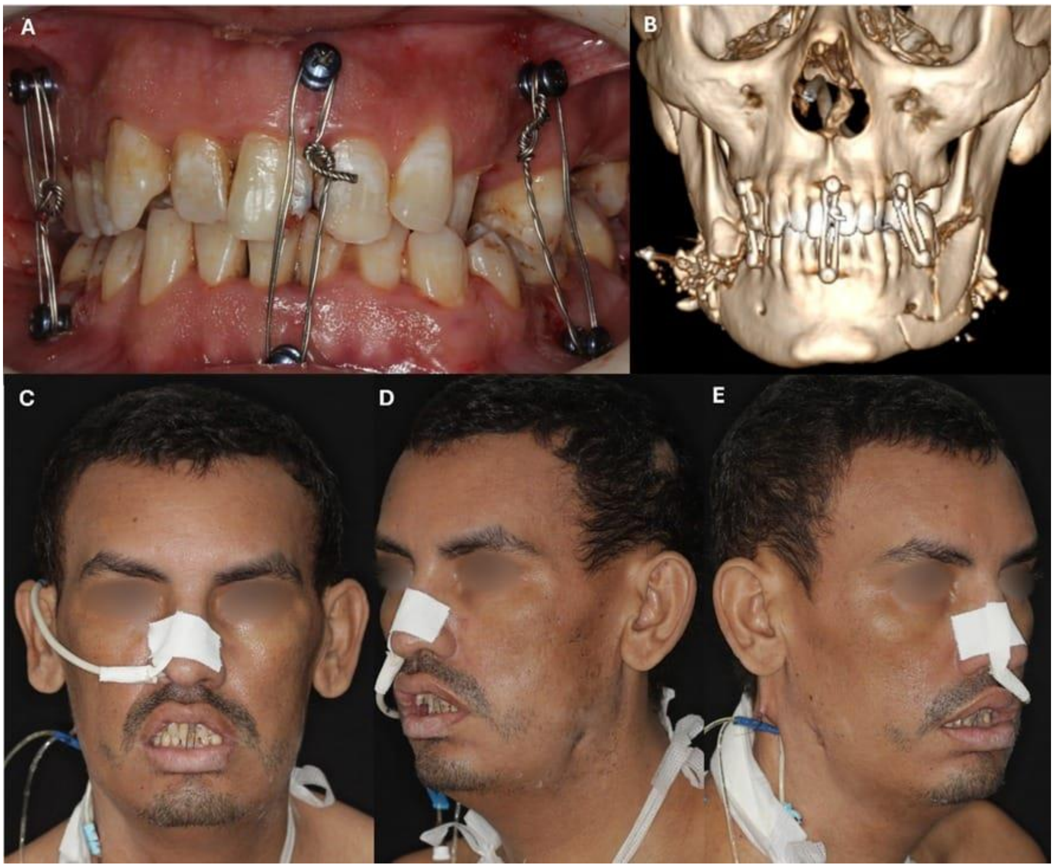


The patient remained hospitalized, and after the infection was resolved, the second surgical stage was performed to treat the mandibular fractures under general anesthesia. Bilateral Risdon incisions were made, and the two previously molded 2.4 mm plates were installed. One plate was used on the right side of the mandible, extending from the ramus to the mandibular body, and was secured with a total of six 2.4 mm screws. The other plate was used on the left side of the mandible, extending from the ramus to the symphysis and secured with a total of six 2.4 mm screws (Figure 3).

In the postoperative period, the patient showed stable dental occlusion, no mandibular mobility upon manipulation, no suture dehiscence, and no clinical signs of infection. CT examination revealed osteosynthesis material in place, with proper mandibular contour and appropriate positioning of the condyles in their respective mandibular fossae (Figure 4). The patient remained hospitalized for six days postoperatively due to transitioning from nasoenteral tube feeding to an oral diet and the gradual weaning from the tracheostomy with subsequent decannulation in the hospital setting, after which he was discharged. After discharge, the patient was instructed to complete antibiotic therapy with Amoxicillin 500 mg + Clavulanic acid 125 mg every 8 hours for 14 days and to take Dipyrone 500 mg every 6 hours for pain relief. He was also advised to undergo physical therapy to increase mouth opening range.

The patient remained under regular outpatient follow-up during the first three months postoperatively and progressed with adequate healing, showing no signs of infection or exposure of the osteosynthesis material. Currently, the patient is in long-term follow-up, 15 months postoperatively, and presents with stable dental occlusion without any postoperative complications.

Figure 2. A. Maxillomandibular block. B. 3D view after maxillomandibular block for the purpose of maintaining dental occlusion. C. Frontal view of the patient. D. ¾ view of the patient, left side. E. ¾ view of the patient, right side.



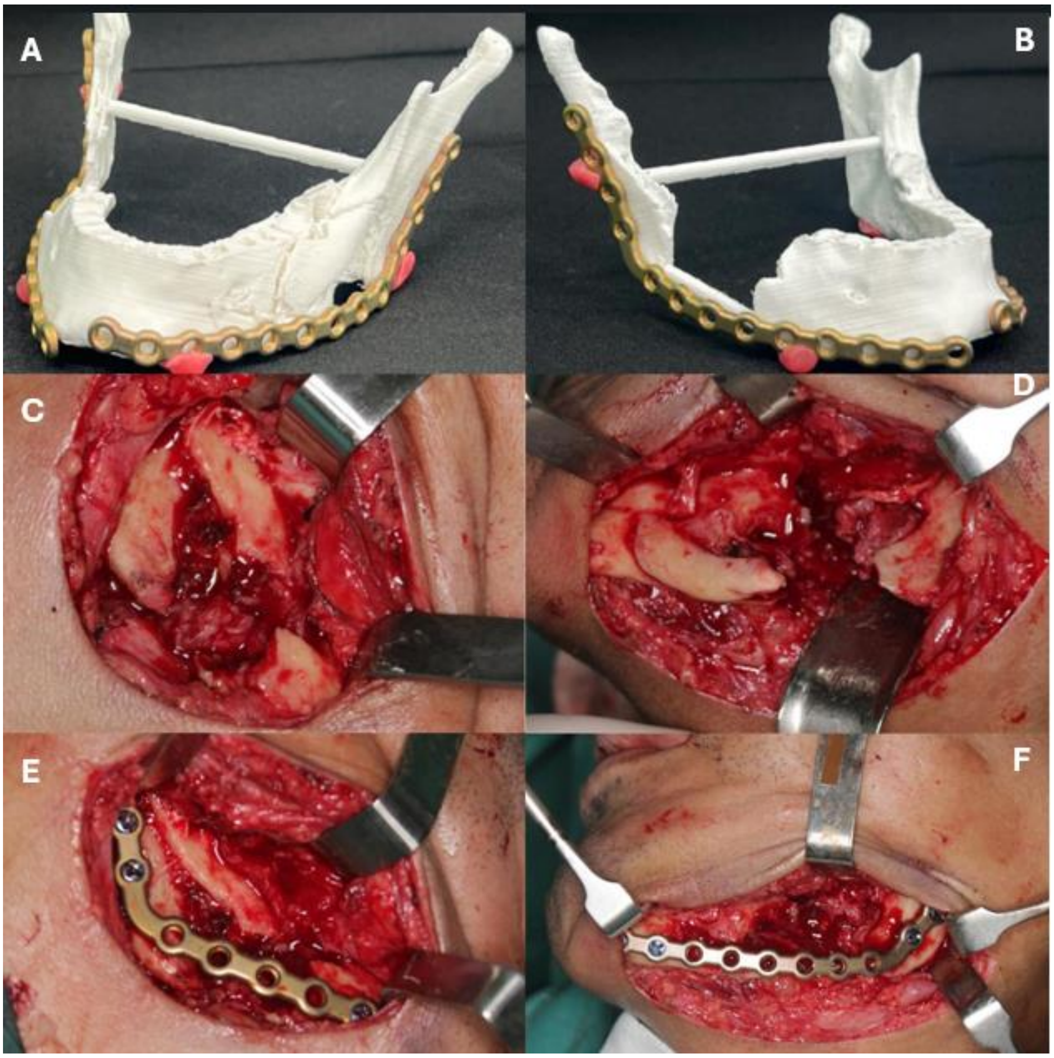
3. Discussion

The treatment of facial fractures caused by gunshot wounds (GSWs) is a major challenge in the field of oral and maxillofacial surgery. It has been proven that surgical debridement of a GSW injury is important in the tissue repair process and the patient's recovery [10,11]. The use of copious irrigation with saline solution and careful debridement of the wound, along with the removal of bone fragments, projectile fragments, and antibiotic therapy, play a fundamental role in achieving a good prognosis for each affected individual [12]. A similar approach was applied in the present case through meticulous wound cleaning during surgery and postoperative medication treatment after the first surgical stage.

Martelli et al. [13], in a systematic review comprising 158 articles on the use of 3D technology in surgical procedures, highlighted benefits related to its application: the multiple possibilities in preoperative planning, the anatomical precision provided by biomodels and reduced surgical time. These advantages can also be noted in the present case, where the use of prototyping for preoperative planning allowed for pre-molding of osteosynthesis plates, resulting in passive and well-fitted fixation of these plates to the bone during surgery. Thus, in addition to reduced operative time, proper positioning of the bone segments was achieved, including anatomical positioning of the mandibular condyles and adequate mandibular contour.

Computer-aided reconstructed and refined models of fractured mandibles are frequently created to facilitate preoperative planning and plate contouring [14]. Preoperative molding of fixation plates is more easily accomplished using the mandibular model and reduces surgical time compared to intraoperative molding [15, 16]. Custom pre-contoured plates can also be created from refined, computer-aided mandibular models [17].

Figure 3. A. Prototype view from the left side with 2.4 system plates shaped to the patient's bone profile. B. Prototype view from the right side. C. Right-side Risdon (submandibular) approach. D. Left-side Risdon (submandibular) approach. E. Rigid internal fixation with 2.4 reconstruction plate on the right side. F. Rigid internal fixation with 2.4 reconstruction plate on the left side.



Velasco et al. [18] state that the use of pre-contoured plates reduces surgical time by 17% to 60%, with an average of 20%. Sales et al. (2017) found that, in a study of complex mandibular fracture treatment using a pre-contoured 2.4 mm plate on a 3D prototype, the surgical procedure was shortened by fifty minutes compared to the same trauma profile without pre-molding. In the clinical case in question, pre-molding had a beneficial effect, as the bilateral fracture would have required more time for intraoperative contouring of the two fixation plates, and inadequate molding could have caused undue torque on the mandibular condyles, impairing mandibular positioning, dental occlusion, and, consequently, the postoperative outcome.

As limitations of the prototyping technique, there is a need for adequate knowledge of the software to plan the biomodel with dimensions and characteristics like the desired printed structure, as well as the high cost of the 3D printer [20]. The patient in this case currently remains in the postoperative period with good adaptability of the fixation material, showing no signs of infection or dehiscence, and with satisfactory occlusion, without the need for further intervention at this time.

Figure 4. A. 3D reconstruction after the surgical procedure. B. Caudo-cranial view in 3D reconstruction. C. Late postoperative occlusion. D. Clinical aspect in frontal view. E. Clinical aspect in caudo-cranial view. F. Clinical aspect in ¾ view from the left side. G. Clinical aspect in ¾ view from the right side.

4. Conclusion

The use of 3D printing is already routine, especially in assisting orthognathic surgeries and implantology. Given this context, it is necessary to emphasize the use of prototyping as a tool for pre-molding 2.4 mm reconstruction plates, thereby affirming an achievable reality in terms of increased plate adaptability to the bone profile and reduced intraoperative time, ensuring greater stability and mimicking the natural mandibular contour. This underscores the need for greater dissemination of this technology in complex mandibular surgeries. Furthermore, studies have incorporated 3D printing as a tool in temporomandibular joint surgeries and maxillofacial prosthetics, achieving satisfactory results that could represent a new promise in oral and maxillofacial surgery.

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Conflicts of Interest: The authors declare no conflicts of interest.

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