



Treatment of comminutive fractures by firearm projectiles with adapted wrist external fixator

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Received: 26 April 2019 / Accepted: 11 September 2019 / Published online: 23 October 2019
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Abstract

Introduction Facial and mandibular aggression with gunshot wound (GSW) is highly complex and represents a challenge for the assistant surgical team because in addition to the inherent lethal potential, they have the capacity for destruction and mutilation caused by the high kinetic energy conferred to the firearm projectile. Among these lesions, comminutive mandibular fractures are difficult to treat because the anatomical planes are distorted, soft tissues are in severe disarrangement, and bone fragments are without periosteum, which, if opted for an open treatment, with internal fixation, favor the development of soft tissue infections, osteomyelitis, and suture dehiscence. The treatment of comminuted mandibular fractures with external fixator, widely used during the Second World War, represents a modality of treatment that minimizes the risks of failure, since it allows stabilization of the fractured mandible with minimal aggression to the soft tissues.

Objectives The objective of this study is to report three cases where surgical procedures were performed to treat comminuted mandible fractures with the adaptation of specific external orthopedic fixator for wrist.

Keywords Fracture fixation · Mandibular fractures · External fixators

Introduction

Facial aggression with gunshot wound (GSW) has an enormous potential for destruction where anatomical planes are difficult to identify, presenting disorganized and multifragmented soft and bony tissues. The treatment of these fractures by means of open reduction and functionally stable fixation with plates and screws can generate several complications such as necrosis of loose bone fragments, avascular necrosis of adjacent stumps by devitalization after periosteal detachment, soft tissue infections, and osteomyelitis [1].

Comminuted jaw fractures as a result of GSW injuries have been treated by various methods, including closed reduction, external fixation, internal fixation with steel wire and open reduction, and stable internal fixation, using plates and/or screws, ranging from late conservative repair to more aggressive early repair in a single stage [2, 3].

The use of external fixators is another option for the treatment of GSW injuries in the mandible [4], being an unusual choice in the treatment of these fractures, besides having a restricted indication. It presents as main advantage to minimize the possible complications when compared with open surgical treatment for reduction and stabilization of fractures [5, 6].

The principles of external fixation were developed and applied in surgical practice during World War II, but the first external fixator applied to the mandible was attributed to Ginestet in 1936, being described as a system of pins or screws placed in each fractured fragment and united between if by an external device of fixing metal that maintains, immobilizing the fragments in certain position [1].

The objective of this study was to report three cases in which surgical procedures were performed to treat comminuted mandible fractures through wrist adapted external fixator in the Doctor José Frota Institute, Fortaleza, Ceará, Brazil.

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Cases report

Application technique

In the reported cases, orthopedic wrist external fixators, Sartori 150, Rio Claro, Brazil, which were adapted to the mandible, were used. After an analysis of the preoperative images, we chose to know how to make the first pins, approximately 1.5 cm apart from the fractured stumps. Skin incisions were made to reduce the injury caused by the drill and manual palpation in the base of the mandible. The perforations were applied based on the indexing system, always aiming to position the pins closest to the base of the mandible, as well as the evolution of adjacent structures such as dental roots, nerves, and vascular bloods. Due to the malleability of the carbon fiber rods, they were manually adapted to the contour of the mandible. The others pins are fixed in sequence, keeping a distance of 1 cm between them and respecting the adaptation of the carbon rods. The distance between the carbon rod and the skin was always greater than 1 cm.

The connection around the pins represents a potential complication in these type of treatment. In these cases, general measures were adopted: Rigid fixation of the external fixation device, careful handling of the tissue at the time of perforation, and installation of the pins and strict hygiene of the skin around the pins in the postoperative period, in addition to systemic antibiotic therapy for at least 15 day. In case of skin infection around the pins, performing a microbiological culture and application of systemic and topical antibiotic therapy were necessary; but fortunately, there was no need in any of the cases reported here.

Case 1

Patient D.R.F.A. male, 16 years old with GSW aggression, presenting extensive avulsive lesion in the lower third of the face with airway involvement and diagnosis of hypovolemic shock, was submitted to tracheostomy, primary closure of facial injuries through suture, vascular ligations and volume replacement through saline, and blood transfusion.

The patient was then submitted to computed tomography (CT) examination, where a comminuted mandibular fracture with large loss of bone tissue in a left mandibular body region can be observed (Fig. 1a).

After 3 days of initial care, the patient evolved with suture dehiscence, necrosis of adjacent tissues and salivary fistula (Fig. 1b). New surgical intervention was performed to remove necrotic tissue, reestablishment of the left parotid salivary duct. and wound closure secondary to necrosis, remaining under antimicrobial therapy for 21 days. Nasoenteral feeding was instituted to avoid contamination of intra-oral wounds with food residues, thus avoiding secondary infection and better healing of oral cavity tissues.

After 30 days of soft tissue clinical healing, the oral mucosa was repaired, the skin was restored, the salivary flow was restored to the oral cavity, and there were no signs of infection. However, the loss of a large amount of soft tissue presented a retraction severe scarring resulting in microstomia, oral opening limitation, facial asymmetry, dental malocclusion, paresthesia, and paralysis in the lower labial and chin regions (Fig. 1c). At this point, it was decided to install the external orthopedic wrist adapted for the purpose of establishing the correct position of the mandible, to maintain the dental occlusion and to dilate the soft tissues to later receive bone graft. Three pins were placed in the proximal region and three in the distal (symphysis region) connected to an external carbon fiber rod previously shaped to fit the mandibular contour (Fig. 1d, e). Aiming at obtaining greater stability, maxillo-mandibular block with intermaxillary fixation screws and steel wires remained for 4 weeks and 14 weeks with external fixator until being submitted to a new surgical procedure where the fixator was removed and mandibular reconstruction with osteochondral bone graft and reconstruction locking plate and screws (Fig. 1f).

Twelve months after of the osteochondral grafting procedure, the patient progresses satisfactorily, being able to observe the reestablishment of the oral functions and adequate facial contour (Fig. 1g), with a total follow-up of 16 months.

Case 2

Patient J.V.C.S. male, 14 years old with GSW aggression, was presented with penetrating lesion in the chin region, loss of mandibular arch integrity, diffuse facial edema, dental dislocation, mouth opening limitation, dysphagia, and sialorrhea. Computed tomography examination revealed a comminuted mandibular fracture in the symphysis region and bilateral mandibular body (Fig. 2a).

After hospital admission and surgical planning, a closed treatment of with external fixator was performed. Two bicortical intraosseous pins were placed on each side of the mandible, connected by two external carbon fiber rods of a fixator for adapted wrist and intermaxillary fixation (IMF) with wires of steel. Patient remained on the diet by nasoenteral tube for 21 days and IMF for 4 weeks (Fig. 2b). After 12 weeks of clinical and radiographic follow-up, bone callus formation (Fig. 2c), adequate buccal opening, satisfactory occlusion, and adequate esthetics were observed. The patient was submitted to removal of the external fixation device under local anesthesia. After 8 weeks of removal of the external fixator, it was possible to observe an adequate restoration of the facial contour and the patient had no functional complaints. (Fig. 2d), with a total follow-up of 7 months.

Fig. 1 **a** Computed tomography with 3D reconstruction. Note great destruction in the region of the left mandibular body. **b** Facial wound 3 days after the initial treatment. **c** Frontal appearance after 30 days of initial treatment. **d** and **e** External fixator adapted to the mandibular contour. **f** Surgical aspect of mandibular reconstruction with rib bone graft and internal fixation. **g** Follow-up of 12 months.

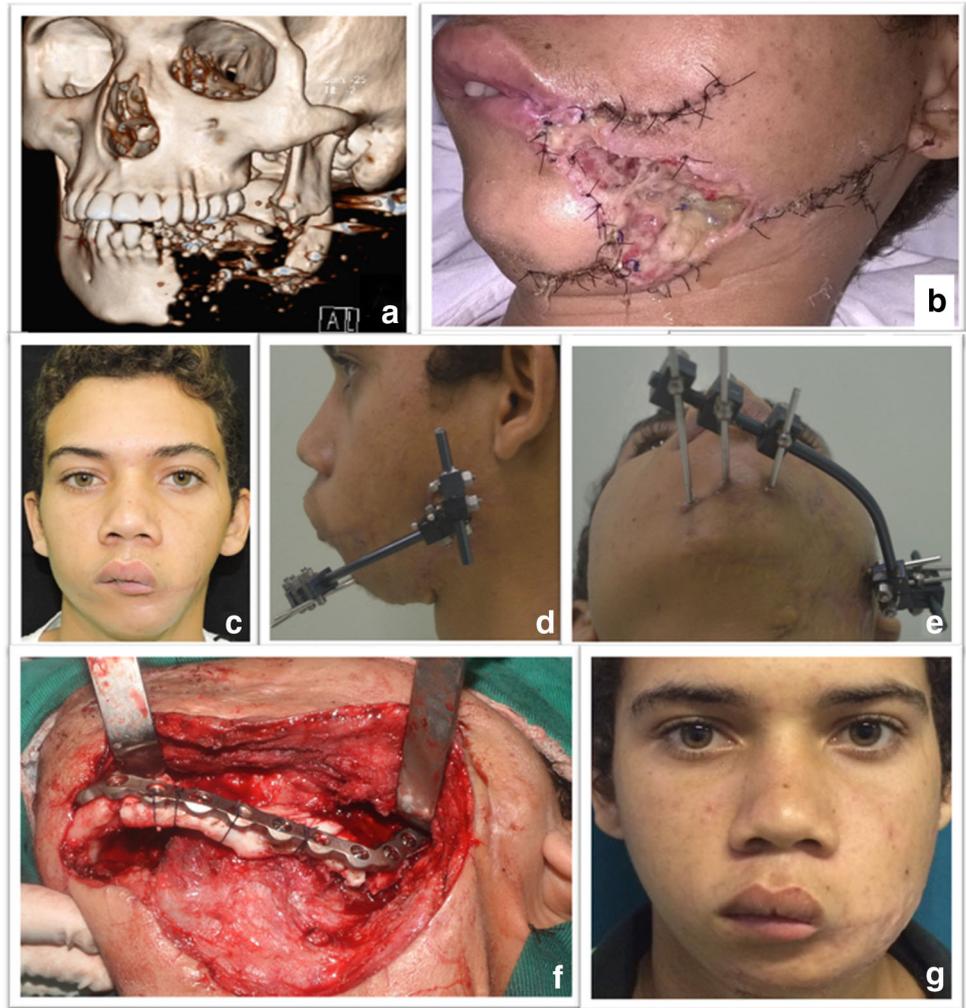
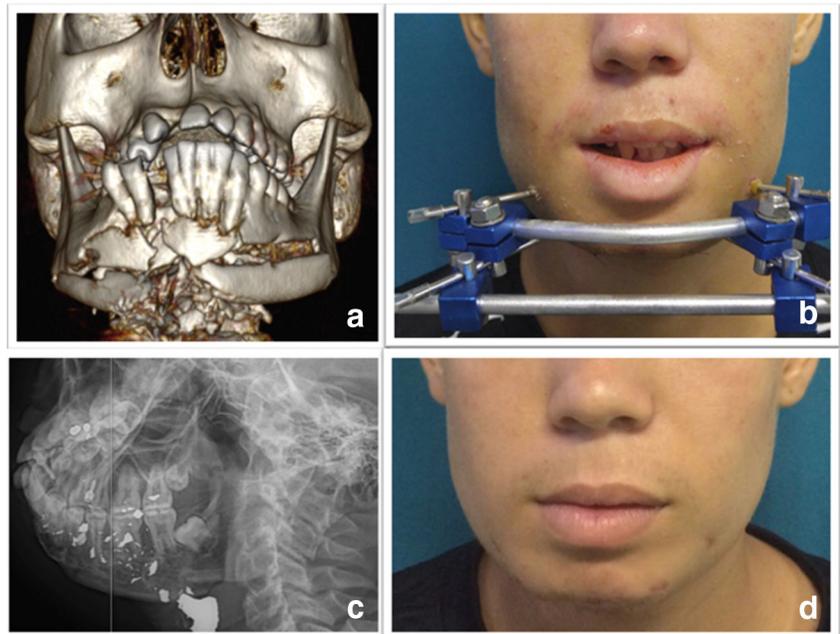


Fig. 2 **a** Computed tomography with 3D reconstruction showing comminuted mandible fracture in symphysis region and bilateral mandibular body. **b** External fixator installed on the face. **c** and **d** Clinical and radiographic follow-up after removal of the external fixator and pins observing adequate bone formation



Case 3

Patient M.S.S, male, 16 years old with GSW aggression, presented a penetrating lesion in a left region of mandibular body and an exit orifice in a region of the left mandibular angle, without hemodynamically unstable airway, requiring a procedure for hemostasis, initial stabilization of IMF fractures, and blood transfusion. There was also loss of integrity of the left mandibular body, diffuse edema in the lower 1/3 of the face, dental malocclusion, limitation of mouth opening, sialorrhea, and dysphagia. Computed tomography examination showed a comminuted fracture in the left region of mandibular body and several dental losses. (Fig. 3a).

Patient remained with IMF for 21 days, and after adequate soft tissue healing, three anterior bicortical intraosseous pins were installed, two in a mandibular ramus region and two in larger intermediate fragments in a mandibular body region. These pins were connected to each other through a preformed carbon fiber rod (Fig. 3b). The patient remained with IMF for another 15 days and with the external fixator for approximately 12 weeks, being weekly evaluated clinically and radiographically. Three months after removal of the fixator, it evolved satisfactorily with adequate facial contour, good bone healing, and stable dental occlusion (Fig. 3c, d), with a follow-up of 6 months.

Discussion

Open reduction and functional stabilization with plates and screws are indicated in comminuted mandible fractures, however, as periosteal detachment is necessary; therefore, there is a potential impairment in the vascularization of already

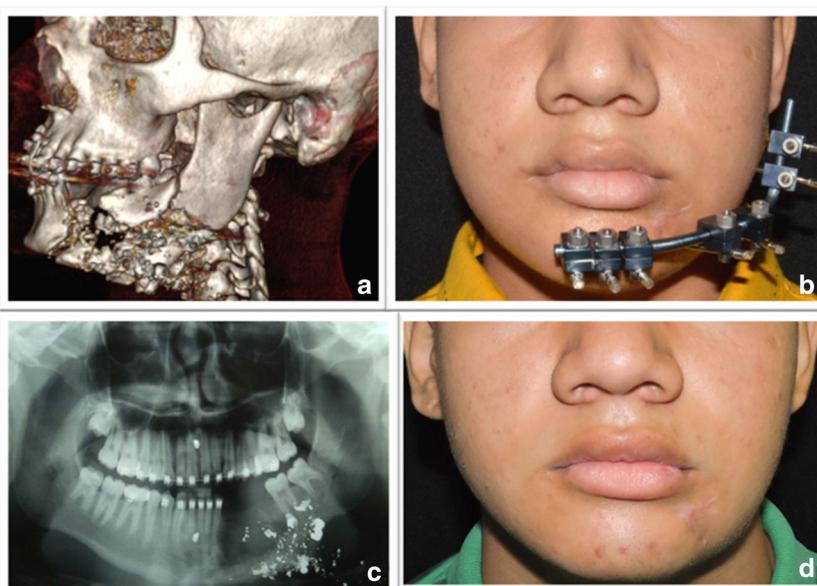
compromised bone tissue. In situations in which comminution is combined with great periosteal, muscular, or mucosal damage, an increase in the incidence of non-union and infections is expected [1]. In this way, when the closed treatment is realized, the viability of the fragments is maintained without interrupting the blood supply [5].

Kinetic energy is the energy associated with the movement of bodies. Projectile velocity, mass, and design strongly influence firearm wound production, since the interaction of each of these factors provides varying amounts of kinetic energy [7].

Low-speed projectile injuries are quite different from high-speed projectiles in that they have only about one third of the kinetic energy compared with high-speed projectiles. They usually cause penetrating lesions that inflict multiple fractures and lacerations of the skin and rarely involve tissue avulsion. High velocity, military style weapons are uncommon among the civilian population in our area and we believe that low velocity handguns were used in each of these patents

The external fixation is performed by installing intraosseous pins, installed in the jaws in adjacent stumps, the fractures interconnected through connectors to a carbon fiber rod that must be a distance of 10 mm from the surface of the skin. It is recommended to install at least two bicortical pins in each segment of the fracture 25 mm apart and at least 10 mm from the edges of the fractures [7, 8]. Aiming to minimize lesions in adjacent structures such as roots and dental germs, facial artery, facial and retromandibular veins, and mandibular canal, the pins are recommended to be installed in the basilar region of the mandible as well in the mandibular branch region avoid the area near the entrance of the mandibular canal [1, 9, 10].

Fig. 3 a Computed tomography with 3D reconstruction showing comminuted fracture in left mandibular body region. b Facial appearance after installation of the external fixator. c Panoramic radiography after removal of the external fixator. d Final image after 3 months of removal of the external fixator



Respecting the anatomical individualities, orthopedic fixators for hand and wrist fractures can be successfully used in the treatment of mandibular injuries, usually requiring preoperative modeling of the external shaft for a suitable mandibular contour, presenting great versatility and simplicity in its use [6, 11]. Although external orthopedic fixators have specific indications, they can also be chosen as a second-choice treatment for cases of comminuted mandibular fractures initially treated with internal fixation, but which evolved with osteomyelitis, bone sequestration, and the need to remove bone synthesis material [12, 13].

The duration of the external fixator usually varies from 8 to 12 weeks, sufficient time for bone repair and remodeling, but there are reports of successfully treated cases in 6 weeks and cases that the treatment lasted for about 16 weeks. There are several factors that directly interfere with the success rate, such as acceptance of the patient to the treatment since it is a device installed on the face, satisfactory oral hygiene, and absence of potential dental infectious focus [6, 9, 11].

Due to the general nature and severity of mandibular fractures treated by external fixation, a high complication rate of up to 35% has been reported. Postoperative infections, cellulitis around the pins, malocclusions, and pin loosening may occur with this fixation technique [13]. However, in the clinical cases reported in this study, there were no infections associated with the use of external fixators.

Mandibular external fixation with adapted wrist external fixator is shown as an effective treatment in the treatment of traumatic lesions of the mandible. This treatment, when closed, presents a lower morbidity when compared with the open treatment, allowing adequate repair of adjacent soft tissues and bone and less potential of infections when compared with the open treatment.

Funding The financial support was provided by the authors and there was not corporate involvement.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent The patients in this study signed a free and informed consent form in which they authorize the publication of their images or photographs in any type of media with educational purpose, research, and dissemination of scientific knowledge.

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