

Wrist external fixator for treatment of comminuted mandible fracture caused by gunshot wound: A case report

Fixador externo de punho para tratamento de fratura cominutiva de mandíbula causada por ferimento de arma de fogo: Um relato de caso

Fijador externo de muñeca para el tratamiento de fractura conminuta de mandíbula causada por herida de bala: Reporte de un caso

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André Pereira Falcão

ORCID: <https://orcid.org/0000-0001-6251-0629>
Universidade de São Paulo, Brazil
E-mail: andre.falcao@usp.br

Mariana Xavier Passos

ORCID: <https://orcid.org/0009-0004-5733-5036>
Universidade de São Paulo, Brazil
E-mail: marianaxavier@usp.br

Caio Machado Mattos

ORCID: <https://orcid.org/0009-0003-6005-7009>
Universidade Federal de Juiz de Fora, Brazil
E-mail: caiomachadomattos@outlook.com

Guilherme Alexandre Silva Prado

ORCID: <https://orcid.org/0000-0001-6370-3035>
Hospital Municipal Dr. Cármino Caricchio, São Paulo, Brazil
E-mail: dr.guilhermepradobmf@gmail.com

Vanessa Fernandes Gaspar

ORCID: <https://orcid.org/0009-0005-1905-3721>
Hospital Municipal Dr. Cármino Caricchio, São Paulo, Brazil
E-mail: vanessa_f_gaspar@hotmail.com

Carina Domaneschi

ORCID: <https://orcid.org/0000-0001-8615-3283>
Universidade de São Paulo, Brazil
E-mail: domaneschi@usp.br

Abstract

Gunshot wounds may cause extensive damage to the facial skeleton, generating complex fractures. Cases of great bone comminution and poor stability can be a challenge with rigid internal fixation. Thus, the use of an external fixator is indicated. The aim of this study is to report a case of a wrist external fixator for initial treatment of a gunshot injury. A 58-year-old male patient was found on the street with extensive comminution and significant mobility of the mandibular bone, tooth loss, crown-root fractures, multiple metal fragments and a firearm projectile lodged in his face. The treatment implemented was surgical debridement with removal of foreign particles, unviable fragments and submental projectile. Next, wrist external fixator was installed bilaterally in the mandible. Good stability of the bone segments was achieved, in addition to preventing bone displacement into the airways. The use of an external fixator is a viable alternative for Traumatology services and can be useful in urgent cases like this one, allowing subsequent refined reconstructions.

Keywords: External fixators; Jaw fractures; Gunshot wounds.

Resumo

Ferimentos por arma de fogo podem causar danos extensos ao esqueleto facial, gerando fraturas complexas. Casos de grande cominuição óssea e baixa estabilidade podem ser um desafio com fixação interna rígida. Assim, é indicado o uso de fixador externo. O objetivo deste estudo é relatar um caso de fixador externo de punho para tratamento inicial de lesão por arma de fogo. Paciente do sexo masculino, 58 anos, foi encontrado na rua com extensa cominuição e importante mobilidade do osso mandibular, perda dentária, fraturas corono-radiculares, múltiplos fragmentos metálicos e projétil de arma de fogo alojado na face. O tratamento implementado foi o desbridamento cirúrgico com remoção de partículas estranhas, fragmentos inviáveis e projétil submentoniano. A seguir, fixador externo de punho foi instalado bilateralmente na mandíbula. Conseguiu-se boa estabilidade dos segmentos ósseos, além de evitar deslocamento ósseo

para as vias aéreas. A utilização de fixador externo é uma alternativa viável para os serviços de Traumatologia e pode ser útil em casos urgentes como este, permitindo reconstruções posteriores refinadas.

Palavras-chave: Fixadores externos; Fraturas maxilomandibulares; Ferimentos por arma de fogo.

Resumen

Las heridas de bala pueden causar daños extensos al esqueleto facial, generando fracturas complejas. Los casos de gran conminución ósea y mala estabilidad pueden ser un desafío con la fijación interna rígida. Por tanto, está indicado el uso de un fijador externo. El objetivo de este estudio es informar un caso de fijación externa de muñeca para el tratamiento inicial de una lesión por arma de fuego. Un paciente masculino de 58 años fue encontrado en la calle con conminución extensa y importante movilidad del hueso mandibular, pérdida de piezas dentales, fracturas de corona y raíz dental, múltiples fragmentos metálicos y un proyectil de arma de fuego alojado en su rostro. El tratamiento implementado fue el desbridamiento quirúrgico con remoción de partículas extrañas, fragmentos inviables y proyectil submentoniano. A continuación, se instaló fijador externo de muñeca de forma bilateral en la mandíbula. Se logró una buena estabilidad de los segmentos óseos, además de evitar el desplazamiento óseo hacia las vías respiratorias. El uso de un fijador externo es una alternativa viable para los servicios de Traumatología y puede ser útil en casos urgentes como este, permitiendo posteriores reconstrucciones afinadas.

Palabras clave: Fijadores externos; Fracturas maxilomandibulares; Heridas por arma de fuego.

1. Introduction

Gunshot wounds (GW) significantly affect soft and hard tissues, sometimes being a therapeutic challenge for oral and maxillofacial surgeons. (Kaufman et al., 2009). The approach of GW aims to ensure the preservation of the airways, control hemorrhages, identify other injuries and promote the repair of traumatic deformities of the face, as well as preserve the blood supply of bone segments. The forms of treatment consist of closed conservative reduction or rigid internal fixation, according to the patient's clinical condition. (Muddassar et al., 2020).

The use of external fixators (ex-fix) is a modality used to treat a range of issues related to the bones of the human body. It has a non-intrusive nature and is versatile in terms of shape and materials. (Fernando et al., 2021). The use of ex-fix on the face has declined with the advent of rigid internal fixation, yet it continues to play a critical role in the treatment of complex mandibular fractures in patients with extensive comminution, multiple tooth loss, significant perimeter loss, and systemic contraindications for open surgeries, being interesting because it does not require extensive surgical dissection or prolonged operation time (Braid & Ziccardi, 2009; Kazi et al., 2019).

The ex-fix is presented in a system in which pins surgically threaded into the bone and different types of connectors are manipulated to optimize the reduction of fractures. The initial consolidation time for removal of the ex-fix system ranges from 8 to 10 weeks. After this period, more sophisticated reconstructions with osteosynthesis material are scheduled (Braid & Ziccardi, 2009). Jaw fractures are among the most common fractures in the facial skeleton and when comminuted are difficult to manage due to distorted anatomical planes and lack of periosteum. In cases of high-energy trauma, there may be extensive comminution and mandibular instability, requiring ex-fix, which is a versatile system for use. (Alencar et al., 2018; Carvalho et al., 2019). The present case reports a mandibular stabilization approach with an orthopedic wrist external fixator in a critically ill polytraumatized patient who was shot, through which we discuss the technique as an option in scenarios of great mandibular comminution and unpredictability of immediate open surgeries for rigid internal fixation. Thus, the aim of this study is to report a case of a wrist external fixator for initial treatment of a gunshot injury.

2. Methodology

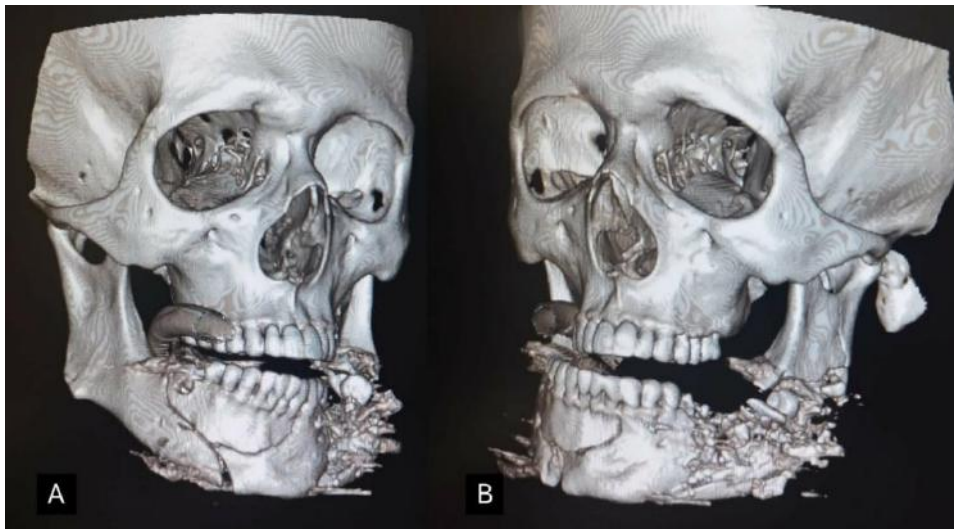
This is a qualitative study, structured as a case report. The main objective is to describe the indication and step-by-step procedure for installing a wrist external fixator in a polytraumatized patient with a complex comminuted jaw fracture due to a gunshot wound. Clinical, trans-surgical and postoperative data were collected through information from medical records and photos. Relevant literature was gathered about the uses of external fixators for facial fractures and discussed with the case

described. The case report is a study that follows a defined structure and it is important for the dissemination of casuistry, with its methodology addressed by authors such as Santini (2019). This project is endorsed by the Ethics Committee of Hospital Municipal Dr. Cármino Caricchio (022023), respects the guidelines and principles of CNS Resolution 466/2012, the CONEP 2018 letter and the Declaration of Helsinki. An informed consent form was signed by the patient's legal guardian, authorizing the use of data and images for scientific purposes.

3. Case Report

A 58-year-old male patient, a probable victim of an extermination attempt, was found on the street by a thoracic surgeon and admitted intubated. He underwent computed tomography scans of the abdomen, pelvis, cervical spine, skull, neck and face, which showed multiple sources of gunshot projectile entry, left scapular fracture, bilateral pulmonary contusions, pneumoperitoneum and aortoiliac atheromatosis. Cranial tomography without alterations. Facial fractures affected the region of the mandibular body bilaterally, left symphysis and left condyle. Added to this was extensive bone comminution, excessive mobility, loss and diastasis of fragments, multiple crown-root fractures and tooth loss (Figure 1). A firearm projectile (FAP) lodged in the submental region and metal fragments distributed throughout the comminuted bone were also observed.

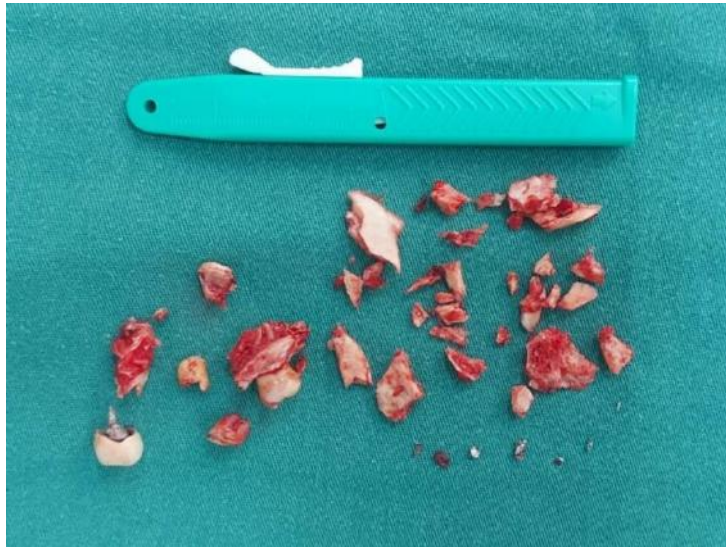
Figure 1 – Patient tomographic reconstruction. Extensive bilateral mandibular comminution, with immersed bone and dental fragments. A: right side view. B: left side view.



Source: Authors (2024).

The patient underwent multiple surgeries to contain hemorrhage foci, with surgical procedures performed by the Oral and Maxillofacial Surgery, General Surgery and Orthopedics teams. The treatment implemented by our team consisted of surgical debridement, removal of included metal fragments, unviable bone fragments and dental residues (Figure 2), in addition to the installation of a bilateral external fixator in the mandible (Figure 3), using a Colles-type fixator for the wrist.

Figure 2 – Bone and tooth fragments, dental crown and bullet particles removed from the patient.



Source: Authors (2023).

Figure 3 – Wrist external fixators installed in the mandible demonstrates its 3D dimensions and disposition. A: top view. B: caudal view.



Source: Authors (2023).

Installation was performed using a transcutaneous orthopedic perforator, through which the skin and buccinatory tissues were perforated, in order to access the cortical and medullary bones. The first fixator was attached on the left side and stabilized by three locking screws of the Colles system. Then, on the contralateral side, a Kirschner wire was slightly bent to ensure curvature of the mandibular perimeter, and it was inserted into two holes of the external fixator in the chin region associated with two locking screws for the set. There was good stabilization of the bone segments, also ensuring perimeter for adequate intraoral sutures. The locking of the wires and screws to the ex-fix was done by locking the mandrel hole by hole with an appropriate key (Figure 4).

Figure 4 – Threadable set screws for Colles-type fixator and chuck key for screw locking.



Source: Authors (2023).

The submental FAP was removed by extraoral incision, divulsion by layers, removal of the projectile and final suture (Figure 5). The patient remained stable during our team's surgical procedures. In the following six days, he remained in the ICU, but died due to the general fragility of the systemic condition.

Figure 5 – Firearm projectile removed from the submental region measuring 2.5 cm in its longest axis.



Source: Authors (2023).

4. Discussion

The management of craniofacial trauma caused by FAP has evolved over the last 50 years due to technological incentives. However, as these are injuries in an anatomically complex area, the technique and repair remain a therapeutic challenge (Wilkening et al., 2012), which requires an integrated view of the patient and multidisciplinary work. As this is a region with contaminated and deeply damaged tissue, the initial management of the case consisted of wounds decontamination and debridement, which, according to the literature, avoids the formation of dead space and minimizes the tension of the sutures. Still, for the study and planning of an appropriate surgical technique, a thorough clinical examination and computed tomography were performed to identify the bone fragments and those acquired immersed (Figure 1), which is essential for delimiting the defects, mastering the complications and precise therapeutic proposal elaboration (Kaufman et al., 2009).

The external fixator aims to maintain the rigidity and stability of the bone structure through percutaneous wires or pins application. Almost always made of steel, it has longitudinal support rods and connection elements (Rotbando & Ramos, 2000).

This technique may require subsequent revision surgery and may maintain defects that require bone grafting to eliminate micromovements. Also, as a disadvantage, the ex-fix has the potential to damage facial nerve branches, such as the marginal branch of the facial nerve, which is near the lower border of the angle of the mandible, and the mental nerve (Wilkening et al., 2012). In addition, there is a greater risk of local infection compared to the rigid internal fixation modality. Thus, topical cleaning and prophylactic antibiotic therapy are indicated when opting for the ex-fix (da Rocha et al., 2021). Its use for jaw fractures began in World War II and, over the years, fixator models were updated (Cornelius et al., 2009). Currently, we have the Colle's external wrist fixator as an option, which is adapted according to the desired mandibular perimeter (Alencar et al., 2018). Thus, the use of a wrist fixator for mandibular fractures has already been used by some authors, with good postoperative results. (Alencar et al., 2018; Carvalho et al., 2019).

In cases of multiple facial lesions and in other concomitant organs, such as the present report, considering the patient's severity, the maintenance of airway patency and bleeding control may still be prioritized over aesthetic recovery, since the laryngeal injury, by aspirated teeth or bone fragments, and excessive bleeding can compromise the airways and generate complex complications for the patient (Kaufman et al., 2009; Kummoona, 2010). Therefore, the emergency care of individuals at war and multiple traumas focuses first on the fundamentals of resuscitation and on the state of the airways, as it is reiterated that bleeding and lesional edema can compromise breathing and lead to death (Motamedi, 2003).

The use of an ex-fix was also recommended for children with displaced condylar fractures, with a low rate of post-surgical affection (Cascone, Marra Marcozzi, et al., 2017). At the same time, there are reports using a customized 3D-printed external fixator in cases of septic mandibular pseudarthrosis, a condition that is clinically important, but which allows for more planning time in relation to multiple trauma patients (Louvrier et al., 2020). The ex-fix technique has also been integrated in cases of tumor resection with extensive loss of bone segment (Vural & Yuen, 2007; Yin et al., 2019). In cases of osteoradionecrosis with sequestrotomy there is also an indication, preventing pathological fractures that are difficult to manage. (Mahdian et al., 2020) Indication for condylar mandibular fractures was also studied and presented good prognoses (Cascone, Spallaccia, et al., 2017).

Ballistic trauma, in which there is extensive bone comminution and excessive mobility, can develop secondary local necrosis, especially when high-velocity bullets are involved, which contraindicates immediate reconstruction with grafting and internal fixation. (Wojcik et al., 2016). The choice of ex-fix allows for initial bone regeneration, stabilizes severely comminuted bone fragments and tends to promote the osteogenic character, helping the healing and bone restoration. The closed installation technique simultaneously avoids periosteal detachment, which could further compromise the local bone blood supply in comminuted fractures (Gibbons et al., 2011). Thereupon, although rigid internal fixation is generally considered the gold standard treatment for facial fractures, there is a precise indication of external fixation (ex-fix) for cases such as the one in this report, preserving the three-dimensional relationships of hard and soft tissues (Kaufman et al., 2009).

5. Conclusion

The use of the wrist external fixator allowed primary stabilization of the bone stumps in a scenario of extensive comminution due to gunshot wound. Thus, the ideal type of fixation will always be based on the clinical and systemic status of the patient, considering their therapeutic limitations. Situations like this can be challenging. Therefore, analysis of the benefits and contraindications of the therapies is necessary for the management of polytrauma patients.

For future studies, it would be interesting to evaluate case series with a larger sample of patients and compare the long-term results of using the external wrist fixator.

References

- Alencar, M. G. M. de, Bortoli, M. M. De, Silva, T. C. G. da, Silva, E. D. de O. e., & Laureano Filho, J. R. (2018). Suitability of Wrist External Fixator for Treatment of Mandibular Fracture. *Journal of Craniofacial Surgery*, 29(4), e371–e372. <https://doi.org/10.1097/SCS.00000000000004375>
- Braidy, H. F., & Ziccardi, V. B. (2009). External Fixation for Mandible Fractures. *Atlas of the Oral and Maxillofacial Surgery Clinics*, 17(1), 45–53. <https://doi.org/10.1016/j.exom.2008.10.001>
- Carvalho, P. H. R., da Hora Sales, P. H., da Rocha, S. S., Cavalcanti, A. M. M., de Jesus Rodrigues Mello, M., & Junior, J. M. S. M. (2019). Treatment of comminutive fractures by firearm projectiles with adapted wrist external fixator. *Oral and Maxillofacial Surgery*, 23(4), 501–505. <https://doi.org/10.1007/s10006-019-00804-y>
- Cascone, P., Marra Marcozzi, M., Ramieri, V., Bosco, G., Vellone, V., & Spallaccia, F. (2017). Mandibular Condylar Fractures in Children: Morphofunctional Results After Treatment With External Fixation. *Journal of Craniofacial Surgery*, 28(7), 1742–1745. <https://doi.org/10.1097/SCS.00000000000003914>
- Cascone, P., Spallaccia, F., Arangio, P., Vellone, V., & Gualtieri, M. (2017). A Modified External Fixator System in Treatment of Mandibular Condylar Fractures. *Journal of Craniofacial Surgery*, 28(5), 1230–1235. <https://doi.org/10.1097/SCS.00000000000003669>
- Cornelius, C.-P., Augustin, J. B., & Sailer, L.-K. (2009). External pin fixation for stabilization of the mandible—comeback of a method: historical review and first experiences with the ‘mandible external fixator.’ *Oral and Maxillofacial Surgery*, 13(1), 1–14. <https://doi.org/10.1007/s10006-008-0142-4>
- da Rocha, S. S., Sales, P. H. da H., Carvalho, P. H. R., Maia, R. N., Gondim, R. F., de Menezes Junior, J. M. S., & Mello, M. de J. R. (2021). Mandibular traumas by gunshot. A systematic review with meta-analysis and algorithm of treatment. *British Journal of Oral and Maxillofacial Surgery*, 59(3), e99–e108. <https://doi.org/10.1016/j.bjoms.2020.08.019>
- Fernando, P. L. N., Abeygunawardane, A., Wijesinghe, P., Dharmaratne, P., & Silva, P. (2021). An engineering review of external fixators. *Medical Engineering & Physics*, 98, 91–103. <https://doi.org/10.1016/j.medengphy.2021.11.002>
- Gibbons, A. J., Mackenzie, N., & Breederveld, R. S. (2011). Use of a custom designed external fixator system to treat ballistic injuries to the mandible. *International Journal of Oral and Maxillofacial Surgery*, 40(1), 103–105. <https://doi.org/10.1016/j.ijom.2010.08.001>
- Kaufman, Y., Cole, P., & Hollier, L. H. (2009). Facial Gunshot Wounds: Trends in Management. *Craniofacial Trauma & Reconstruction*, 2(2), 85–90. <https://doi.org/10.1055/s-0029-1202595>
- Kazi, A. A., Lee, T. S., Vincent, A., Sokoya, M., Sheen, D., & Ducic, Y. (2019). The Role of External Fixation in Trauma and Reconstruction of the Mandible in the Age of Rigid Fixation. *Facial Plastic Surgery*, 35(06), 614–622. <https://doi.org/10.1055/s-0039-1700799>
- Kummoona, R. (2010). Management of Missiles Injuries of the Facial Skeleton. *Journal of Craniofacial Surgery*, 21(4), 976–981. <https://doi.org/10.1097/SCS.0b013e3181e56e7e>
- Louvrier, A., Sigaux, N., Meyer, C., Benassarou, M., & Lutz, J. C. (2020). Customized three-dimensionally printed mandibular external fixator. *International Journal of Oral and Maxillofacial Surgery*, 49(11), 1445–1448. <https://doi.org/10.1016/j.ijom.2020.02.012>
- Mahdian, N., Onderková, A., Brizman, E., Pavlíková, G., Vlachopoulos, V., Drahoš, M., & Foltán, R. (2020). External fixation greatly improves outcomes in the surgical treatment of osteoradionecrosis of the jaws without affecting quality of life: a five-year retrospective study. *British Journal of Oral and Maxillofacial Surgery*, 58(9), e45–e50. <https://doi.org/10.1016/j.bjoms.2020.05.031>
- Motamedi, M. H. K. (2003). Primary management of maxillofacial hard and soft tissue gunshot and shrapnel injuries. *Journal of Oral and Maxillofacial Surgery*, 61(12), 1390–1398. <https://doi.org/10.1016/j.joms.2003.07.001>
- Muddassar, M., Arshad, R., Rabbani, S., Qureshi, I. S., Khattak, I. K., & Rana, Z. (2020). Management of Gunshot Injuries of Mandible with Open Reduction and Internal Fixation versus Closed Reduction and Maxillo-mandibular Fixation. *Cureus*. <https://doi.org/10.7759/cureus.7830>
- Rotbände, I., & Ramos MR. (2000). Atualização em fixação externa: conceitos e revisão. *Rev Bras Ortop*, 35(4).
- Santini, A. (2019). Spotlight on How to Structure a Case Report. *The Journal of Critical Care Medicine*, 5(2), 76–79. <https://doi.org/10.2478/jccm-2019-0007>
- Vural, E., & Yuen, J. C. (2007). Combining Use of Resin Models With External Fixation in Mandibular Reconstruction. *Archives of Otolaryngology–Head & Neck Surgery*, 133(6), 603. <https://doi.org/10.1001/archotol.133.6.603>
- Wilkening, M. W., Patel, P. A., & Gordon, C. B. (2012). External Fixation in a Low-Velocity Gunshot Wound to the Mandible. *Journal of Craniofacial Surgery*, 23(5), e418–e419. <https://doi.org/10.1097/SCS.0b013e31825daecc>
- Wojcik, T., Nicot, R., Ferri, J., & Raoul, G. (2016). A Cheap Hand-Made Mandibular External Fixator? *Journal of Craniofacial Surgery*, 27(7), 1839–1841. <https://doi.org/10.1097/SCS.00000000000002963>
- Yin, X., Tan, Y., Liu, Y., Sun, W., Zhang, X., Hu, Y., Sun, J., Zhang, C., & Zhong, L. (2019). Clinical Application of Temporary External Fixator for Immediate Mandibular Reconstruction. *Journal of Craniofacial Surgery*, 30(4), e337–e342. <https://doi.org/10.1097/SCS.00000000000005303>