

## Research Article

# Gunshot Wounds to the Mandible: A 21-Year Urban Trauma Center's Experience

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### Abstract

**Purpose:** Gunshot wounds to the mandible are complex injuries that are difficult to treat and have a high complication rate [1]. This study examined an urban trauma center's experience in the methods of treatments used and the outcomes of mandibular gunshot wounds.

**Methods:** A retrospective review of the trauma center registry identified 105 patients with gunshot wounds to the mandible treated between February 1991 and December 2012. Sufficient data was found on 67 patients and descriptive information was collected regarding demographic information, fracture location, and treatment regimen. Outcome data was measured in patients with documented follow-up of 4 weeks or longer.

**Results:** A total of 67 patients with mandible fractures due to gunshot wounds were identified. The mean patient age was 30.8 years (range, 15 - 71 years), with most patients being male (86.6%). The mandibular angle was the most commonly affected region (43.4%) followed by the mandibular body (36.3%). 40.3% of patients presented with multiple mandibular fractures. Of the 60 patients who underwent surgical management, 22 (36.6%) underwent closed reduction with Maxilla-Mandibular Fixation (MMF), 3 (5%) underwent external fixation only, 2 (3.3%) underwent MMF and external fixation, 12 (20%) underwent Open Reduction and Internal Fixation (ORIF), and 21 (35%) underwent ORIF with MMF or external fixation. Fifty patients had adequate follow-up time ranging from 4 to 530 weeks (median 18 weeks.) From this group, we identified 19 major and 1 minor complication (42%). Minor complications included complications managed in an outpatient setting (infection treated with oral antibiotics, seroma, etc.). Major complications included infected hardware, infection requiring incision and drainage, non-union, malocclusion, and extrusion of hardware.

**Conclusions:** Mandibular fractures as a result of gunshot wound injury are devastating injuries often characterized by multiple fractures, comminuted fractures, and large areas of missing bone [1,2]. The common presentation of multiple facial fractures and significant anatomic displacement are frequent indications to treat with ORIF [3]. The results of our study show that the complication rate in patients treated with ORIF remains high. The patients included in this study had variable clinical presentations, and we can only conclude that treatments other than ORIF, such as closed reduction with MMF or external pin fixation, must still be considered [1,3-5].

**Keywords:** Fracture; Gunshot wound; Mandible; Maxilla-Mandibular Fixation; Rigid fixation

## Introduction

Gunshot wounds to the head and neck are complex injuries that pose a unique challenge to healthcare providers. Mandibular injury secondary to gunshot wounds occurs frequently [6]. Presentations of these injuries are highly variable and multiple treatment techniques have been described in the literature [7,8]. Historically, closed reconstructive techniques including Maxilla-Mandibular Fixation (MMF) and external fixation were often preferred. It is theorized that by avoiding periosteal stripping and minimizing osseous devitalization, blood supply to the bone would be optimized [2,9-11]. However, with the advancement of biocompatible titanium plating systems and surgical techniques, open reduction of the fracture with rigid internal fixation has become a widely used treatment modality [7,12-15].

The purpose of this study is to examine outcomes of all patients who were treated for mandibular gunshot wounds at the Virginia Commonwealth University Medical Center. We focused our study on fracture characterization, treatment method, and associated complications.

## Methods

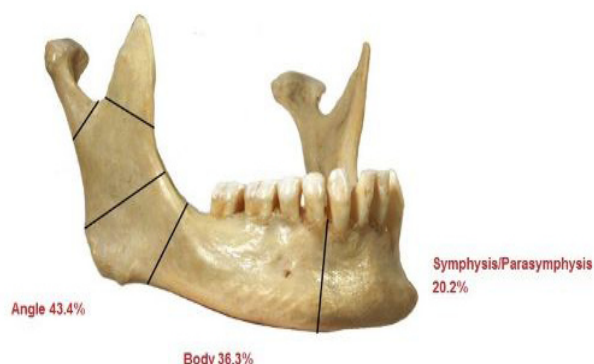
We performed a retrospective review at the Virginia Commonwealth University Medical Center for all patients who have sustained gunshot wounds to the mandible from February 1991 through December 2012. Using a computerized search based on ICD-9 code, 105 patients were identified in the trauma registry. Patients were treated by the plastic and reconstructive surgery, otolaryngology, and oral-maxillofacial surgery services. Individual chart review was performed and demographic information (gender and age) and fracture location (angle, body, and symphysis/parasymphysis) were recorded. Specific emphasis was placed on identifying all treatment regimens, follow-up periods, and associated complications. Treatment options included conservative management, MMF, external fixation, and Open Reduction and External Fixation (ORIF). For outcome analysis, inclusion criteria included a minimum follow-up period of 4 weeks. Associated complications were categorized into major and minor complication groups.

## Results

The initial database search identified 105 patients with mandible fractures secondary to gunshot wounds. 33 patients with insufficient documentation and 5 patients who expired from other injuries were excluded from the study. Analysis of the remaining 67 patients yielded a mean patient age of 30.8 years (range, 15 - 71

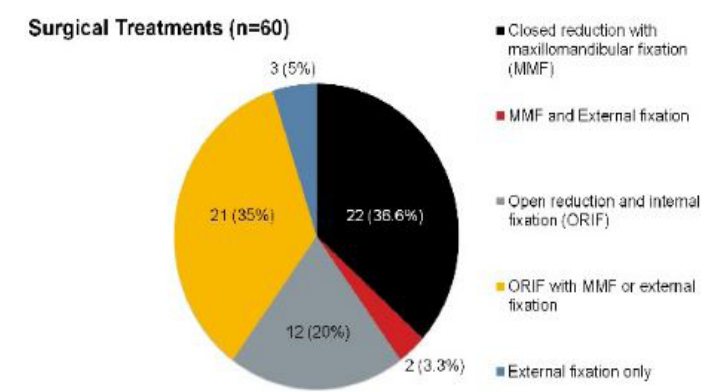
years), with a majority (58 patients, 86.6%) being male. 57 had associated Cause E codes (ICD-9-CM) available. 41 injuries (72%) were caused by an assault by handgun (965.0), shotgun (965.1), or other unspecified firearm (965.4). Twelve injuries (21%) were caused by self-inflicted wounds by handgun (955.0), shotgun (955.1), unspecified firearm (955.4), or firearms and explosives (955.9). Two injuries (3.5%) were caused by accident by handgun (922.0), or an unspecified firearm missile (922.9). Lastly, the remaining two injuries (3.5%) were caused by handgun (985.0) or shotgun (985.1) undetermined whether accidentally or purposely inflicted.

Twenty-six patients presented with Multiple Mandibular Fractures (40.3%). The distribution of the mandibular fractures can be seen in (Figure 1). The most commonly affected region was the mandibular angle (44 fractures, 43.4%), followed by the mandibular body (36 fractures, 36.3%), and symphyseal/parasymphyseal (20 fractures, 20%).



**Figure 1:** Distribution of mandibular fractures.

Of the 67 patients, 7 underwent conservative treatment. Surgical repair for the remaining 60 patients is depicted in (Figure 2). 24 patients (40%) underwent MMF. Of these 24 patients, 2 patients were also fitted with external fixators. 3 patients (5%) were treated with external fixation alone. The remaining 33 patients (55%) underwent ORIF with rigid plating systems. 21 of these patients who were placed in ORIF were also placed, either initially or simultaneously, in MMF or external fixation. 2 patients were also treated with a vascularized free fibula graft. Follow up for these patients were not sufficient to comment on their postoperative outcomes. Additionally, 11 patients were treated with an iliac crest bone graft. 1 out of the 11 became infected and was replaced by an osteocutaneous distal radial free flap. The bone graft was performed in 2009 and the radial free flap was performed in 2011. The patient was followed for 2 years post operatively and there were no complications during that time.



**Figure 2:** Surgical management for patients undergoing operative treatment. (n=60).

Complications were evaluated in 50 patients who had a minimum follow-up time of 4 weeks. The median follow-up time was 18 weeks and ranged from 4 weeks to 530 weeks. From this group, 15 patients experienced post-operative complications and 5 of these patients experienced multiple complications. A total of 20 complications were identified (19 major and 1 minor complication). Major complications included infected hardware, infection requiring incision and drainage, non-union, malocclusion, and extrusion of hardware. Minor complications included issues that were managed in an outpatient setting (infection treated with oral antibiotics, seroma, etc.). A summary of all identified complications is provided in (Table 1).

Surgical Treatment Group	Major complications	Minor complications
	(infected hardware, infection requiring incision and drainage, non-union, malocclusion, extrusion of hardware)	(infection treated with oral antibiotics, seroma)
MMF	1	
MMF, external fixation	2	
External fixation	2	1
ORIF	4	
ORIF, MMF	8	
ORIF, external fixation	2	
Total	19	1

**Table 1:** Summary of major and minor complications identified in surgical treatment groups.

Of the 11 patients who received bone grafts, 6 patients initially underwent ORIF without external fixation and need for

bone graft was deemed a result of complications from the primary surgery: 2 patients of the 6 complications that had bone grafting were secondary to mandibular defects one performed in 2003 and the other in 2004, 1 was from chronic osteomyelitis performed in 2009, 1 was to fill a soft tissue and bone defect performed in 1993, 1 was from exposed hardware performed in 2007, and 1 was to repair a continuity defect performed in 2004. The other 5 patients who had bone grafting, were performed on patients that had external fixation devices. Bone grafting in these individuals were not categorized as procedures secondary to complications.

External fixation, with or without MMF or ORIF, had a complication rate of 50%. 1 case had a seroma that was drained in office, 2 cases had abscesses that required intraoperative incision and drainage, and 1 had hardware exposure. The rates of major complication for ORIF and ORIF with MMF are 33% and 38%, respectively. MMF alone had a major complication rate of 4.5% (1 out of 22 patients), which an infection secondary to a fistula formation that required I&D.

Discussion

While firearm injuries involving the mandible are an uncommon cause of mandible fractures, the resultant injuries are some of the most devastating [16]. Mandibular fractures resulting from firearms are highly destructive injuries often characterized by multiple fractures, comminuted fractures, and large areas of missing bone [1,2,17]. Fracture patterns based on gunshot wounds to the mandible have been previously described. Most published studies have noted a higher incidence of fractures located in the symphysis/parasymphysis region overall, with gunshot wounds mainly occurring in the mandibular body [18]. Our series noted a similar fracture pattern secondary to mandibular gunshot wounds, which mainly occurred in the body and angle (Figure 3).



**Figure 3:** Pre-operative image (A) of patient who sustained a gunshot wound injury to the mandible. Post-operative image. (B) After soft tissue repair and external fixation.



Treatment and reconstructive options must be tailored to the specific needs of the population served. This variability inadvertently provides an increased number of treatment and reconstructive options in dealing with mandibular gunshot wounds. Overall, management of firearm injuries to the mandible has evolved over the last 50 years and although rigid internal fixation techniques have become more widely utilized, a definitive consensus on treatment on fractures secondary to gunshots has yet to be elucidated [1,5,12].

The use of ORIF in the treatment of gunshot wounds to the mandible has advantages as well as disadvantages over the use of MMF. ORIF remains a viable treatment option for patients with minimally displaced fractures and localized area of comminution [12]. Advantages include: significantly shortened treatment course, quicker return to function, potential for better oral hygiene and nutrition, often single-stage definitive treatment, and direct visualization of bone fragments allowing better anatomic reduction [1,3,4,19-21]. Benefits of MMF with or without external fixation are that it provides stabilization of a fracture without the risk of disrupting the vascular supply to the fracture, is most cost effective, and has less risk of postoperative infection [3,4,16,21].

We do not have adequate numbers of patients undergoing free tissue transfer or external fixation to draw meaningful conclusions from these groups. Studies have shown that these have been well established options for reconstruction in the setting of mandibular trauma with large enough defects requiring free tissue transfer [22]. Complications in patients who underwent bone grafts to those who did not have bone grafting is revealing. In our study, bone grafting was reserved for reconstructing previously performed ORIF that had a complication in 55% of cases (6 out of 11). The other 45% (5 out of 11) cases that underwent bone grafting were planned procedures.

The results of our study show that the complication rate for patients who are treated surgically remains high. In our study, our overall complication rate of 40% is similar to previous reports in the literature [1,5]. External fixation, with or without MMF or ORIF, had a complication rate of 50%. The rates of major complication for ORIF and ORIF with MMF are 33% and 38%, respectively [23]. MMF alone had a major complication rate of 4.5%. The most likely reason that patients who underwent external fixation suffered higher complication rates was not necessarily the use of external fixation itself, but nature of their complex injury. External fixation is reserved for fracture patterns that are unable to be reduced with either closed reduction or ORIF [24].

Our study is a retrospective review in which the cases had variable clinical presentation and different operative surgeons under different specialties. This makes it difficult to elucidate a

meaningful relationship between treatment modalities and their direct causality in complication rates. Previous studies have suggested a positive correlation between the severity of the injury and the complications after treatment [1,24].

A limitation to this study would be the patient population who suffer from gunshot wounds. Our study did not compare the rates of uninsured or noncompliance and how it could affect the rates of complication. Other studies have compared these factors in trauma and specifically gunshot wound patients. Most patients in this population are uninsured [24]. Also, to this date, there is no literature comparing post-operative compliance in this patient population. This may be representative of the complexity in treating this patient population. There are many factors that work congruently in affecting outcomes. While higher complication rates and in some cases death tends to be associated with trauma patients that are uninsured, this is an association not necessarily a cause.

## Conclusion

Our study shows the varied management of traumatic gunshot wounds to the mandible over the past 21 years at an urban trauma center. Although the overall complication rates are similar to literature already published, it is not without caveats. The number of surgeons who operated on the 60 patients varied from different surgical services. Also, out of the patients treated with ORIF 21 out of the 33 patients (64%) were treated in conjunction with MMF thus clouding the differentiation of complications from ORIF versus MMF alone. These factors make it difficult to ascertain the exact causes of surgical complications postoperatively.

As noted in the discussion, external fixation with or without MMF or ORIF had an extremely high complication rate. This may be attributed to the complexity of the injury itself and not necessarily the use of the external fixation device. This same conclusion could be drawn in comparison to major complication rates among ORIF, ORIF with MMF, and MMF alone where MMF alone had the lowest complication rate and patients that received ORIF had a higher complication rate.

Gunshot wounds remain a rare cause of mandibular trauma. Determining a consensus on approaches to treatment of gunshot wounds to the mandible remains elusive. Our study shows a wide variety of treatment methods and modalities. It relies heavily on surgeon preference and training. Further prospective studies will be needed to fully establish a standard of care for treatment of mandibular injury secondary to gunshot wounds. Due to the wide variety of traumatic injuries and treatment options for gunshot wounds to the mandible, this may prove to be difficult. Ultimately, the choice of reconstructive technique is based on the patient presentation, fracture characterization, and surgeon experience.

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