



# Locked Bridge Plating is a Suitable Option for Forearm Fractures Secondary to Civilian Low Velocity Gunshot Injuries

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## Abstract

**Introduction:** The purpose of this retrospective study is to compare the outcomes of low velocity gunshot fractures of the forearm treated with minimal debridement and locked bridge plating to patients treated with formal debridement and conventional plating.

**Materials and Methods:** A 10 year IRB approved retrospective review of our national trauma database was conducted. Initial treatment consisted of wound care and sterile dressing. Forearm radiographs were acquired to determine bony involvement. All patients received intravenous antibiotics upon presentation to the emergency department and for a minimum of forty-eight hours after admission or operative intervention. Patients were placed into two categories of operative or nonoperative treatment. Those placed into operative treatment were further divided into the subcategories of formal debridement and plating or minimal debridement and plating.

**Results:** 94 patients were included in the study. 29 were treated nonoperatively and 65 were treated operatively. Of those 65, 30 underwent minimal debridement and bridge plating and 35 were treated with formal debridement and bridge plating. All patient radiographs displayed fracture healing at latest follow-up with no evidence of infection or osteomyelitis. Nerve injuries were found among 15 patients and vascular injuries were present in 7.

**Conclusions:** Both methods of irrigation and debridement resulted in reliable osseous union with no instances of osteomyelitis. These results suggest that immediate locked bridge plating with minimal debridement is a suitable option for the treatment of forearm fractures following low velocity gunshot injuries.

**Keywords:** Irrigation; Debridement; Forearm; Gunshot; Fracture; Minimal

## Introduction

There are 300,000 injuries and 30,000 hospitalizations from gunshot wounds annually in the United States [1-3] primarily from low-velocity handguns. These weapons produce less soft-tissue injury than high-velocity rifles or shotguns attributed to lower mass, velocity and energy transfer of the projectiles to surrounding tissues [4, 5]. Gunshot wounds of the forearm have been reported in several small series in the literature; however, no treatment guidelines backed by adequate scientific evidence exist. Prior studies with limited numbers have recommended debridement irrigation,

antibiotics and compression plating for displaced fractures of one or both bones, and immobilization for undisplaced simple fractures of single bones. We feel that aggressive debridement and conventional compression plating may not be practical for these injuries which often have bony comminution but minimal soft tissue injury. A potential alternative is limited debridement and bridge plating. The purpose of this study is to compare the outcomes of low velocity gunshot fractures of the forearm treated with minimal debridement and locked bridge plating to patients treated with formal debridement and conventional plating.

## Materials and Methods

An IRB approved 10-year retrospective review of our hospital trauma database revealed one-hundred and one patient admitted to the hospital with forearm fractures following gunshot wound (2000-2010). Seven patients were excluded from the study as their injuries were the result of a high-velocity firearm, leaving ninety-four patients treated for gunshot wounds of the forearm with hospitalization. Patients who were discharged from the emergency room with gunshot wounds with or without fractures and patients who left the hospital against medical advice prior to treatment were not captured in this database. There were eighty-three males and eleven females. The average age was 27.7 years with a range of 16-52 years. The average duration of follow-up of all patients was 27.3 months with a range of 9 to 105 months. Treatment was initiated with wound care by applying a sterile dressing in the emergency department. Forearm radiographs were acquired to determine bony involvement. Clinical suspicion of limb ischemia by physical exam was an indication for angiography. All patients received intravenous antibiotics upon presentation to the emergency department and for a minimum of forty-eight hours after admission or operative intervention. The initial antibiotic selected was cefazolin with or without gentamicin, and some patients with concomitant thoracic or abdominal injuries received additional antibiotics for greater time periods. Patients with non-displaced or minimally displaced fractures were treated non-operatively with local wound care, antibiotics, and casting. Displaced fractures were divided into 2 groups.

During the first 5 years 35 patients underwent aggressive debridement and irrigation of wounds, fracture stabilization using

compression plating techniques when feasible and bridge plating when there was bone loss. Antibiotic cement spacers were placed where there was bone loss followed by delayed grafting using iliac crest bone. Eight were stabilized with initial external fixation followed by plating and 27 had immediate plate fixation. The second 5 years included 30 patients treated with open reduction and internal fixation (ORIF) with a bridge plating technique, limited irrigation and debridement of entry and exit wounds locally at the level of skin and subcutaneous tissue without debridement of bone. This was intended to minimize soft tissue stripping around the fracture site. Bullet fragments were not disturbed unless they were superficial and easily removed without further damaging the surrounding soft tissues. Entrance and exit wounds were not closed primarily. Patients with non-displaced or minimally displaced fractures (29) were treated non-operatively with local wound care, antibiotics and casting. These were often admitted for concomitant injuries and thus were picked up in our database. We reviewed all radiographic images obtained at presentation and during treatment. Fractures were classified as radius, ulna or both (Figure 1). The fracture location was noted whether they were proximal, midshaft or distal and if they were non-displaced or minimally displaced versus comminuted and displaced. Radiographic data were used to determine the status of fracture healing or hardware failure. Patients were examined in the clinic (Figure 2) to assess for fracture healing, infection, presence of deformity, sensory or motor deficits, and range of motion. Range of motion was classified as good (<10 degrees flexion extension loss and <25 degree pronation/supination loss), satisfactory (<30 degree flexion extension loss and <50 degree pronation/supination loss) or poor (>30 degree flexion extension loss or >50 degree pronation/supination loss)



Figure 1: Radiographic images of, isolated radial, isolated ulna, and both bone fractures.



Figure 2: Example of soft tissue wound clinical examination.

### Results

#### Operative Treatment

Sixty-five patients were treated operatively. Thirty patients underwent bridge plating and minimal debridement of the gunshot wounds without excision of only frankly necrotic tissue and minimal to no bone debridement and no bone grafting (Figure 3). Thirty-five patients were treated with formal irrigation and debridement of the wounds and stabilization (Figure 4). Of the thirty patients with bridge plating and limited debridement twenty-nine patients

displayed fracture healing at their latest follow up and one patient required revision surgery for delayed union. There were no signs of infection or osteomyelitis at final follow up. Of the thirty-five patients treated with more aggressive irrigation and debridement with fracture stabilization, seven patients were determined to have more extensive soft tissue injury requiring multiple surgeries and more aggressive debridement and eventual soft tissue coverage. Five of these seven required early bone grafting after original damage control surgery and prior to soft tissue reconstruction. All patients displayed radiologic evidence of healing at their latest follow up with no patient showing signs of infection or osteomyelitis.



Figure 3: Example of patients treated with minimal debridement and locked bridge plating.

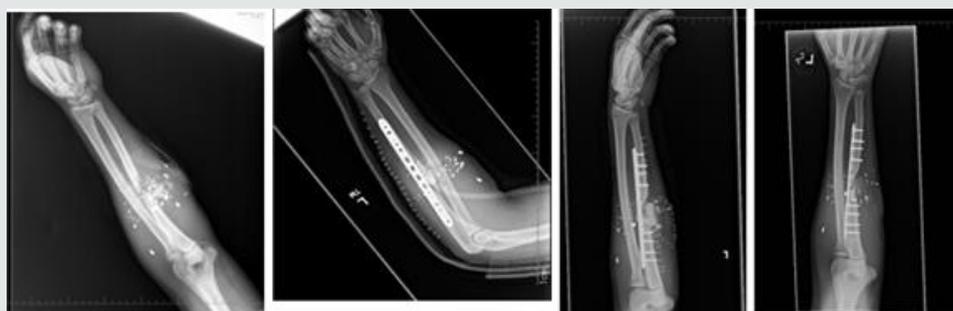


Figure 4: Example of patients treated with formal debridement and plating.

## Non-Operative Treatment

Twenty nine patients were treated non-operatively with local wound care and casting for forearm fractures. All patients had a single bone non-displaced or minimally displaced fracture. All patients displayed radiographic evidence of fracture healing at their latest follow up with no patient showing signs of infection or osteomyelitis. Range of motion in this subset was determined to be satisfactory or good at final follow up.

## Nerve Injuries

There were fifteen patients with an associated nerve injury. The ulnar and median nerve were the most common nerves injured (six patients each) followed by the radial nerve in four patients and the palmar cutaneous nerve and anterior interosseous nerves in one patient each. Three patients had multiple nerve injuries. In seven patients the nerve injury resolved completely and in five patients a partial nerve deficit was observed. Three patients showed no recovery with one patient displaying a classical ulnar claw hand deformity.

## Vascular Injury

Seven patients presented with signs of associated vascular injury of the forearm. There were four radial artery injuries and four ulnar artery injuries. One patient had both arteries injured and repaired. All patients had a viable limb on follow up. Three patients had nerve injury associated with vascular injury. One patient developed a compartment syndrome requiring fasciotomy.

## Discussion

Early stabilization of forearm fractures is important after a gunshot injury and the management of the open wound and soft tissue injury is always an important consideration for surgical planning. In this study, we showed that minimal irrigation and debridement of the entrance and exit wounds is adequate for low velocity gunshot injuries to the forearm with minor visible soft tissue injury, and that bridge plating with minimal surgical dissection through the zone of injury is sufficient to achieve reliable union of these fractures. Dicipinigitis, et al. showed that most non-displaced fractures of the radius or ulna can be effectively managed with casting in their review of the literature addressing gunshot wounds to the extremities, but displaced fractures should be treated operatively with compression plating [4]. reported superior results in patients treated with delayed primary ORIF with displaced forearm fractures secondary to gunshot wounds [12]. In the same study, no patients treated by delayed ORIF went on to malunion or delayed union, but all patients did have decreased range-of-motion, particularly pronation and supination. Rodrigues, et al. recommended a treatment protocol involving early wound care and provisional stabilization followed by definitive treatment with internal fixation within one week [18-20]. In our review, thirty five patients were successfully treated with a more extensive soft

tissue debridement with fracture stabilization, and thirty patients with comminuted and displaced fractures were effectively treated with local wound care followed by internal fixation with bridge plating.

Several studies have also examined the effectiveness of non-surgical treatment in non-displaced or minimally displaced forearm fractures resulting from low-velocity firearms. Elstrom, et al. reported on fourteen patients that were treated with casting [12]. In eight non-displaced single bone fractures, seven had good outcomes. In six displaced fractures, closed reduction and casting lead to poor outcomes in four patients. Lenihan, et al. reported on thirty-seven patients with civilian gunshot wounds to the radius and ulna [13]. Twenty-three patients with non-displaced fractures were treated by closed means with twenty-one showing good outcomes. However, in the fourteen patients with displaced fractures, the outcomes of the eight patients who had closed reduction were worse than the six patients treated surgically. Dickson, et al. prospectively evaluated patients with non-displaced fractures treated as outpatients with closed reduction and casting [3]. Only one patient in their study went on to delayed union [3]. also reported excellent results in patients of non-displaced fractures treated with closed reduction in a long arm cast, with seven of eight patients showing evidence of fracture healing and good functional outcome. The same study reported that four out of six patients with comminuted and displaced fractures treated with casting went on to malunion or delayed union resulting in a poor functional outcome. The authors concluded that closed reduction has satisfactory results in non-displaced fractures while displaced fractures require internal fixation to achieve superior outcomes. In our retrospective review we found similar results and agree that patients with minimally displaced or non-displaced extra-articular fractures can be adequately treated with closed reduction and casting without surgical debridement. We add to these findings that extensive surgical debridement can also be withheld with low risk of infection or nonunion after bridge plating for fracture stabilization.

Past studies have shown that bullets are not sterilized during discharge of the weapon and may act as a vector introducing pathogenic bacteria into the wound [4]. Controversy exists, however, as to the necessity of administering prophylactic antibiotics to this patient population. Patzakis, et al. demonstrated an infection rate of 13.9% in patients with open fractures resulting from gunshot wounds not treated with antibiotics and an infection rate of 2.3% in patients treated with cephalothin [7]. The study also showed no statistically significant difference in infection rate between the control group (13.9%) and a group treated with penicillin and streptomycin (9.7%) [7]. Conversely investigated the efficacy of antibiotics in a similar patient population and showed no significant difference in infection rate between the control group and the experimental group treated with at least twenty-four hours

of intravenous cefazolin [2]. concluded in a prospective study that short-term intravenous antibiotics did not decrease the risk of infection [9]. recommended the use of prophylactic antibiotics in high-velocity and intra-articular injuries but did not support the use of prophylactic antibiotics for low-velocity injuries [10]. Howland and Ritchey in a retrospective analysis concluded that prophylactic antibiotics were unnecessary in the treatment of low-velocity gunshot fractures [11-20]. In our study, all patients were treated with intravenous first generation cephalosporin antibiotics, and in some cases additional antibiotics to treat other concurrent injuries. As no patient in our review developed osteomyelitis even with a large subset undergoing limited debridement, we support the use of a first-generation cephalosporin for 48 hours in patients reporting with open forearm fractures secondary to low-velocity gunshot wounds.

We recognize the following limitations of our study. First, it is retrospective in nature and carries all the associated risks of bias. It is additionally possibly biased towards more severe injuries since all included patients were admitted for at least 48 hours. Patients with minor gunshot forearm injuries and treated as outpatients had variable antibiotic regimens or no antibiotics and were not captured in this database. Thirdly, the patient population of this study is small, although it is larger than previously published studies. Furthermore, we had difficulty in contacting patients in our study for longer term follow up.

## Conclusion

Forearm fractures caused by low velocity gunshot wounds in a civilian setting are often comminuted single bone injuries with minor soft tissue injury. Both the aggressive and limited debridement regimens resulted in reliable osseous union and no instances of osteomyelitis. These results suggest that immediate locked bridge plating with minimal debridement is a suitable option for the treatment of forearm fractures following low velocity gunshot injuries.

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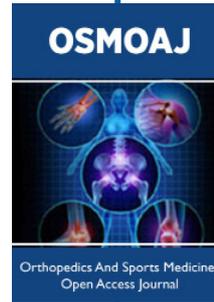
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