

Management of gunshot wound-related hip injuries: A systematic review of the current literature

Ilene Tisnovsky, Simon D. Katz, Jorge I. Pincay, Lucas Garcia Reinoso, James A.I. Redfern, Scott C. Pascal, Bradley C. Wham, Qais Naziri, Nishant Suneja*

Department of Orthopaedic Surgery and Rehabilitation Medicine, State University of New York (SUNY) Downstate Medical Center, Brooklyn, NY, USA

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ABSTRACT

Purpose: To propose a gunshot wound-related hip injury algorithm and improve patient outcomes.

Methods: Multiple online databases were queried to identify studies reporting on management of gunshot-wound hip injury.

Results: Of 47 papers included, 5 and 14 studies recommended surgical intervention for the treatment of low- and high-velocity gunshot wounds, respectively, and 1 paper advocated the use of prophylactic antibiotics in the treatment of high-velocity injuries. All remaining papers had mixed and conflicting results.

Conclusion: Various therapeutic strategies have been used for the management of gunshot wound-related hip injuries but further prospective studies are necessary to determine the optimal therapeutic modality.

1. Introduction

Every year, 113,000 people in the United States (US) are shot; 2% of whom present with gunshot wound (GSW) injuries to the hip.¹ Using a velocity cut-off of 2000 feet per second, gunshot wounds are divided into low and high-velocity.² Low-velocity gunshots are much more common occurring from most hand-held guns, while the latter originate from shotguns and military rifles. The distinction is important due to the difference in energy imparted and resulting amount of tissue destruction.

Although lacking a clear standard protocol, low energy GSW to the hips have conventionally been treated with antibiotics and local debridement. Surgical intervention is indicated in cases requiring fracture stabilization or removal of intraarticular missiles or loose bodies.³ One review of the outcomes of low-energy gunshot wounds to the lower extremities treated in a level one trauma center recommends that the treatment plan of all gunshot injuries, to any body part, be determined by the flight, speed, mass, behavior, and type of bullet.⁴ Lastly, Tornetta et al. in a review of intraarticular knee GSWs found arthroscopic evidence of intraarticular debris, meniscal or chondral injury in 71% of knees. There was no evidence of injury or foreign body on the plain films and thus, Tornetta et al. recommended against using imaging as the basis for nonoperative management.⁵ While these recommendations can

be considered, there is no treatment protocol regarding GSWs of the hip.

In the following study, we discuss cumulative evidence in hip fracture management following GSWs and propose a therapeutic algorithm to improve patient outcomes and survivorship. Currently, there is a lack of reliable information regarding gunshot wounds to the hip. The goal of this study is to fulfill the need for published literature on this specific injury.

2. Materials and methods

PubMed, Embase, Cochrane Library, Scopus, and Web of Science databases were systematically searched up to September 3, 2020 for studies reporting gunshot-related hip injuries. The search syntax used included the keywords “gunshot wound”, “hip”, “gunshot wound”, and “hip fracture”. Additionally, articles were obtained from full-text manuscript reading. The literature was then checked for eligibility. Case reports, commentaries, and expert opinions were excluded from the analysis. Systematic reviews and retrospective case-control studies were checked for eligibility to ensure they reported hip-specific GSWs. Study participants in different age ranges with hip specific GSWs were included in the study without restricting nationality, sex, or race. Articles were then classified by whether they described injuries sustained from high-velocity or low-velocity weapons. Within this division, each

* Corresponding author. Department of Orthopaedic Surgery and Rehabilitation Medicine SUNY Downstate Medical Center, 450 Clarkson Ave, MSC 30, Brooklyn, NY, 11203, USA.

E-mail address: nsuneja@gmail.com (N. Suneja).

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article was then separated even further by treatment: debridement, antibiotic, and surgical management. These different variables determined the organization of this study. These treatments were deemed successful if the patients did not develop an infection and continued to a healthy recovery.

3. Results

A flow diagram describing the selection process of retrieved articles is depicted in Fig. 1. The search syntax used included the keywords “gunshot wound” AND “hip”, which produced 139 results, “gunshot wound” AND “hip fracture”, which produced 27 results. Additionally, 36 articles were obtained from full-text manuscript reading. The literature search yielded a total of 202 articles, which were then checked for eligibility using the PRISMA algorithm for literature reviews. Once the 202 articles were analyzed, 72 articles were screened out due to irrelevant titles and/or abstracts, 35 case reports were excluded, and 48 articles were removed due to improper comparison or control or irrelevant/unavailable outcomes. Excluding the articles that did not meet the criteria, 47 papers were deemed eligible to be included in the study (Table 1).

3.1. Low-velocity gunshot wounds

3.1.1. Debridement

Sathiyakumar et al. performed a systematic review of articles that used debridement as a treatment of low-velocity GSWs.⁶ They recommended superficial debridement instead of extensive irrigation and debridement when there is no need for surgical fracture fixation, no vascular injuries, and no large tissue defect because patients who were treated with superficial debridement had a lower infection rate than patients who endured extensive debridement. However, owing to the design of the studies included in their analysis, they were incapable of conclusively evaluating the therapeutic value of debridement in the management of low-velocity GSW. Despite the literature being clear, they found that the few numbers of high-quality studies restricted them from making any definite recommendations. A retrospective chart review of 42 gunshot fractures identified 10 and 9 patients with hip and acetabular fractures, respectively.⁷ The 42 patients were treated at a level 1 urban trauma center from 1999 to 2008. The average age was 30.0 years and ranged from 19 to 54 years. Two of the patients were female and 40 were male. Although half of the patients with hip fractures endured an incision with irrigation and debridement of the joint in

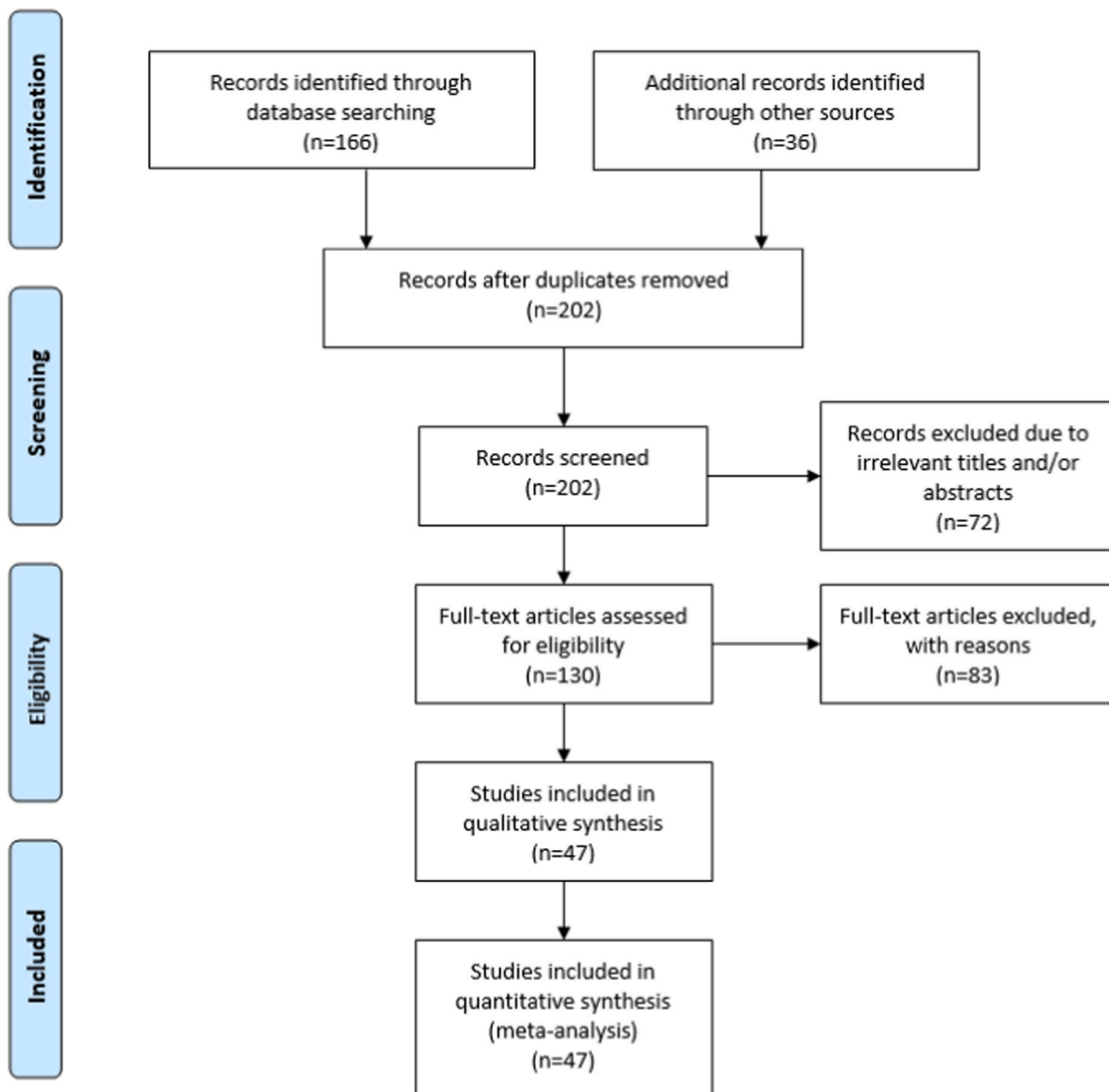


Fig. 1. The PRISMA flow diagram adopted in the current systematic review.

Table 1
Studies included in the current systematic review.

Study	Study Design	Sample Size	Research Topic	Outcomes
Maqungo et al. ¹	Retrospective study	10	Efficacy of surgical hip dislocation for removal of retained intra-articular bullets	<ul style="list-style-type: none"> •Surgical hip dislocation provides an unlimited view of the acetabulum, head, and neck, and allows for easy removal of retained bullets
Dicpinigaitis et al. ²	Systematic review	NA	Operative management of hip ballistic fractures	<ul style="list-style-type: none"> •Hip aspiration and arthrogram are warranted in the context of high-velocity gunshot wound to the hip •Immediate arthrotomy is required with associated abdominal injuries or intra-articular osseous fragments •Isolated gunshot-wound hip fractures can be electively managed with hip arthroplasty/fusion
Nguyen et al. ³	Retrospective study	53	Demographics, interventions, infection rates, and other complications after intra-articular hip gunshot wounds	<ul style="list-style-type: none"> •Patients with vascular injuries are at higher infection risk compared to those without •Infection incidence after low-velocity gunshot injuries is low with routine antibiotic prophylaxis
Abghari et al. ⁴	Retrospective study	133	Outcomes of treating patients with a low-velocity hip gunshot wound via a standard protocol	<ul style="list-style-type: none"> •Gunshot victims are predominantly young men. •Complications included compartment syndrome, arterial injuries, and infection
Sathiyakumar et al. ⁶	Systematic review	3083	Operative treatment and antibiotic use for hip ballistic fractures	<ul style="list-style-type: none"> •In the absence of vascular injury, wound contamination, and compartment syndrome, superficial debridement for low-velocity ballistic fractures is a satisfactory alternative for irrigation and debridement •Extensive debridement seems necessary for all high-velocity gunshot fractures
Bartkiw et al. ⁷	Retrospective study	7	Civilian hip and pelvic gunshot wounds and surgical interventions	<ul style="list-style-type: none"> •Civilian gunshot wounds often require emergent surgery for vascular, visceral, and urogenital injuries •Orthopedic intervention is indicated for intra-articular pathology and acetabular/hip reconstruction
Rehman et al. ⁸	Retrospective study	24	Effectiveness of surgical debridement with gastrointestinal tract injuries in the setting of hip gunshot wounds	<ul style="list-style-type: none"> •Gunshot pelvic fractures do not require orthopedic fracture debridement even with gastrointestinal involvement •Debridement with bullet removal should be done in cases with intra-articular involvement
Najibi et al. ⁹	Retrospective study	38	Acetabular gunshot wounds patterns and poor outcome predictors	<ul style="list-style-type: none"> •Most common injuries associated with acetabular gunshot wounds are bowel involvement •Significant predictors of poor outcome are high velocity missiles •Successful treatment of bowel injury directly correlates with infection control
Dickson et al. ¹⁰	Prospective study	41	Open non-operative management of grade 1 or 2 hip fractures resulting from low-velocity missiles	<ul style="list-style-type: none"> •Patients with stable, low-velocity gunshot fractures are successfully treated with antibiotics
Hansraj et al. ¹¹	Prospective study	100	Efficacy of antibiotic therapy in the prophylactic management of extra-articular hip fractures due to low-velocity gunshot wounds	<ul style="list-style-type: none"> •Patients need not be hospitalized for longer than 2 days and improve greatly with the use of ceftriaxone
Geissler et al. ¹²	Prospective study	25	Irrigation and debridement with tetanus prophylaxis and a long-acting cephalosporin for low-velocity hip gunshot wounds	<ul style="list-style-type: none"> •Patients with low-velocity gunshot wounds do not need short-term intravenous antibiotics
Brettler et al. ¹³	Retrospective study	148	Conservative treatment of low-velocity hip gunshot wounds by wound dressing and systemic antibiotics	<ul style="list-style-type: none"> •Conservative management is appropriate in patients with low-velocity gunshot wounds
Marcus et al. ¹⁴	Prospective study	97	Treatment of low-velocity hip gunshot wounds with prophylactic antibiotics compared to surgical protocol	<ul style="list-style-type: none"> •Prophylactic antibiotics are comparable to more aggressive surgical protocol
Parisien et al. ¹⁵	Prospective study	61	Evaluation of the management of low-velocity hip gunshot fractures to the extremities with superficial care, immobilization, and antibiotics	<ul style="list-style-type: none"> •A limited approach for low-velocity gunshot wounds is valid but caution is advised to avoid infection
Navsaria et al. ¹⁶	Prospective study	239	Evaluation of the effectiveness of non-operative management of abdominal gunshot injuries	<ul style="list-style-type: none"> •Non-operative management of pelvic gunshot wounds is safe and an effective alternative to routine laparotomy
Dickey et al. ¹⁷	Prospective study	73	Evaluation of the prophylactic use of IV antibiotics to prevent infection following low-velocity hip gunshot fractures	<ul style="list-style-type: none"> •Infection prophylaxis did not change infection rates significantly
Hollmann et al. ¹⁸	Prospective study	26	Analyzed the treatment of low-velocity gunshot fractures of the femur with intra-medullary fixation	<ul style="list-style-type: none"> •Intra-medullary fixation followed by delayed closed intra-medullary nailing is an appropriate treatment with favorable outcomes in patients with low-velocity gunshot wounds
Cannada et al. ¹⁹	Prospective study	73	Examined the results of retrograde intra-medullary nailing of femoral diaphyseal fractures caused by low-velocity gunshots	<ul style="list-style-type: none"> •Intra-medullary nailing is a good alternative for these types of injuries due to low rates of shortening, angular deformity, and infection rates
Nowotarski et al. ²⁰	Retrospective study	37	Examined the effect of static interlocking nailing following low- and mid-velocity fractures of the femur	<ul style="list-style-type: none"> •Immediate interlocking nailing of the femur is an effective and safe treatment
Wiss et al. ²¹	Prospective study	56	Examined the efficacy of interlocking nailing for the treatment of femoral fractures due to gunshot wounds	<ul style="list-style-type: none"> •Interlocking nailing for femoral shaft fractures yielded low complications and is an appropriate treatment for such injuries
Levy et al. ²²	Prospective study	32	Evaluation of the efficacy of intra-medullary nailing used within 36 h to treat femoral shaft fractures caused by low-velocity gunshot wounds	<ul style="list-style-type: none"> •Immediate intra-medullary nailing is a safe, effective, and economic option
Nicholas et al. ²³	Prospective study	12	Evaluation of the efficacy of intra-medullary nailing within 8 h of injury to treat femoral fractures caused by gunshot injuries	<ul style="list-style-type: none"> •Immediate intra-medullary nailing of gunshot femoral fractures yields results similar to the treatment of closed femoral fractures
Wright et al. ²⁴	Prospective study	21	Evaluation of the efficacy of intra-medullary fixation to treat low-velocity gunshot-related femoral fractures	<ul style="list-style-type: none"> •Immediate internal fixation for treatment of low-velocity gunshots causing femoral shaft fractures is recommended
Bergman et al. ²⁵		65		

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Table 1 (continued)

Study	Study Design	Sample Size	Research Topic	Outcomes
Ryan et al. ²⁶	Prospective study Prospective study	143	Evaluation of 65 patients with femoral fractures that were treated with immediate intra-medullary nailing Evaluation of femoral shaft fractures due to low-velocity gunshot wounds for healing time, fracture alignment after healing, complication, and characteristics	<ul style="list-style-type: none"> •Intra-medullary nailing is an effective treatment for femoral fractures •There are low infection rates in patients with femoral shaft fractures secondary to low-velocity gunshot wounds •Debridement is necessary in such injuries
Peonim et al. ²⁷	Retrospective study	22	Evaluation of the characteristic of entrance and exit wounds secondary to high-velocity bullets	<ul style="list-style-type: none"> •Most entrance wounds had microtears but no collar abrasion •Exit wounds had various sizes and shapes depending on which section of wound ballistics exited
Atesalp et al. ²⁸	Prospective study	142	Evaluation of the efficacy of Ilizarov fixation and delayed primary closure for Gustily-Anderson type IIIa limb fractures caused by high-velocity gunshot wounds	<ul style="list-style-type: none"> •Type IIIa limb fractures caused by high-velocity gunshot wounds can be treated with this procedure, as it yields good outcomes
Dar et al. ²⁹	Prospective study	37	Evaluation of external fixation followed by delayed interlocking intra-medullary nailing in high-velocity gunshot wounds of the femur	<ul style="list-style-type: none"> •External fixation provides more than adequate stabilization to facilitate recovery •Delayed intra-medullary interlocking is an effective method of treatment of such injuries
Miric et al. ³⁰	Prospective study	17	Evaluation of patients with open fractures of the upper third of the femur using pelvifemoral external fixation device	<ul style="list-style-type: none"> •Stable fixation is difficult using external fixation, whereas the risk of infection is high following intra-medullary nailing •Pelvifemoral external fixation allows adequate management of soft tissue twounds and provides stable bone fixation, as well as allows early patient mobility
Rowley et al. ³¹	Prospective study	200	Evaluation of high velocity missile injuries to the hip treated with either traction or external fixation	<ul style="list-style-type: none"> •In an environment where facilities are limited and surgeons have only general experience, carefully initial wound excision is the most important factor determining outcomes
Nikolic et al. ³²	Prospective study	41	Evaluation of treatment results of subtrochanteric missile fractures of the femur	<ul style="list-style-type: none"> •External fracture fixation facilitates the care, stability, and soft tissue repair needed to treat these injuries
Mack et al. ³³	Retrospective study	41	Evaluation of the treatment of proximal open femoral fractures that are sustained from high-velocity gunshot wounds	<ul style="list-style-type: none"> •Cephalomedullary nail fixation of type III subtrochanteric and pertrochanteric femoral fractures is effective
Tornetta et al. ³⁴	Retrospective study	36	Evaluation of anterograde interlocking nailing as a technique for distal femoral fractures after gunshot wounds	<ul style="list-style-type: none"> •Anterograde interlocked intra-medullary nailing is an effective means of fixation for distal femur fractures
Sclafani et al. ³⁵	Prospective study	14	Evaluation of patients seen 6 weeks to 7 years after gunshot wounds for lead arthropathy	<ul style="list-style-type: none"> •Arthritis can be caused by lead poisoning •Lead deposit within cells that is then deposited extracellularly can cause synovial hypertrophy with chronic inflammation and fibrosis
Brien et al. ³⁶	Prospective study	10	Evaluation of the complication of septic arthritis when gunshot wounds to the hip are complicated by involvement of the alimentary tract	<ul style="list-style-type: none"> •Early diagnosis, diverting colostomy, and immediate arthrotomy are recommended for gunshot wounds to the hip involving the alimentary tract
Watters et al. ³⁷	Retrospective study	56	Evaluation of the use of surgical debridement in the management of low-velocity gunshot injuries	<ul style="list-style-type: none"> •There is no increased incidence of infection in the absence of aggressive surgical debridement of pelvic gunshot wounds •Bullets and bullet fragments do not increase the risk of infection even after penetrating GI tract organs
Knapp et al. ³⁸	Prospective study	190	Compared the use of IV and oral antibiotic therapy in the treatment of low-velocity gunshot fractures	<ul style="list-style-type: none"> •Oral and IV antibiotics are equally effective for prophylaxis against infection from a low-velocity gunshot wound
Woloszyn et al. ³⁹	Retrospective study	126	Evaluation of the efficacy of superficial debridement and antibiotic therapy in management of low-velocity gunshot fractures to the hip	<ul style="list-style-type: none"> •All low-velocity gunshot fractures can be managed with superficial debridement and antibiotics •There is no advantage found between oral and IV antibiotic therapy
Papasoulis et al. ⁴⁰	Systematic review	NA	Evaluation of the use of antibiotics in the treatment of low-velocity gunshot-induced fractures to the hip	<ul style="list-style-type: none"> •There is no significant benefit in the use of antibiotics versus operatively •Oral antibiotics are as effective as IV antibiotics
Miller et al. ⁴¹	Prospective study	176	Evaluation of the treatment of <i>trans</i> -abdominal gunshot wounds of the hip and pelvis that affect the GI tract	<ul style="list-style-type: none"> •Intra-articular gunshot wounds should be urgently debrided and irrigated, whereas extra-articular wounds should be managed with observation and antibiotics
Howse et al. ⁴²	Prospective study	7	Evaluation of the efficacy of arthroscopy for bullet removal from the central and peripheral compartments of the hip joint	<ul style="list-style-type: none"> •Arthroscopy is an appropriate, minimally invasive procedure for bullet removal •The procedure, however, carries a risk of extravasation
Pazarci et al. ⁴³	Retrospective study	10	Evaluation of the use of total hip arthroplasty in the treatment of gunshot wounds to the hip	<ul style="list-style-type: none"> •Total hip arthroplasty is an appropriate procedure for young patients, however, carries a high risk of infection in patients with GI involvement
Naziri et al. ⁴⁴	Prospective study	4	Examination of the presence of post-traumatic arthritis after a gunshot wound to the hip and an effective way to treat	<ul style="list-style-type: none"> •Total hip arthroplasty is an effective way to prevent post-traumatic arthritis after a gunshot wound
Long et al. ⁴⁵	Retrospective review	53	Evaluation of the need for arthrotomy in gunshot wounds that traverse the abdominal tract	<ul style="list-style-type: none"> •Immediate arthrotomy is required in patients with gunshot wounds that traverse the abdominal tract •If an arthrotomy is not performed, the physician must follow the patient due to high risk of infection

order to remove bullet fragments, all fractures healed regardless of their therapeutic management. However, the research team advocated irrigation and debridement in all hip-associated low-velocity GSWs to mitigate the imminent contamination and ensuing infection risk.

3.1.2. Antibiotics

Despite acknowledging the need for higher level of evidence to draw definitive guidelines regarding antibiotic administration in the management of low-velocity GSW, Sathiyakumar et al. recommended a short course of antimicrobial agents for fractures that do not require surgical treatment.⁶ Nguyen et al. conducted a web-based study across 172

Orthopedic Trauma Association (OTA) members. The study found that infection incidence after low-velocity gunshot injuries is low with routine antibiotic prophylaxis. Rehman et al. evaluated 84 patients with pelvic gunshot fractures and bowel injuries, of whom 15 (17.9%) had acetabular fractures treated nonoperatively (6 patients) or surgically (9 patients).⁸ All individuals in the nonoperative group achieved a successful recovery with antibiotics alone. Najibi et al. evaluated 39 acetabular fractures spanning a 13-year period, 32 of which stemming from a low-velocity mechanism.⁹ These 32 patients all received intravenous antibiotics, consisting of first or third generation cephalosporins based on the absence or presence of an associated intra-abdominal injury, respectively. Surgical treatment of 21 fractures included irrigation, debridement, and removal of the bullet. The authors recommended immediate antibiotic prescription at initial hip GSW patient presentation to avoid infection, followed by physical exams and scans to assess the injury extent and need for surgical intervention. Dickson et al. evaluated 41 patients with grade 1 or 2 open fractures that were treated non-operatively.¹⁰ These patients were treated with a standard protocol of 1 g of cefazolin and a 7-day course of cephalexin. The results showed that of the initial 41 patients, 32 had follow up. Additionally, one developed a superficial infection, one had a delayed union, and two had painful retention of shrapnel. Overall, the study demonstrated that patients with stable, low-velocity GSWs were successfully treated with antibiotics. These findings agree with the results of the study performed by Hansraj et al. who evaluated 100 patients with low-velocity GSWs involving bone but not joint.¹¹ The study examined the efficacy of ceftriaxone versus cefazolin in the prophylactic management of these type of patients. It concluded that these patients need not be hospitalized for longer than 2 days. Furthermore, they improved greatly with the use of ceftriaxone. Geissler et al. conducted a study that compared management of patients with low-velocity gunshot-induced fractures.¹² The study compared patients treated with local irrigation and debridement, tetanus prophylaxis, and a long acting cephalosporin to a group being treated with local debridement and 48 h of intravenous antibiotics. The study concluded that these types of injuries can be managed with short-term antibiotics without an increased risk of infection. Brettler et al. conducted a retrospective study on low-velocity GSWs of extremities in 148 patients.¹³ The authors claimed that conservative treatment for these types of injuries was effective, consisting of cleansing the wound and systemic antibiotics. These results were comparable to multiple studies that evaluated similar injuries.^{14–16} In contrast, Dickey et al. evaluated the use of intravenous antibiotics as a prophylactic measure to prevent infection following low-velocity gunshot-induced fractures.¹⁷ The study found that upon comparison of two groups, one receiving antibiotic and one without, there was no significant change in infection rates with the use of infection prophylaxis.

3.1.3. Surgical management

Evidence regarding irrigation, debridement, and missile removal in hip GSW patients is conflicting. In 1 study with 15 patients suffering intraarticular violation of the hip joint, 7 of 8 patients with retained bullet in the joint underwent either arthrotomy or arthroscopy with irrigation and debridement and removal of the bullet. One patient, who had a concomitant intestinal viscus injury as well as unsuccessful removal of the bullet during the initial surgery, developed a septic hip. Six total subjects had intestinal viscus injury in addition to hip joint violation, with 1 additional subject having a retained bullet that was surgically removed and 4 other subjects without retained bullets who did not undergo surgical debridement. Other than the aforementioned patient, no joint infections progressed.⁸ Debridement was thus recommended in GSW with intra-articular involvement, particularly when bullet fragments remain within the joint.⁸

These findings were not supported by a previous study that enrolled hip gunshot patients treated with irrigation and debridement or open reduction and internal fixation.⁷ In this study, regardless of the therapeutic modality used, whether conservative or surgical, surgical

stabilization of the fracture was not always necessary since all fractures healed. However, the authors recommended that bullet fragments be removed when located within a joint or in close vicinity of the synovial fluid. Additionally, this paper recommended irrigation and debridement for all hip joint violations, regardless of whether bullet is retained.

Hollmann et al. conducted a study on 26 patients that sustained low-velocity gunshot fractures of the femur and were treated with intramedullary fixation.¹⁸ The results were favorable, with only 1 case of delayed union and one case of nonunion. The study concluded that intramedullary fixation was an effective option in the treatment of low-velocity gunshot-induced fractures. These results agree with Canada et al. who performed a similar study and arrived at a similar conclusion.¹⁹ Furthermore, Nowotarski et al. examined the effect of static interlocking nailing to treat 39 fractures of the femur induced by low-to-mid velocity handgun missiles.²⁰ The authors concluded that immediate interlocking nailing of the femur is an effective and safe treatment for these types of injuries. These results agree with numerous other studies performed evaluating similar treatments.^{21–25} Ryan et al. examined 43 fractures to the femoral shaft secondary to low-velocity GSWs.²⁶ The study confirmed that femoral shaft fractures due to this mechanism of injury are best managed with surgical debridement.

3.2. High-velocity gunshot wounds

3.2.1. Antibiotics

Sathiyakumar et al.'s systematic review also includes studies on antibiotic distribution for the treatment of high-velocity gunshot injuries.⁶ Although the articles that they included in their paper support the use of antibiotics in such settings, those studies were performed retrospectively, and none of them were randomized controlled trials that tested the benefits of antibiotics. Given ethical considerations and general acceptance of antibiotics in these injuries, it would be difficult to conduct such studies. A retrospective chart review recommended that all patients with GSWs be given prophylactic antibiotics.⁷ No matter the type of weapon that was fired, there is still a chance of contamination from clothing and skin being sucked into the wound during the vacuum like pull that forms the moment of the bullet's impact. Since this contamination is not always easily visible instantaneously, prescribing antibiotics to all gunshot wounds would decrease the chance of infection.

3.2.2. Surgical management

Due to the fact that high velocity GSWs tend to produce severely contaminated wounds and more soft-tissue damage than low-velocity GSWs, surgical debridement is traditionally used to treat the injury.⁷ It is recommended that the patient undergo aggressive debridement of devitalized tissue since the margins of the entrance and exit wounds are usually larger than those from low-velocity GSWs.²⁷ Numerous studies have been conducted to examine procedures to treat high-velocity GSWs. Atesalp et al. studied the treatment of 163 Gustily-Anderson type IIIa fractures caused by high-velocity GSWs with Ilizarov fixation and primary delayed closure.²⁸ All fractures healed with good anatomic alignment and proper functional outcomes. Nabi Dar studied the effectiveness of external fixation followed by delayed interlocking intramedullary in treating high-velocity GSWs of the femur.²⁹ These results were comparable to other studies that have studied use of external fixation in the treatment of high-velocity GSWs.^{30–32} Mack et al. evaluated the treatment of proximal open femoral fractures sustained in combat from high-velocity GSWs.³³ The study determined that cephalomedullary nail fixation of type III subtrochanteric and pertrochanteric femoral fractures is effective, with the most common complication being infection and heterotopic ossification. Lastly, Tornetta et al. conducted a study that examined the use of anterograde interlocked nailing as a technique for distal femoral fractures after GSWs.³⁴ The study evaluated 38 patients, all of whom achieved early motion.

If fragments of the bullet remain in the body, they should be removed

to prevent infection or lead toxicity. Retained foreign body may also lead to mechanical wear and degeneration of the articular surface.³⁵ The patient may need to be returned to the operating room within 72 h to remove contaminated fat and affected muscle. This treatment plan is not as controversial as the one for low-velocity injuries. It is agreed upon by most physicians and researchers that surgical management will be necessary for a successful outcome.³⁵

In addition, GSWs to the hip have been complicated by involvement of the gastrointestinal and genitourinary systems. Involvement of these systems have been shown to increase the risk of infection and poor outcomes.^{9,36} Brien et al. evaluated the complication of septic arthritis when GSWs to hip are complicated by involvement of the alimentary tract. The study concluded that early diagnosis and immediate surgical involvement via arthrotomy have shown favorable outcomes.³⁶ Najibi et al. classified the patterns of GSWs to the acetabulum and identified the predictors of poor outcomes and deep infection.⁹ The authors found that the most common associated injuries were bowel involvement. Furthermore, the successful treatment of bowel injury directly correlated with infection control. Bartkiw et al. evaluated 42 patients with fractures of the hip and pelvis as well as their required surgical intervention(s).⁷ The authors concluded that civilian gunshot to the hip and pelvis often require emergent surgery to address vascular, visceral, and urogenital injuries.

In contrast, multiple studies have described the involvement of these systems as factors that do not influence outcomes in patients with hip GSWs. Rehman et al. evaluated the effectiveness of surgical debridement when hip GSWs involve the alimentary tract.⁸ They concluded that gunshot pelvic fractures do not require debridement even when the alimentary tract is involved. They did, however, claim that debridement with bullet removal should be performed in the case of intraarticular involvement as it has been shown to prevent infection. Watters et al. evaluated the use of surgical debridement in the management of low-velocity GSWs.³⁷ In addition to concluding that there was no increased risk of infection in the absence of surgical debridement, they also claimed that bullets and bullet fragments penetrating gastrointestinal organs did not increase the risk of infection.

4. Discussion

Initial care when treating a patient with a gunshot should prioritize any life or limb threatening injuries. If there is a suspected bowel or bladder injury, the patient should undergo surgery to address those injuries first.³⁶ If the gunshot did not affect these areas, radiograph and CT imaging should be performed to pinpoint the location of the bullet and any possible associated fractures.

If the bullet does not create an unstable fracture, is not intraarticular, is not fired from a high velocity weapon, and does not create extensive damage to the soft tissue, there is no need for the patient to undergo surgery.⁹ Antibiotics in combination with debridement of the entrance and/or exit wound under local anesthesia should be sufficient treatment. Furthermore, the physician may choose their preferred route of administration, as intravenous antibiotics have no significant advantage over oral antibiotics.^{38–40}

Surgical treatment should be considered when the bullet appears to be intraarticular or to communicate with the hip joint through a fracture. This situation would increase the risk of septic contamination of the hip joint and lead toxicity from the bullet if it were to remain there.⁴⁶ Additionally, surgical intervention is more likely to be necessary, with consensus for its use, in high velocity wounds because the bullets have more energy with associated significant soft tissue trauma.

One surgical approach that has had favorable bullet retrieval and post-operative infection rates is hip arthroscopy.^{42,47} Arthroscopy prevents the need for more morbid open approaches and/or surgical hip dislocation. However, it is associated with a small risk of developing infection in the case of gastrointestinal involvement.⁴⁷ Additionally, post-traumatic arthritis following GSWs has been reported, a

complication that has been shown to be resolved with performing a total hip arthroscopy.⁴⁴ Furthermore, in the case of GSWs that traverse the abdominal tract, arthrotomy has shown favorable results and less infectious complications.⁴⁵ If the physician chooses to not perform arthrotomy when presented with these types of injuries, they should monitor the patient for potential infection.

A different surgical method of treatment is surgical dislocation of the hip. This allows for strong access to the acetabulum while also providing full visualization of the femoral head. This procedure can be done safely, without the limitations of an arthrotomy with no dislocation, and does not need a traction table, making it more accessible when compared with hip arthroscopy.¹ Thus, this surgery makes it easier to directly access foreign bodies that are in the femoral head or the acetabulum. The drawback, however, is the need for an osteotomy and subsequently healing of the osteotomy site. The rehabilitation time for patient after undergoing surgical hip dislocation tends to be more prolonged than that of arthroscopy.⁴⁸

This study is limited because of a lack of evidence that focuses on high velocity GSWs to the hip. Additionally, many studies do not specify if the gunshot wounds were low or high velocity. Since the distinction between low and high velocity is not made clear, this study could not use those articles. Future studies should exclude patients who have injuries in addition to a hip fracture from a gunshot in order to create more accurate treatment policies.

5. Conclusions

In a GSW patient, obvious injuries should be surgically addressed first; otherwise, imaging should be used to pinpoint the location of the bullet and any associated fractures. In the absence of intraarticular injuries, unstable fractures and extensive soft-tissue damage, no surgery is warranted. When present, such injuries can be best managed with antibiotics in combination with debridement. Surgical treatment is more likely to be necessary in high-velocity GSWs and should be considered when the bullet is intraarticular or communicates with the hip joint through a fracture. While associated with favorable bullet retrieval and post-operative infection rates, hip arthroscopy increases the risk of abdominal compartment syndrome. Surgical hip dislocation is a safer alternative to arthrotomy but requires osteotomy and subsequent healing of the osteotomy site, in addition to a longer recovery time.

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Declaration of competing interest

The authors declare that there are no conflict of interests.

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