

Retained Bullet Removal in Civilian Pelvis and Extremity Gunshot Injuries

A Systematic Review

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Abstract

Background Although gunshot injuries are relatively common, there is little consensus about whether retained bullets or bullet fragments should be removed routinely or only in selected circumstances.

Questions/purposes We performed a systematic review of the literature to answer the following questions: (1) Is bullet and/or bullet fragment removal from gunshot injuries to the pelvis or extremities routinely indicated? And, if not, (2) what are the selected indications for removal of bullets and/or bullet fragments?

Methods A search of the English-language literature on the topic of gunshot injury and bullet removal was performed using the National Library of Medicine and

MEDLINE® and supplemented by hand searching of bibliographies of included references. Studies were included if they provided clinical data on one or both of our study questions; included studies were evaluated using the levels of evidence rubric. Most studies on the subject were expert opinion (Level V evidence), and these were excluded; one Level III study and seven Level IV studies were included.

Results No studies provided a rationale for routine bullet removal in all cases. The studies identified bullet fragment removal as indicated acutely for those located within a joint, the palm, or the sole. Chronic infection, persistent pain at the bullet site, and lead intoxication were reported as late indications for bullet removal.

Conclusions The evidence base for making clinical recommendations on the topic of bullet and bullet fragment removal after gunshot injury is weak. Level I and II evidence is needed to determine the indications for bullet removal after gunshot injury.

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Introduction

Although gunshot injuries are relatively common, there is little consensus about whether retained bullets or bullet fragments should be removed routinely or only in selected circumstances. The effects of systemic lead toxicity are well known [25, 29]. Many current recommendations are aimed at preventing the subsequent development of lead intoxication.

Some sources suggest that bullets and bullet fragments not in contact with synovial fluid or cerebrospinal fluid cause little to no harm and can be left where they come to rest indefinitely [5, 10, 18]. However, modern hollow-point bullets are designed to fragment, deform, and tumble when entering a body cavity, which prevents overpenetration and

allows a more efficient and complete transfer of kinetic energy than a projectile that passes through its intended target. It has been our observation that fractures with a substantial amount of retained bullet fragments near the fracture site are at risk for delayed or nonunion. Previous studies in animals have shown that bone lead levels significantly affect bone healing [3]. We believe the first step in addressing this issue is to use the literature to determine, if possible, the most correct indications for bullet removal.

Accordingly, we performed a systematic review of the literature to answer the following questions: (1) Is bullet and/or bullet fragment removal from gunshot injuries to the pelvis or extremities routinely indicated? And, if not, (2) what are the selected indications for removal of bullets and/or bullet fragments?

Search Strategy and Criteria

An extensive search on the topic of bullet removal after gunshot injury-induced orthopaedic trauma was performed by one of the authors (JTR) using the National Library of Medicine and MEDLINE[®]. Studies were limited to those written in the English language between January 1950 and December 2012. To address the research questions, a Boolean search was performed with the following terms: (bullet OR gunshot) AND (retained OR removal). The bibliography listed in each of the papers chosen was also evaluated for the presence of additional pertinent articles to ensure a thorough and complete literature review.

The objective of this systematic review was to address the question of indications for bullet removal after gunshot injury. The criteria for identifying the subset of data pertaining to this question consisted of data collected from (1) clinical comparative studies that discussed bullet removal or retention and its effect on outcome and (2) clinical case series that discussed instances of retained bullets (or portions thereof) and their long-term effects.

A preliminary evaluation was performed by review of article titles and abstracts found through the database search. We excluded studies that (1) did not look specifically at bullet removal or the effect of retained bullet fragments as pertaining to clinical patient outcome or (2) did not deal with gunshot injuries to the pelvis or extremities. We also excluded Level V evidence (expert opinion, case reports), as well as editorials, letters to the editor, and other studies that did not include results of patients treated for gunshot injuries.

A total number of 567 papers pertaining to the study questions were identified using the aforementioned search criteria and the abstracts were reviewed by the authors of this systematic review. After excluding studies that did not (1) pertain to the topics of bullet removal from the pelvis or

extremities or (2) discuss the effect of retained bullet fragments as pertaining to patient outcome, 55 articles remained. Of those, 48 were Level V evidence, reducing the count to seven studies; hand searching the bibliographies of these yielded one additional study. The final number of studies included in this review therefore was eight, including seven Level IV studies (case series) [1, 2, 11, 15, 19, 22, 28] and one Level III study (retrospective study with a control group) [30] (Table 1).

In determination of indications for bullet removal, the included studies were searched for any and all indications used for bullet removal in the patients in each study. Indications for bullet retention were also recorded. Patient outcomes were then studied for both groups and formed the basis for final recommendations concerning the two primary research questions.

Results

Evidence in Support of Routine Bullet Removal

There was no clear evidence in support of routine removal of bullet fragments. Existing Level III evidence pertaining to bullet fragment removal consisted of one article, which looked at subsequent infection as its main outcome measure. Watters et al. [30] reported on 47 patients with pelvic gunshot injuries. The incidence of infection was determined for patients with retained bullets or bullet fragments and for those in whom bullet fragments had exited the body or been surgically removed. There were 34 patients who had retained bullet or bullet fragments, with one (3%) patient developing a trochanteric bursa abscess around the retained bullet fragment. The remaining 33 patients did not develop an infection relating to the gunshot injury wound. Furthermore, 12% of the patients with retained bullet fragments had gunshot injuries that had penetrated the gastrointestinal tract and none of these resulted in infection. Antibiotic coverage varied in this study according to surgeon preference. The authors of that study concluded that retained bullets and bullet fragments do not increase the risk of infection in pelvic fractures, even after penetrating the gastrointestinal tract.

Selected Indications for Bullet Removal

There was evidence in support of removal of bullet fragments when they are lodged in a joint or in the palm of the hand or the sole of the foot. Indications for delayed removal of bullet fragments included pain at the site of the bullet or lead intoxication. In addition to the study mentioned above, two additional studies written on the subject

Table 1. Supporting evidence addressing the study questions

Study	Year	Study description	Level of evidence	Outcome
Watters et al. [30]	2011	Retrospective cohort of 47 patients with pelvic GSIs Primary outcome was incidence of infection related to pelvic GSIs at least 1 year after injury	III	34 patients had retained bullet or bullet fragments One patient developed an infection Retained bullets did not increase the risk of infection, even after penetrating the gastrointestinal tract organs
Rehman et al. [22]	2011	Retrospective cohort of 84 patients with GSIs and pelvic fractures, of which 59% had a perforated bowel	IV	Infection occurred in only one patient with intraarticular and intestinal injury
Bartkiw et al. [2]	2010	Retrospective cohort of 42 patients with GSIs to the hip or pelvis	IV	Pelvic GSI rarely causes pelvic injury Intraarticular bullet fragments should be removed
Mazotas et al. [15]	2012	Retrospective cohort of 107 patients with GSIs and retained bullet fragments Indications for bullet removal were chronic pain, infection, and cosmetic concerns	IV	34% of patients with followup experienced long-term complications related to the foreign body; 20% of patients with followup ultimately required bullet removal
Sclafani et al. [28]	1985	14 patients with GSIs and retained intraarticular bullets	IV	Radiographic, gross, and microscopic changes were evident by 6 weeks and caused the authors to recommend early removal of intraarticular bullets
Ashby [1]	1974	Retrospective cohort of 7 patients with low-velocity GSIs to the knee	IV	Recommendation for débridement and bullet or bullet fragment removal in cases where missiles remain intraarticular
Lee et al. [11]	2008	Retrospective cohort of 11 patients with GSIs and intraarticular missiles treated with arthroscopic removal	IV	Arthroscopic bullet extraction is safe and effective in most cases where bullets come to rest in an intraarticular location
Parisien and Esformes [19]	1984	Retrospective cohort of 8 patients with GSIs to the knee who underwent arthroscopic débridement and bullet removal	IV	Arthroscopy allowed for bullet removal and is safe and effective

GSI = gunshot injury.

of gunshot injuries to the pelvis cited intraarticular bullet or bullet fragments as an indication for bullet removal [2, 22]. These articles did not scientifically address the subject of bullet removal but did recommend intraarticular location as an indication for removal. Incidentally, both articles demonstrated that the need for orthopaedic stabilization is rare in cases of gunshot injury to the pelvis and that intestinal viscus injury does not mandate bullet removal in cases of gunshot injury to the pelvis. Type and duration of antibiotic coverage were not mentioned in the study by Rehman et al. [22]. Bartkiw et al. [2] reportedly used cefazolin and gentamicin for a minimum of 48 hours, with any additional antibiotics at the discretion of the general trauma surgeon based on coverage for intestinal or urogenital injuries.

Sclafani et al. [28] reported a retrospective case series of 14 patients with retained intraarticular bullets. Patients were seen at between 6 and 7 weeks from injury. Radiographic analysis showed a hazy opacification surrounding the articular cartilage and the synovium. Pathologic analysis showed synovial hyperplasia with black stippling and a gray stained and pitted articular surface. The authors recommended early removal of intraarticular missiles to

prevent complications of lead intoxication and damage to joint surfaces. Ashby [1] came to the same conclusion in 1974 after an analysis of seven cases of intraarticular gunshot injury to the knee treated with operative débridement and bullet removal through arthrotomy. Arthroscopic bullet removal was recommended in two recent case series [11, 19]. Both reported the ability to consistently remove retained missiles from within joints without the need for a formal open approach, while accomplishing intraarticular irrigation at the same time. This approach may speed recovery over conventional arthrotomy and bullet removal. Indications for removal were identical to the indications for open bullet removal in these studies.

Indications for late bullet fragment removal were evaluated in a Level IV study performed by Mazotas et al. [15]. In this study, which evaluated pediatric patients with retained bullet fragments, 34% of patients had fragment-related complications. Twenty percent of patients eventually required bullet fragment excision to treat symptomatic foreign bodies, chronic infection, and cosmetic concerns.

In summary, bullet fragment removal is indicated acutely for those located within a joint, the palm, or the

Table 2. Suggested orthopaedic indications for bullet removal

Indication
Intraarticular location
Palm of hand or sole of foot location
Systemic lead intoxication
Pain caused by bullet
Infection

sole (Table 2). Chronic infection, persistent pain at the bullet site, and lead intoxication are reported as late indications for bullet removal.

Discussion

Although there is a large amount of literature on gunshot injuries, relatively few studies have focused specifically on the question of whether (or when) bullets should be removed from those injured by firearms. This systematic review sought to formulate treatment recommendations regarding the following two questions: (1) Is bullet and/or bullet fragment removal routinely indicated from gunshot injuries to the pelvis or extremities? And, if not, (2) what are the selected indications for removal of bullets and/or bullet fragments?

This systematic review was limited by a literature that consisted predominantly of Level IV evidence (retrospective case series); there was only a single study [30] that included a control group (Level III evidence). Due to the lack of high-level evidence available in the literature pertaining to the primary research questions, any treatment recommendations based on this literature must be made with caution. While we believe that the potential risks and morbidity of bullet removal are outweighed by the benefits of removal for the indications described earlier, owing to the lack of high-quality Level I evidence, strong treatment recommendations could not be reached.

With regard to the question of whether bullet and/or bullet fragment removal from gunshot injuries to the pelvis or extremities is routinely indicated, as noted, very little evidence outside of expert opinion, case reports, and retrospective cohort studies exists to guide physicians. Although several case reports of lead poisoning from extraarticular bullet fragments in the extremities have been published [7, 8, 13, 16], this remains a rare phenomenon [9, 24]. When symptoms develop and a diagnosis has been made, however, chelation therapy along with bullet removal may be indicated [21]. No studies were found through an extensive search of the literature that either recommended or presented evidence in support of routine bullet fragment removal in all cases.

In terms of selected indications for removal of bullets and/or bullet fragments, the literature suggests that bullet fragments that come to rest intraarticularly should be surgically removed. Although Level I and II studies to support this statement are not available, given the known complications found in case reports and in small case series on the subject (eg, lead intoxication, damage to joint surfaces), as well as the basic science supporting this assertion, the recommendation for intraarticular bullet removal is strong. The encapsulation of the bullet that occurs within the soft tissues of the extremities does not occur within the joints of the body. This, coupled with the solubility of lead immersed in synovial fluid, can result in toxic levels of lead being released into the bloodstream [12, 13, 24]. Cartilage degradation can also result from bullet fragments that remain; therefore, surgical removal is indicated. Bullets that become lodged in the palm of the hand or the sole of the foot have an indication for removal due to the prominence and the discomfort a bullet will cause in these body regions. In close-range shotgun wounds, exploration to remove retained wadding is indicated to prevent subsequent infection [4]. Although outside of the scope of this review, it is worth noting that bullets that come to rest in contact with cerebrospinal fluid should be removed as well. No scientific study or case report was found suggesting an indication for removal of bullet fragments based on the energy of the gunshot injury alone. However, expert opinion has listed high-energy injuries as an indication for bullet removal [23]. Finally, there is some evidence, though the numbers are small, that a bullet that penetrates a hollow viscus before causing orthopaedic injury does not necessarily need to be removed [22, 30].

While high-level clinical studies are absent on the subject of bullet removal after gunshot injury to the pelvis and extremities, basic science studies show further possible detriment that may be caused by retained bullet fragments that would be vitally important in cases of gunshot-induced fracture. Previous studies in animals have shown that bone lead levels significantly affect bone healing [3]. Several authors have shown the adverse effects of lead on bone formation and resorption by demonstrating its impact on osteoblast and osteoclast activity [6, 14, 17, 20, 26, 27]. One such study investigated the response bone lead levels exhibited on tibial fractures treated with intramedullary fixation in mice [3]. A dose-dependent relationship was found to negatively affect fracture healing with increasing bone lead levels. Fracture calluses in the lead-exposed groups showed a significant delay in endochondral ossification with a greater increase in unossified cartilage formation several times that of the unexposed calluses. At lower lead levels, exposure did not completely inhibit fracture healing but delayed the ossification process. However, a second group was exposed to ultrahigh doses

of lead. In this group, 75% of the subjects exhibited fibrous nonunions, suggesting that lead can completely inhibit fracture healing at very high doses. This finding has not been validated in human studies. Therefore, prevention of nonunion and delayed union is not an indication for bullet removal at this time.

While this systematic review found relatively no evidence supporting the routine removal of bullets and/or bullet fragments after orthopaedic injury, there was support for the decision to remove bullets or bullet fragments acutely when they come to rest within any intraarticular location or in the palm of the hand or sole of the foot. Routine exploration and removal of bullet fragments that come to rest in the soft tissues of the extremities or around a fracture site are not recommended. In cases of chronic pain, infection, and the late development of lead intoxication, bullet removal may also be indicated.

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