

Indications for bullet removal: overview of the literature, and clinical practice guidelines for European trauma surgeons

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Abstract

Purpose The incidence of gunshot wounds from civilian firearms is increasing. Despite this fact, guidelines on indications for bullet removal are scarce. In this analysis, we combine an overview of the available literature in these rare entities with our experiences in our own clinical practices.

Methods We conducted a systematic literature search of computerized bibliographic databases (Medline, EMBASE, and the Cochrane Central Register). The local experience of the authors was reviewed in light of the available literature.

Results 145 full-text articles were suitable for further evaluation. Only six retrospective studies were available, and no prospective study could be retrieved. Most of the articles were case reports. In the South African co-author's own clinical practice, approximately 800 patients are treated per year with gunshot wounds.

Conclusions In summary, there are only a few clear indications for bullet removal. These include bullets found in joints, CSF, or the globe of the eye. Fragments

leading to impingement on a nerve or a nerve root, and bullets lying within the lumen of a vessel, resulting in a risk of ischemia or embolization, should be removed. Rare indications are lead poisoning caused by a fragment, and removal that is required for a medico-legal examination. In all other cases the indication should be critically reviewed.

Keywords Bullet removal · Gunshot wounds · Missile · Fragment

Introduction

Gunshot wounds from civilian firearms are still uncommon in emergency rooms in Europe. Nevertheless, their incidence is rising, and trauma surgeons are increasingly confronted with new injury patterns in this regard [1]. In other parts of the world (e.g., North and South America, South Africa), gunshots occur more frequently, so knowledge of the correct treatment and proper timing of life-saving surgery procedures can be imported from these countries. New course concepts in the education of the relevant surgeons (e.g., the DSTC course concept) have been inaugurated, and meet these concerns [2, 3].

As the incidence of gunshot victims rises, the number of patients with retained bullets also increases. Guidelines on this medical problem are currently scarce.

Despite the fact that patients often request rapid and complete removal of all bullet fragments, there are limited medical reasons to perform such procedures. Additionally, in the acute phase, the extent of debridement of the missile track is crucial. In this article, we review the available literature and comment based on our own experiences and

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international contributions on concepts for the removal of bullets and the extent of initial debridement required [4].

Materials and methods

A comprehensive literature search was conducted in January 2011. Computerized bibliographic databases were individually searched using specifically developed search strategies to identify eligible studies, using the headings “bullet,” “fragment removal,” “gunshot,” “gunshot wounds,” “firearm,” “missile,” and “missile wounds.” Our search strategy covered the major medical databases (Medline, EMBASE, and the Cochrane Central Register). Articles in English and German were included. In addition to this, the local experiences of the authors were reviewed in light of the available literature and personal data.

The different phases of a systematic review were conducted according to the PRISMA statement [5]. Among the over 5,000 citations initially identified by our search, roughly 4,800 were irrelevant by title, repeated naming, or double publication. 145 manuscripts were relevant by title and abstract and suitable for evaluation (Fig. 1).

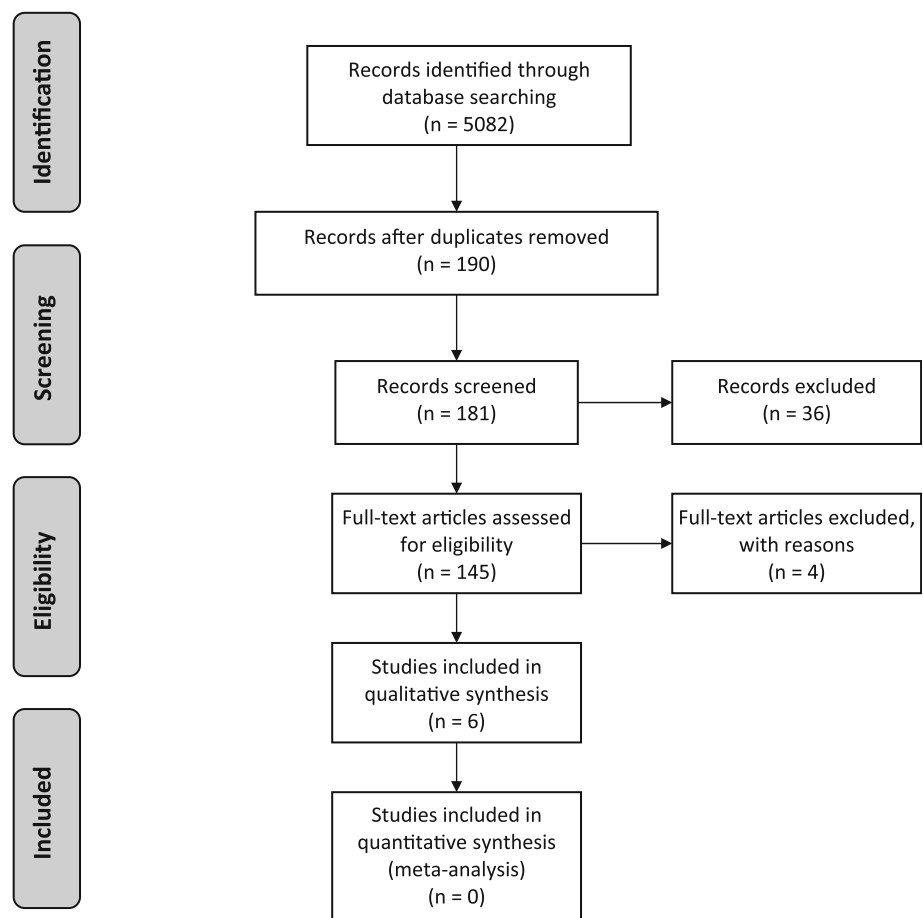
Results

There were no prospective and only six retrospective studies available [6–11]. Most articles described case reports. In the South African co-author’s own clinical practice (data from Tygerberg Academic Hospital, Cape Town and Inkosi Albert Luthuli Central Hospital, Durban), approximately 800 patients are treated per year with gunshot wounds [12, 13]. Approximately 2% of all gunshot victims require medically justified bullet removal. Most of these are for palpable bullets, visible bullets at surgery, or exposure of the bullet to either synovial fluid or cerebrospinal fluid, or due to an eye injury. Two fatal cases of bullet emboli were recorded in the South African co-author’s experience.

Discussion

The limited available clinical studies and the large number of case reports in the literature stimulated the authors to present a clinical overview on the removal of remaining fragments after missile injuries.

Fig. 1 PRISMA flow chart



Bullets may be localized through direct palpation, with conventional X-ray or CT diagnostics, using an image intensifier in the operating room, or with special adaptive electronic amplifiers [14]. The presence of metal fragments is generally a contraindication for the use of magnetic resonance imaging.

To summarize our own clinical concepts from hospitals with a high frequency of gunshot victims (Tygerberg Hospital, Cape Town; Inkosi Albert Luthuli Central Hospital, Durban) and the results of our literature review, the following indications were found for the removal of bullet fragments.

A bullet located *close to the skin* in combination with clear patient discomfort (due to pressure effects) is an obvious reason to remove the bullet. This might be the case when the bullet is located under the skin of an exposed area like the ventral lower leg, or temporary high-pressure zones like the bottom area. Cosmetic effects when the bullet is visible in delicate zones like the skin of neck or even the face are approached differently. It is often no problem to locate and extract such palpable bullets, so we would support this indication provided there is patient desire and compliance for the removal of the missile.

Although debridement and irrigation are often indicated in bullet injuries with articular involvement, this is not routinely done for extra-articular injuries. Treatment of extra-articular gunshot injuries to the extremities is frequently performed without radical operative debridement, and local wound care is a safe option in most cases [15]. There are no data supporting extended debridement of bullet tracks [16, 17]. There are a few reported cases of necrotizing fasciitis in the literature. Despite those—often lethal—cases, it could not be shown that aggressive surgical treatment would have prevented the tragic outcomes [18]. If extra-articular pelvic fracture is associated with bowel injuries, formal orthopedic fracture debridement is not required, even with concomitant intestinal viscus injuries [8].

Independent of the location of the retained bullet, a clear indication for surgical treatment is the formation of an *abscess*. This is not usually caused by the bullet itself, but by dirt and smoke particles that are forced inside by the impact of the entering projectile. When clearing the abscess, there is often the chance to remove the bullet in the same setting [1].

Intraarticular bullet fragments have to be removed. Posttraumatic arthritis may be caused by mechanical symptoms and subsequent destruction of the joint. Additionally, it is known that lead toxicity can cause periarticular fibrosis and chondrolysis and destroy the joint over time [19, 20]. Arthroscopy or arthrotomy are the preferred methods for superficial joints [10, 21], with a success rate of over 90%. Special removal techniques are described for anatomically complex joints like the sacroiliac joint [22].

Bullets in the *globe of the eye* represent a devastating injury. The largest study presently found was conducted on patients with rubber bullet injuries in the Palestinian territories. 21% of the patients ($n = 9$) had a bullet lodged in or around the orbit [7]. A ruptured globe is rarely salvageable, so repairing the defects leads to the removal of the globe and its incorporated bullet. Retained intraorbital metallic foreign bodies are considered to be well tolerated if the eyes remain intact [23]. However, they are described as being able to spontaneously migrate, with the extrinsic ocular muscles playing a role in the movement of large foreign bodies over time. Here, surgical treatment should also be considered, even if symptoms occur in the late phase of follow-up [24].

When the bullet *impinges on a nerve* or a nerve root and causes pain to the patient it should be removed. However, it has been shown that there is no evidence of the prevention or minimization of future pain when bullets are removed in patients suffering from spinal cord injury due to a gunshot wound. Some studies can prove that pain might be intensified when caused by a gunshot wound, but there is no evidence that bullet removal will be beneficial to those patients regarding future pain [6, 25]. In a study of 56 patients with spinal cord injuries with and without gunshot wounds, there was no statistical difference in pain measurement variables. Bullet removal was not associated with a reduction in subsequent pain. Some authors favor surgical resection when the bullet is located inside the vertebral disc to prevent chronic pain, abscess formation, or lead poisoning [26]. Patients with penetrating spinal cord injuries due to gunshots, with retained missiles in the medulla, were as likely to undergo surgery for bullet removal as if the bullet remained somewhere else. Furthermore, Richards [6] emphasized that there was no consensus among different spine centers about whether bullets in patients with spinal cord injuries should be removed, despite some evidence that those at or below T12 have higher re-ambulation rates after bullet removal [27]. Bullets in contact with cerebrospinal fluid may undergo electrolysis and cause plumbism, which is again a reason for bullet removal [28].

Retained metallic fragments do not have to be extracted at all costs. There is no proof of increasing infection rates when retained foreign bodies are left inside. In *intracranial lesions* due to missiles, repeated surgery is necessary when a brain abscess has occurred. Depressed bone fragments and/or cerebrospinal fluid leaks, however, are associated with a higher rate of infection [29–31]. Splavski et al. [9] demonstrated this with 160 war missile penetrating craniocerebral injuries in a four-year period. Only when there was evidence of an infection or abscess formation was surgical exploration and removal of accessible bullets mandatory. The main predisposing factor for intracranial infection in penetrating head wounds was cerebrospinal

fluid fistula, retained bone and bullets, and trajectory through an air sinus.

Bullets found in the *lumen of a vessel* should be removed if they are causing ischemia, especially in all cases involving main arteries supplying the extremities or the extracranial internal carotid artery [32]. Another potential avertable risk is an embolization of the brain or the lung. This is particularly true for shotgun fragments such as “birdshot” and small-caliber bullets, which may migrate. Here, surgical intervention is warranted. Bullets in the venous system and even the intra-arterial system may be removed with modern endovascular techniques. Percutaneous transvenous basket extraction or arterial endovascular snare retrieval decrease the rate of complications in comparison to open surgical approaches [11, 33]. Foreign bodies in minor vessels can be tolerated, but should be regularly observed, as Nguyen [32] described for the hypogastric artery.

Lead poisoning from retained firearm bullets is rare. Bullets in the big joints like the knee or hip joints are usually responsible, but even intradiscal retained bullets may cause elevated lead serum levels [26]. This can begin to occur even after a long follow-up period. The onset of symptoms can occur from days to decades after the initial accident [34]. Patients with lead intoxication may present a wide range of symptoms, including neurologic, hematologic, or gastrointestinal abnormalities [35]. There are significantly higher resorption rates when the bullet is retained in contact with synovial, pleural, or cerebrospinal fluid [36]. Elevated lead levels in patients with a retained bullet are an indication for bullet removal. Additionally, chelation therapy should not be delayed if the diagnosis is confirmed [35].

A special situation develops when the bullet is required for *forensic investigation*. Here, the patient and the treating surgeon should be in full agreement that the removal procedure will not result in increased pain, suffering, complications, or injury. It is essential that both the patient and the treating surgeon agree on the removal procedure. It may be that the surgeon is ordered to remove the bullet by a court order, and the bullet may then be removed against the patient's will [37].

Summary

Gunshot wounds in Europe are a rare but increasing entity. Despite the desire of the patient for rapid and total removal of all bullet fragments, there are considered to be only a few medical indications for bullet removal. This scheme might be particularly useful in areas where gunshot wounds are rare and a high level of uncertainty is present in both patients and their treating surgeons.

In summary, the following are clear indications for bullet removal:

1. Bullets found in joints, CSF, or the globe of the eye
2. Bullets leading to impingement on a nerve or a nerve root
3. Bullets lying within the lumen of a vessel, resulting in a risk of ischemia or embolization
4. Bullets causing lead poisoning
5. Bullets seen or clinically palpated at examination
6. Bullets requiring removal for a medico-legal examination

In all other cases, the indication should be critically reviewed prior to removal.

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Conflict of interest The authors declare that they have no conflict of interest.

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