Removal of retained bullets from the hip joint in civilian gunshot injuries

Sithombo Maqungo,[1]* Andrew Nicol,[2] Ntambue Kauta,[3] Simon Graham,[4] Stefan Swanepoel,[3] Maritz Laubscher,[3] Anna Antoni[3]

[1] Division of Orthopaedic Surgery, Division of Global Surgery, University of Cape Town, Cape Town, South Africa
[2] Division of General Surgery, University of Cape Town, Groote Schuur Hospital, Cape Town, South Africa
[3] Division of Orthopaedic Surgery, University of Cape Town, Groote Schuur Hospital, Cape Town, South Africa
[4] Nuffield Department of Orthopaedics, University of Oxford, Oxford, United Kingdom

Corresponding author: sithombo@msn.com

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Abstract

Background

Removal of bullets retained within joints is indicated to prevent mechanical blockade, third body wear and resultant arthritis, plus lead arthropathy and rarely, systemic lead poisoning. We aimed to report on the largest series of removal of bullets from the hip joint using open surgical techniques.

Methods

This is a retrospective cohort study of all patients who presented to a single Level 1 trauma unit with civilian gunshot injuries that had breached the hip joint between 1 January 2009 and 31 December 2022.

Results

We identified 117 adult patients who met our inclusion criteria. Of these patients, 72 had bullets retained within the hip joint area. Forty-six patients underwent bullet removal using the following techniques: hip arthrotomy (n = 19), surgical hip dislocation (n = 18), direct removal without capsulotomy (tractotomy) (n = 5), removal at site of fracture fixation/replacement (n = 3), posterior wall osteotomy (n = 1).

No patients underwent hip arthroscopy. In 26 patients we did not remove bullets for the following reasons: the final location was extra-capsular embedded in the soft tissues (n = 17); a clinical decision to not remove the bullet due to the patient's clinical condition not allowing for further surgery (n = 8); and patient refusal (n = 1).

Conclusion

With adequate preoperative imaging and surgical planning, removal of retained bullets from the hip joint can be achieved using open surgical techniques without the need for hip arthroscopy. This is particularly important in clinical settings where hip arthroscopy is not readily available.

Level of evidence: 4

Keywords: civilian gunshots, low velocity gunshots, hip joint, bullet removal

Introduction

Civilian gunshot injuries of the hip are relatively rare injuries comprising 2–17% of all gunshot injuries.[1] Removal of bullets retained within joints is indicated to prevent mechanical blockade, third body wear and resultant arthritis, plus lead arthropathy and rarely, systemic lead poisoning (plumbism). Bullets also act as a potential nidus for infection.[2-4] The myth that bullets auto-sterilise upon discharge has been disproved by Wolf et al.[5] They coated bullets with *Staphylococcus aureus* and fired into sterile ballistic blocks, and they cultured the same organism from the bullet tracts. Infrequently, bullets are removed for forensic analysis to aid law enforcement agencies.[6]

We present a series of 46 patients who underwent removal of retained bullets from the hip joint using open surgical techniques of arthrotomy, surgical hip dislocation, tractotomy, as well as posterior wall osteotomy.

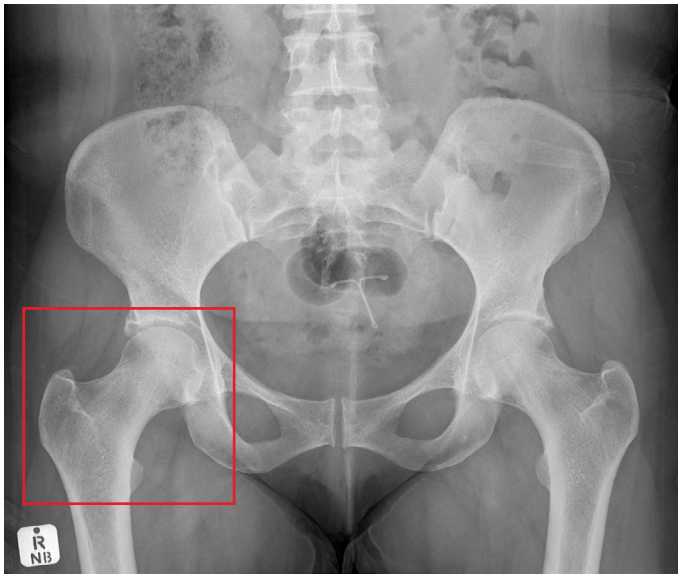

Figure 1. Hip joint area

Methods

We reviewed prospectively collected data of skeletally mature patients who presented to a single Level 1 trauma institution with civilian gunshot injuries that breached the hip joint capsule between 1 January 2009 and 31 December 2022.

We included all cases where the bullet was retained within the hip joint area. Breaching the hip joint was defined as the presence of a bullet or shrapnel retained in the joint, or presence of a femoral head or neck fracture. We defined the hip joint area as the area covered by a line drawn from the pelvic brim 2 cm above the acetabulum dome, to the greater trochanter laterally, and proximal pole of the lesser trochanter inferiorly, and the lateral border of the obturator foramen medially (*Figure 1*).

Cases where the hip joint was not breached, bullets were not retained within the hip area as described, or cases with isolated acetabulum involvement and no bullet retention were excluded. Preoperative plain X-ray films and CT scans were used to confirm the intra-articular location of the bullet (*Figure 2*).

Results

One hundred and seventeen patients with bullets traversing the hip joint were identified. The majority of patients were male (89%) with a mean age of 28 years (range 18–63). Of these 117 patients, 45 had the bullet traverse the hip joint, but the final resting position was outside of the hip joint area. These were excluded from the final analysis.

This left a final sample size of 72 patients where the bullets had breached the hip joint and were retained within the hip joint area. In 46 of these 72 patients, we undertook bullet removal using the following methods: hip arthrotomy alone (n = 19), surgical hip dislocation (n = 18), direct removal without capsulotomy (tractotomy) (n = 5), removal at site of fracture fixation/replacement (n = 3), and posterior wall osteotomy (n = 1).

In 26 patients we did not remove bullets for the following reasons: the final location was extra-capsular and embedded in the soft tissues (n = 17); a clinical decision to not remove due to patient's clinical condition not allowing for further surgery (n = 8); and patient refusal (n = 1).

No patients underwent hip arthroscopy.

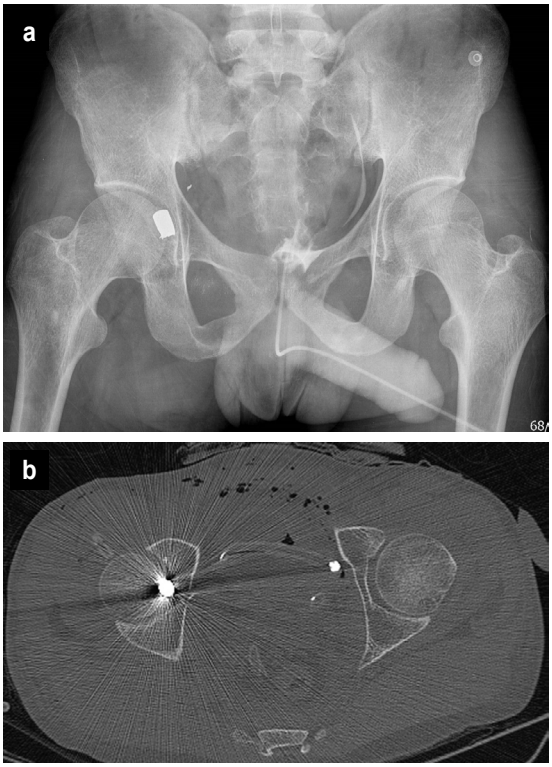

Figure 2. Preoperative X-ray and CT scan

Discussion

Bullet wounds affecting the hip joint are relatively rare injuries, accounting for 2–17% of all civilian gunshot wounds.[1,7,8] The final resting place of the missile can be free-floating within the joint, located peri-articularly or lodged within the bone of the femur head, neck or acetabulum.

Retained intra-articular bullets are removed for a variety of reasons, mainly to prevent infection, third body wear, lead arthropathy and rarely, systemic lead poisoning.[9]

The literature on bullet removal from the hip joint is sparse, with mostly small case series and sporadic case reports. Twenty-five publications appear in the English literature regarding removal of retained hip bullets, with a total of number of 48 bullets removed over a 47-year period. We report on the largest series with 46 hip bullets removed at a single institution over a 13-year period, using open surgical techniques (*Table I*).

Hip arthroscopy is the most commonly used modality to remove retained bullets in the hip. Goldman was the first to report its use to remove a bullet from the hip joint though this was combined with a limited open approach for insertion of the posterior portal.[10] Hip arthroscopy offers the advantages of minimally invasive surgery with quicker recovery and reduced hospitalisation days. It can be performed in lateral or decubitus positions, using traditional anterior portals or inferomedial or posterior portals. Hip arthroscopy

Table I: Bullet removal methods

Removal technique	Number of cases
Hip arthrotomy	19
Surgical hip dislocation	18
Tractotomy	5
Direct removal at site of fracture fixation/ replacement	3
Posterior wall osteotomy	1

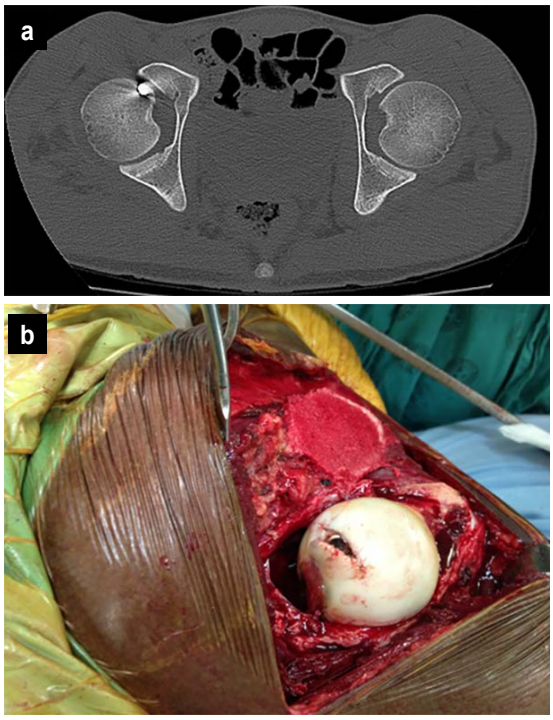

Figure 3. Surgical hip dislocation

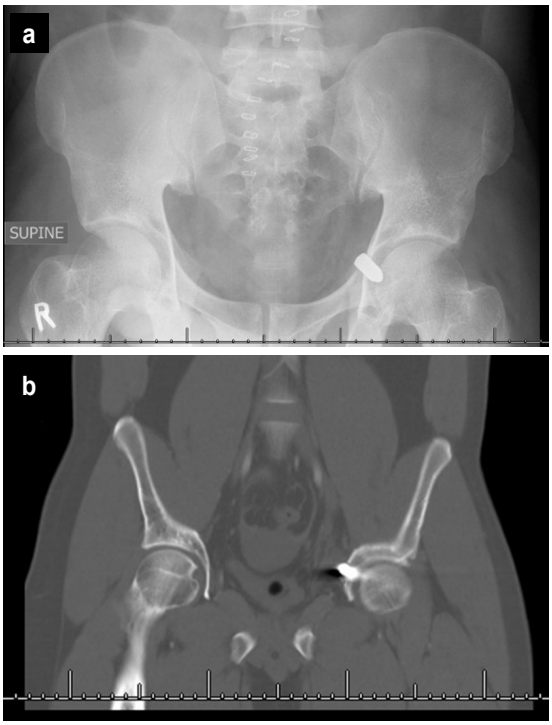

Figure 4. Anterior intrapelvic approach

can be performed in isolation or with 'tractoscopy', or combined with limited open techniques.[11] It also offers the opportunity for treatment of concomitant lesions such as debridement of chondral flaps, chondroplasty and microfractures.

It does, however, have a steep learning curve, requires additional specialised equipment such as C-arms for screening, and is not readily available in most institutions. Grasping the bullet may also prove challenging and there are reports of fluid extravasation leading to cardiac arrest.[12,13] Despite limitations, removal of bullets has been one the most common indications for hip arthroscopy in the trauma setting.[2,3,11,14-26] In all our cases we were able to remove the bullets utilising open surgical techniques.

Sometimes the final resting place of the soft missile may be embedded in hard bone which can lead to iatrogenic joint damage during attempts at removal.[27] To ensure complete inspection of the femoral head and acetabulum, and to aid safe removal of retained missiles, Maqungo et al. performed surgical hip dislocation (SHD) to remove retained missiles and they reported a 100% success rate.[28] SHD also allowed for treatment of associated chondral lesions with debridement and microfracture techniques. SHD is a safe procedure first described by Ganz for treatment of femoroacetabular impingement.[29] In this series we successfully used SHD with a trochanteric step osteotomy to remove 18 bullets (*Figure 3*). Other open techniques such as posterior wall osteotomy and open arthrotomy have also been reported.[8,30]

Krishnan et al. used an extra-articular approach without dislocating the hip to remove a bullet that was lodged into acetabulum posterior column, with only the tip protruding into the hip joint.[31] The bullet was removed by creating a window in the posterior column, guided by a K-wire placed under fluoroscopic guidance.

Williams used a dynamic hip screw (DHS) triple reamer to remove a bullet that was lodged in the femoral head.[20]

We used open arthrotomy via anterior Smith-Petersen (n = 12) or posterior approaches (n = 7) in 19 patients. In one case, the bullet had been observed to be lodged anteriorly inside the hip joint capsule. The patient was booked for insertion of a sliding hip screw plus removal of bullet. However, during attempts at removal using the Smith-Petersen approach, the bullet was noted to have migrated and was by then lodged posteriorly. The anterior approach was abandoned and a posterior arthrotomy was performed two days later and the bullet successfully removed (*Figure 4*).

A tractotomy was utilised in cases where the bullet was resting in bone and in direct communication with the hip joint. This entails following the bullet tract without the need to perform an arthrotomy. The hip joint is then washed through the bullet tract. In two patients, the bullet was lodged in the posterior wall of the acetabulum, with the tip in communication with the hip joint. In two patients, a modified Stoppa approach (anterior intrapelvic approach) was used to retrieve bullets that were lodged medially in the quadrilateral plate of the hip joint (*Figure 5*). This approach has been described for a similar indication previously.[32]

Three patients had direct bullet removal from the fracture site at the time of surgical fixation (n = 2) or total hip arthroplasty (n = 1). Total hip arthroplasty has been described for post-traumatic arthritis secondary to gunshot injuries.[33-37] Ours is a rare case of primary total hip arthroplasty in a 31-year-old male performed in the acute setting following a gunshot injury (*Figure 6*). This was due to the extensive comminution of the femoral head and neck as well as a very vertical fracture line which would increase the likelihood of fixation failure as these cases have a poor prognosis with fixation and have been described as 'doomed to failure'.[38] We have been following this case up for two years and he continues to do well, with excellent function and no signs of infection.

Table II summarises the cases where the bullets were not removed. In 17 cases the final resting place of the bullet was extracapsular even though the bullet had traversed the hip joint capsule en route to its final resting position. In these instances,

Table II: Reason for bullets not removed

Reason for non-removal	Number of cases
Final location extracapsular	17
Clinical decision not to remove (patient unwell)	8
Patient refusal	1

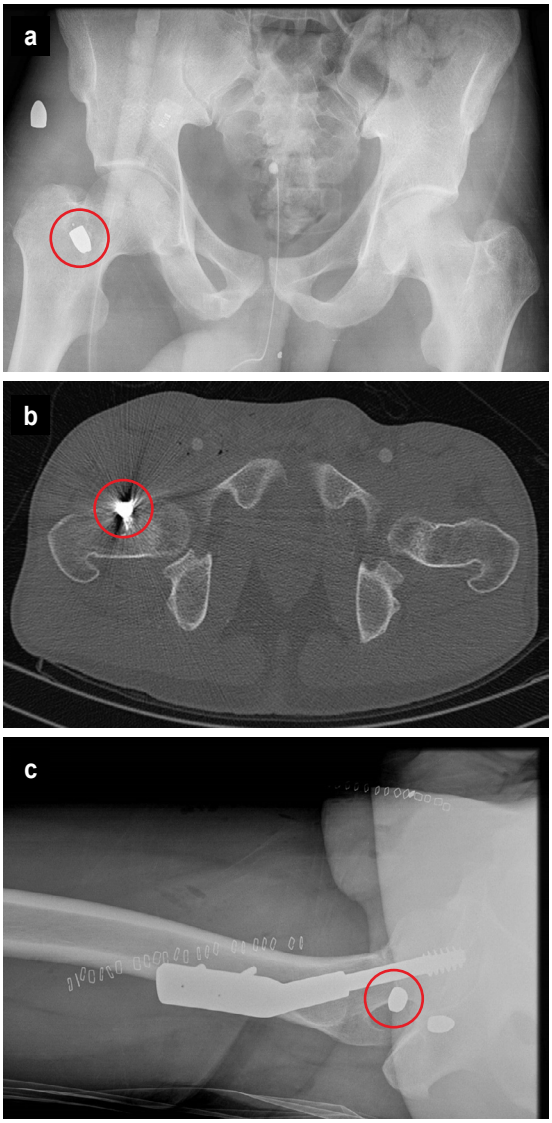

Figure 5. Migrating bullet

it is expected that the soft tissues will close and seal the missile from contact with the hip joint. Projectiles located in soft tissues are sealed off by non-vascular scar tissue, which reduces the chances of infection or lead poisoning.[9]

In eight cases, a clinical decision was made to not remove the bullets due to the patients' clinical condition not allowing for further surgery, and seven of these patients subsequently demised. In one of these cases the final location of the bullet was deeply imbedded in the femoral neck and a decision was made to not remove it (*Figure 7*). This is a clinical stance supported by Howse et al., as well as Christie et al.[11,39]

One patient refused bullet removal and was discharged without further follow-up.

In all the cases in this series, as well as in the quoted studies, the bullets were removed early in the clinical course because missed injuries and late retrievals have been shown to have poor outcomes with increased risk of septic arthritis[8,40] Our average time to removal was six days (range 1–12).

The relatively low numbers represent a limitation of our study. This is, however, the largest series to date published from a single institution. Long-term clinical outcomes are beyond the scope of this manuscript as our endpoint was successful removal of bullets utilising proven surgical techniques with known long-term outcomes. The epidemiology of associated injuries is also beyond the scope of this manuscript.

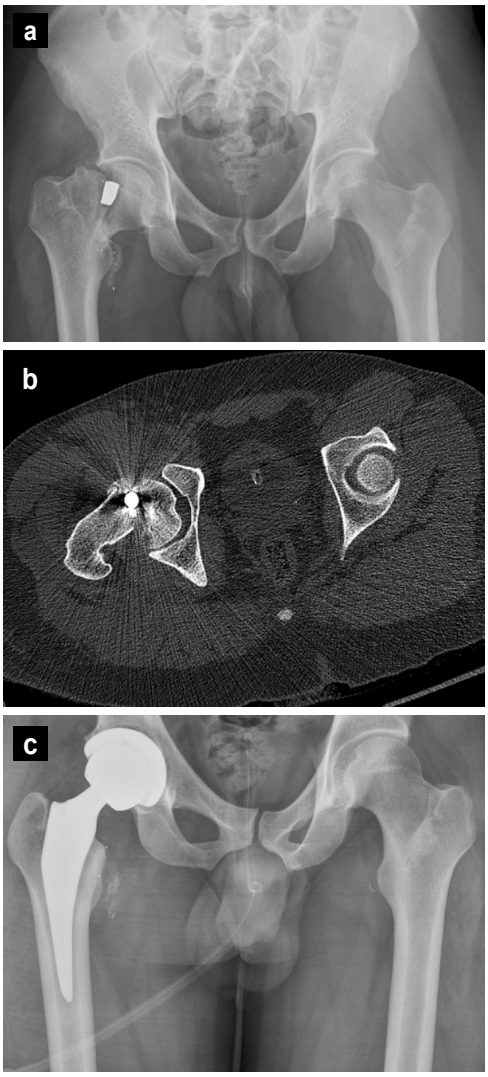

Figure 6. Total hip arthroplasty

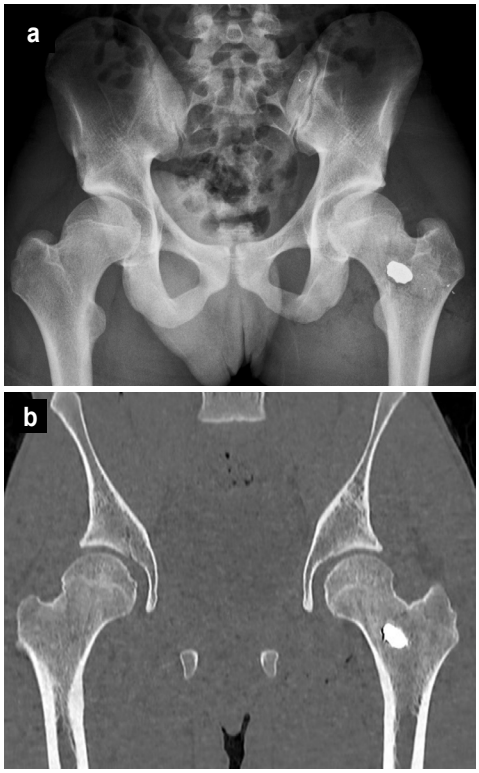

Figure 7. Bullet embedded in bone

Conclusion

We present the largest series of bullet removal from the hip joint in which all bullets were successfully removed.

With adequate preoperative imaging and careful surgical planning, safe surgical removal of retained bullets in the hip joint can be achieved without the use of hip arthroscopy, using the traditional open surgical approaches of arthrotomy, tractotomy and surgical hip dislocation. This is particularly helpful in clinical settings where hip arthroscopy is not readily available.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study, ethics approval was obtained from our institution on 16 October 2023, approval number 440/2020. Informed consent was obtained from all subjects for both clinical intervention as well as use of clinical information for research purposes.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

SM: conception and study design, ethics, literature review, analysis and interpretation of relevant data, writing of the manuscript
AN: conception and study design, review and final approval of manuscript
NK: review and approval of final manuscript
SG: review and approval of final manuscript
SS: data collection and review and approval of final manuscript
ML: study design, data collection, review and approval of final manuscript
AA: data collection and review and approval of final manuscript

ORCID

Maqungo S https://orcid.org/0000-0002-8735-8341
Nicol A https://orcid.org/0000-0001-5181-1151
Kauta N https://orcid.org/0000-0002-7099-2506
Graham S https://orcid.org/0000-0002-4091-7548
Swanepoel S https://orcid.org/0000-0003-2553-4343
Laubscher M https://orcid.org/0000-0002-5989-8383
Antoni A https://orcid.org/0000-0003-2294-649X

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