Gunshot Wounds to The Hip

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ABSTRACT

Gunshot wounds to the hip region are likely to cause complex peritrochanteric fracture. The fracture patterns are often highly comminuted and accompanied by injuries to local structures and abdominal viscera.

Our case series analyses 25 orthopaedic procedures performed. The overall union rate for primary fixation was 66%. Two patients underwent revision surgery for failed primary fixation. Two cases where fixation had failed were revised to total hip replacement successfully.

These types of injuries present a formidable challenge. Preservation of the femoral head should be prioritised to avoid arthroplasty. Long-term follow-up is necessary in assessing the success of these procedures.

1. Introduction

Cape Town regularly ranks in the top ten tourist destinations in the world. It is also placed in the top ten cities worldwide when it comes to murder rates with a large proportion of assaults involving firearms.¹ Low velocity handguns are often used in these assaults.

Low velocity is defined as bullets which travel less than 2000 feet per second.² Aside from velocity, the extent of tissue damage depends on a number of factors related to the types of bullet used. Bullets are usually made from a lead alloy which has a high specific gravity. This makes the bullets heavy with minimal air resistance. Different bullet tips can produce very different characteristics when the bullet interacts with tissue upon impact. Pointed bullets have poor balance and become very unstable when meeting resistance, the opposite of which is true when they are travelling at high velocity as the point confers a stable flight pattern. As tissue is encountered, a bullet typically tumbles and can turn drastically on its short axis. This is called yaw, the kinetic energy disperses and often creates a far larger wound.

Gunshot wounds (GSWs) to the hip are often associated with abdominal injuries and carry substantial morbidity and mortality. Bullets are frequently embedded in the acetabulum, femoral head or neck. In a number of cases there may be no fracture visible, with the bullet contained within the joint capsule itself. The joint can become

contaminated when the bullet enters and thus requires removal. Long et al.³ have suggested a bullet wound between the umbilicus and the proximal third of the thigh conveys a high risk that the hip joint may be involved.

A study done at our unit in 2011 showed as many as 8445 admissions to the trauma unit over a 16 month period, 35% were related to violence.⁴ This puts a huge strain on healthcare systems with figures on average of USD 2940 per orthopaedic GSW reported.⁵ There is very limited literature available on how to successfully treat fractures involving the femoral head and neck resulting from gunshots. The fracture patterns are often complex due to high levels of comminution. As a result, there is often difficulty applying traditional classifications which guide fracture management. There is a need to for surgeons to share their experience in managing these frequently complex injuries to understand which forms of fixation are likely to succeed.

1.1. Aims

We aim to report on clinical (infection rate) and radiological outcomes (union, failure of intervention) of patients who have suffered GSWs to the hip. These include injuries to the head of femur, neck of femur and the peritrochanteric region. We will be reporting on any associated injuries and detailing the surgical interventions selected in

Abbreviations: GSWs, Gunshot Wounds; USD, United States Dollar; ATLS, Advanced Trauma Life Support; LODOX, Low-dosage, digital X-ray scan; CT, Computed Tomography; NOF, Neck of Femur; DHS, Dynamic Hip Screw; THR, Total Hip Replacement.

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these difficult to treat cases.

2. Materials and methods

Between 2010 and 2015 we found a total of 32 patients who had suffered a GSW to the hip resulting in a fracture to the head of femur, neck of femur, peritrochanteric region or the bullet being embedded in bone. Seven notes were not obtainable and hence excluded from the study. Subtrochanteric fractures were excluded from the study.

We included the remaining 25 patients, of which, 23 were male and two female. The mean age was 27.2 years (range 18–42). Patients were treated using the principles of Advanced Trauma Life Support (ATLS) in the specialised trauma unit where they were seen by emergency department physicians and trauma surgeons. The patients were triaged and stabilised before being referred to the orthopaedic team for hip and pelvis fractures. Orthopaedic treatment was coordinated with the trauma surgeons to ensure that life-saving measures were prioritised according to ATLS principles. Orthopaedic intervention included: initial wound assessment and surgery for the stabilization of fractures when indicated. Irrigation and debridement of joints along with removal of bullets was performed for intraarticular bullets.

All patients received a whole-body, low-dosage, digital X-ray scan (LODOX).⁶ Formal radiographs were obtained based on indication and location of injuries. Computed Tomography (CT) scans were performed when required.

3. Results

There was considerable heterogeneity in our series with a range of different fracture configurations which occasionally included multiple fractures within the peritrochanteric region. This resulted in numerous fixation techniques being implemented. The procedures were performed

by various surgeons occasionally undertaking procedures many days after the initial injury.

The most common site for bullet entry was the buttock; 11 patients in total (44%). This is followed by the thigh, numbering nine entry wounds (36%). Six of these entered laterally and three entered anteriorly. Other sites included the groin, flank and iliac fossa and are listed in Table 1. Images were reviewed pre-operatively, retained bullets were seen most commonly within the hip joint (48% n = 12).

3.1. Non-orthopaedic surgical interventions

Six patients (24%) suffered GSW which penetrated the abdominal cavity and required an emergency laparotomy. Within this group four patients had other associated injuries which included injuries to the diaphragm, hand, scrotum, penis and an open fracture of the parietal bone.

Laparotomies were performed on the basis of haemodynamic instability or presence of peritoneal signs without an obvious alternative bleeding source. Patients were treated according to the Trauma Society of South Africa protocol for the management of the abdominal GSWs.⁷

Three patients (12%) sustained scrotal injuries. One of these patients sustained injuries to the penis and scrotum which required debridement and a right orchiectomy. One patient required scrotal exploration and underwent a left orchiectomy. A single patient was discovered to have a minor injury the vas deferens which was treated conservatively.

4. Orthopaedic injuries and interventions

4.1. Fractures

There were 15 neck of femur (NOF) fractures. Four involved a single cortex and the remaining 11 were complete. Three NOF fractures were

Table 1
Patient demographics and injury details.

Case No.	Gender	Age (years)	Bullet entry site	Bullet location	Fracture(s)	Associated Injuries
1	Male	24	Lt Iliac fossa	Intra-art	Acetabulum	Multiple GSW, Abdominal organ injuries, multiple bowel resections and bladder repair.
2	Male	34	Rt buttock	Groin	Fem head	None
3	Female	27	Lt ant thigh	Intra-art	Fem head	None
4	Male	27	Lt Flank	Exited	NOF	Right arm, shoulder tangential. Left thigh lodged in soft tissue.
5	Male	28	Rt Buttock	Intra-art	NOF basicervical, subtrochanteric	None
6	Male	42	Lt lat thigh	Intra-art	NOF	None
7	Male	21	Rt Buttock	Intra-art	NOF	None
8	Male	19	Rt Buttock	NOF	NOF	Multiple GSW abdomen, diaphragmatic hole, multiple abdominal organ injuries requiring laparotomy.
9	Male	29	Lt Buttock	Intra-art	Acetabulum	None
10	Male	28	Lt lat thigh	Great. troch	NOF	None
11	Male	18	Lt Buttock	Exited	NOF	Tangential GSW scrotum. Scrotal exploration and left orchidectomy
12	Male	21	Lt Buttock	Intra-art	Fem head, acetabulum, sacrum	GSW abdomen. Laparotomy to repair damage to left iliac vessels and pelvic organs.
13	Male	27	Lt lat thigh	Intra-art	Abrasion of acetabulum, extra-chondral NOF	Left flank tangential bullet
14	Male	24	Rt groin	Acetabulum	Bullet embedded	None
15	Male	24	Lt lat thigh	NOF	NOF	GSW Chest, bullet remains in anterior axillary line.
16	Male	23	Lt buttock	Intra-art	Bullet embedded	GSW head. Parietal compound fracture with underlying haemorrhage.
17	Male	28	Lt flank	Intra-art	Acetabulum	Multiple GSW abdomen, multiple repairs and resections of organs.
18	Male	19	Lt lat thigh	Exited	NOF	Multiple GSW abdomen requiring small bowel resections. Tangential GSW Right hip. 1st metacarpal fracture right hand.
19	Male	20	Rt buttock	Intra-art	NOF	Minor injury to vas deferens
20	Male	36	Rt ant thigh	Exited	NOF	None
21	Male	18	Lt buttock	Intra-art	NOF	Femoral nerve injury. No Quads power.
22	Male	31	Lt buttock	Ant thigh	NOF	None
23	Male	30	Rt ant thigh	NOF	NOF	None
24	Male	35	Rt lat thigh	Pelvis	Right fem head, acetabulum	Multiple GSWs. Left thigh tangential, penis, scrotum. Required right orchidectomy and debridement.
25	Female	28	Rt groin	Fem head	Acetabulum	None

extracapsular, twelve were intra-capsular. Four patients sustained multiple fractures: one acetabular and head of femur, one acetabular and NOF, one NOF and head of femur. A single patient sustained three fractures: head of femur, sacrum and acetabulum. There were four isolated acetabular and two head of femur fractures. Two patients in our study were found to have the bullet embedded within the bone.

4.2. Orthopaedic procedures

25 orthopaedic procedures were performed on 23 patients. The most commonly performed procedure was a surgical hip dislocation, performed on 8 patients for the purpose of bullet retrieval. Four cases were combined with internal fixation for fractures of the head and neck of femur. One of these procedures included the insertion of a lag screw for a femoral head fracture, one required three cannulated screws for a unicortical NOF fracture, and one had three headless compression screws inserted for a complete NOF fracture and a single case of dynamic hip screw insertion for a comminuted NOF fracture. A single case of intra-articular bullet removal (Fig. 3) was done through an ilioinguinal approach, requiring drainage of bowel contents and pus from the bullet tract.

A proximal femoral locking plate was applied in four cases. Three were for complete NOF fractures. One required a femoral plate with two proximal screws, a calcar screw and five shaft screws, for a highly comminuted NOF fracture involving basicervical and subtrochanteric regions. This included bullet retrieval.

A dynamic hip screw (DHS) was inserted in three cases of complete intracapsular NOF fracture and two cases of extracapsular NOF fracture. As previously mentioned, an additional case required disarticulation for bullet retrieval, prior to DHS insertion.

4.3. Complications

We observed a complication rate of 20% ($n = 5$) in our series with two patients undergoing revision surgery at the time of last follow-up. These are demonstrated in Table 2. The most common complication was DHS cut-out occurring in two cases, a further case of varus collapse was associated with a DHS. One patient treated with a femoral plate for an intracapsular NOF fracture was found to have broken screws on plain films. He has had no further operations but walks with a Trendelenburg gait.

Two patients required revision surgery; they both received a total hip replacement. Initial fixation using a DHS in one case and a femoral plate in the other failed due to cut-out and NOF collapse, respectively. Uncemented total hip replacements (THRs) were implanted using ceramic-on-ceramic bearings.

5. Discussion

There were 2451 homicides recorded in Cape Town in 2015. In a population of 3.74 million people that is a rate of 65.53 per 1,00,000 people.⁸ South Africa has around 20 gun-related homicides per day

Table 2
Complications and further management.

Case No.	Fracture(s) description	Orthopaedic procedure	Complications	Revision Surgery	Time to complication	Follow-up time
1	Acetabulum	Surgical dislocation				12 days
2	Fem head	No surgery				15 days
3	Fem head	Surgical dislocation and screw insertion				23 days
4	NOF Intracapsular complete	DHS	DHS cut-out	Right THR uncemented	9.2 months	10.6 months 5 days
5	NOF Intracapsular complete basicervical, subtrochanteric	Femoral plate and screws				14 days
6	NOF Intracapsular unicortical	Surgical dislocation				25 days
7	NOF Intracapsular unicortical	Surgical dislocation				8.2 months
8	NOF Intracapsular complete	Surgical dislocation and DHS	DHS cut-out		2.6 months	1.5 months
9	Acetabulum	Surgical dislocation				4.5 months
10	NOF Extracapsular complete	DHS				20 days
11	NOF Intracapsular complete	Femoral plate				6.4 months
12	Fem head, acetabulum, sacrum	Surgical dislocation				7 days
13	Abrasion of acetabulum , extra-chondral	Surgical dislocation				2.1 months
14	NOF Intracapsular unicortical None	Surgical dislocation				11.9 months
15	NOF Intracapsular complete	Femoral plate	Broken screws. Admitted with pain and discharged. Currently, Trendelenburg gait.		2.9 months	2.5 months
16	None	Surgical dislocation				11 days
17	Acetabulum	Bullet retrieval				21 days
18	NOF Extracapsular complete	Screw insertion				8 days
19	NOF Intracapsular unicortical	Surgical dislocation and screw insertion				4 months
20	NOF Extracapsular complete	DHS	Varus collapse		2 months	13.6 months
21	NOF Intracapsular complete	Surgical dislocation and screw insertion	Trendelenburg gait and collapsed NOF. Severe osteoarthritis.	Left uncemented THR	1.4 months	1.8 months
22	NOF Intracapsular complete	Femoral plate				11 days
23	NOF Intracapsular complete	DHS				4 years
24	Right fem head, acetabulum	Screws				6.1 months
25	Acetabulum	No surgery				

which equates to an annual rate of 14.0 gun-related homicides per 1,00,000 people.⁵ The cost of treating non-fatal GSWs is very high, with data from 2005 estimating a total of 1,27,000 GSW hospital attendances in a single year across South Africa.⁹ These figures confirm the economic burden imposed on healthcare services and emphasises the need publish data to guide the management of these complex injuries to prevent complications and multiple operations.

GSWs are potentially serious injuries which should be treated in a major trauma centre with access to a full range of surgical specialties. GSWs to the hip have a high incidence of associated visceral organ, neurologic, or vascular injuries and are associated with increased morbidity and mortality.¹⁰ Low velocity GSWs as those described in our series do not always require surgical intervention and if there is no associated fracture or intra-articular bullet they may be treated non-operatively. Classically, high velocity GSWs with contamination are treated with surgical debridement and prophylactic antibiotics. Low velocity GSWs however do not necessitate prophylactic antibiotics and in our series were prescribed on a case by case basis dependant on factors such as level of contamination, abdominal or pelvis cavity involvement. Equally, bullets are not autosterilised when fired¹¹ and contaminated material such as clothing and skin may track into the wound or joint. This process occurs via a temporary cavity and vacuum created at impact.¹² Therefore, bullets which enter joints are at risk of septic arthritis. We encountered no cases of infection in our series.

5.1. Intra-articular bullets

Bullet removal is indicated when intra-articular or are symptomatic when located within soft-tissues.¹³ The bullet can cause traumatic arthritis by third body wear if it remains in joint.¹⁴ If it remains within the joint there is also a risk of joint sepsis, lead arthropathy, and systemic lead poisoning (plumbism).¹⁵ In the majority of our cases we used the posterior approach for hip dislocation and intra-articular bullet removal, described by Ganz et Al.¹⁶ In one case this was combined with a lag screw insertion for a fracture of the femoral head. Utilising this approach for intra-articular bullet retrieval allows for effective assessment and treatment of femoral head fractures.¹⁷

5.2. Neck of femur fractures

GSWs resulting in fractures of the femoral neck are rare, with few reports in existence.^{3,12,18,19} We report on 15 cases, the largest series to date, which includes both unicortical and complete fractures. All complications in our study occurred in patients with complete NOF fractures (33%), two required THR due to failure of fixation. Four of the five complications occurred in intracapsular fractures.

Fig. 1. Case 4: 3D reconstruction showing high levels of comminution of the right femoral neck.

These fractures are difficult to classify due to do often high levels of comminution as seen in Fig. 1. Case four demonstrates a highly comminuted femoral neck on CT. Intra-operative reduction was very difficult to achieve resulting in a 5 h operation for DHS insertion. The implant failed at four months post-operatively due to cut-out, demonstrated in Fig. 2. This was revised to an uncemented THR at nine months following initial surgery.

Case 21 required a surgical dislocation for bullet retrieval using a posterior approach and trochanteric osteotomy. Once the bullet was retrieved, three cannulated screws were implanted into the femoral head to stabilise the femoral neck fracture. Films post-operatively and at two month follow-up were satisfactory. At eleven months the patient presented with a Trendelenburg gait and shortening of the affected leg. Imaging showed metal-work failure, the three cannulated screws had broken and severe osteoarthritis could be seen. He received a THR nine months later.

Case 15 had a femoral plate fitted for an intracapsular NOF fracture. At 2.9 months post-operatively the patient presented with groin pain. The screws holding the proximal femoral locking plate had broken, additionally, a delayed union of the femoral neck was seen. Once his pain resolved he was discharged and at one year follow-up union was achieved. He continues to walk with a Trendelenburg gate, yet remains pain free. We encountered two cases of DHS cut-out and a single case of varus collapse in our series. At the time of injury it is not possible to determine, definitively, if the blood supply to the femoral head has been disrupted. Fig. 4 demonstrates the embedded bullet within the femoral neck. However, even in cases where it is likely; adequate bone stock should prompt attempts at stabilization. The young patient group affected by these injuries necessitate such attempts. We believe THR should be considered as a last resort if the fracture is technically fixable.

Due to the velocity of bullets when coming into contact with bone, there may be fracture lines which cannot be appreciated on imaging initially. There are many reports of the delayed diagnosis of NOF fractures.^{3,20} The assessment of occult injuries may sometimes be inhibited by distracting injuries and altered mental status, which often accompany trauma situations. Thus, careful surgical planning with experienced team members is essential to ensure appropriate equipment is available in theatre.

We acknowledge the limitations of our study. Our study contains a small number of cases which makes statistical analysis difficult. The series suffers from a large range of follow-up times with many patients having insufficient follow-up to confirm bony union. We thus believe the complication rates are underreported.

Fig. 2. Case 4: Right dynamic hip screw cut-out.

Fig. 3. Case 14: Intra-articular bullet right hip.

Fig. 4. Case 8: Bullet located within the right neck of femur.

6. Conclusions

GSWs to the hip present the orthopaedic surgeon with a formidable challenge. They are potentially serious injuries which should be treated in a major trauma centre by surgeons experienced at treating these types of injuries. We advocate attempts to preserve the native joint in this young patient group.

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Sithombo Maqungo: was responsible for, Conceptualization, Supervision. **Daniel Fegredo:** was responsible for, Writing - review & editing, Visualization. **Milos Brkljac:** was responsible for, Methodology, Data collection, Writing - original draft. **Maritz Laubscher:** Supervision, was responsible for supervision.

Declaration of competing interest

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