

Firearm Injuries of the Knees without Neurovascular Damage in Police Encounters: Case Series and Review of Literature

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Abstract:

Background: Firearm injuries to the knee, particularly in police encounters, present unique medical, forensic, and legal challenges. While these injuries often spare neurovascular structures, they may result in complex musculoskeletal trauma. Understanding knee anatomy, especially neurovascular relationships with surrounding tissues, is crucial in assessing injury severity, management strategies, and forensic analysis.

Case Presentation: This case series examines multiple patients with firearm-related knee injuries sustained during police operations, discussing their presentation, management, rehabilitation, forensic analysis, and legal implications. All three patients presented with firearm injury, soft tissue compromise, and without retained bullet fragments. Radiological investigations confirmed there were no retained firearm products. One had simple 2-part horizontal fracture of patella, second had a stellate fracture of patella, and the third had no bony injury. Patella fracture patients underwent emergency surgical interventions including debridement, open reduction, internal fixation. Post-operative rehabilitation was initiated, though constrained by the custodial setting. Functional outcomes were satisfactory in the short term, with no immediate signs of deep infection or neurovascular complications.

Conclusion: A coordinated strategy involving orthopaedics, trauma care, law enforcement, and medico-legal services is necessary for inmate firearm injuries to the knee joint. Fracture stabilization, proper surgical decontamination, early diagnosis, and unambiguous medico-legal documentation are crucial. Within the limitations of custodial care, rehabilitation must be customized with a focus on joint mobility and infection control.

Keywords: Firearm Injury, Gunshot Wound, Knee Joint, Intra-Articular Fracture, Prisoner, Orthopaedic Trauma, Custodial Care.

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Introduction

Gun-related violence kills over one thousand people and injures millions of others worldwide every day. [1-3] This growing burden of gunshot injuries demands evidence-based ballistic trauma management. Musculoskeletal ballistic injuries constitute a unique group in terms of demographics, injury patterns, management, surgical techniques, and clinical outcomes. [4-8]

Gunshot wounds (GSWs) involving the knee joint are uncommon in civilian trauma but can occur in the context of law enforcement encounters, criminal activity, or armed conflict. [8-9]

GSWs to the knee differ from other extremity injuries due to the joint's complex biomechanics and articulations. [10] Neurovascular structures—comprising arteries, veins, and nerves—play a vital role in knee function.

These injuries are usually high-energy and often leads to intra-articular fractures, contamination from retained bullet fragments, soft tissue trauma, and potential neurovascular injury. While injuries sparing major neurovascular components may seem less severe, extensive damage to soft tissues, cartilage, and bone can still lead to long-term disability. [11-14]

Timely and appropriate management is vital to prevent complications such as joint instability, septic arthritis, osteomyelitis, and post-traumatic osteoarthritis. [15-16]

When such injuries occur in incarcerated individuals, additional complexities arise. Treatment may be delayed due to logistical issues in prisoner transport, and access to advanced imaging, rehabilitation services, and multidisciplinary care may be limited. Ethical

concerns such as obtaining informed consent under custodial oversight and medico-legal documentation must also be considered.

This article provides a detailed anatomical review of the knee, focusing on the neurovascular network, along with a case series and forensic discussion.

Anatomy of the Knee with Neurovascular Emphasis

The knee is a hinge-type synovial joint composed of:

1. **Bony structures:** Femur, tibia, patella, and fibula (supporting bone).
2. **Ligaments:** Cruciate and collateral ligaments maintain stability.
3. **Cartilage:** Menisci and articular cartilage enable smooth movement.
4. **Muscles and Tendons:** Quadriceps, hamstrings, and patellar tendon regulate extension and flexion.
5. **Neurovascular Structures:** The popliteal artery, veins, and sciatic nerve branches (tibial and common peroneal) regulate circulation and sensation.

Neurovascular Components and Their Relationship with Surrounding Tissue

Arterial Supply

- **Popliteal Artery:** The principal blood supply to the knee joint, located posteriorly in the popliteal fossa, deep to the semimembranosus and biceps femoris tendons.
- **Genicular Arteries** (Superior, Middle, and Inferior): Branch from the popliteal artery, supplying the joint capsule, synovium, and ligaments.
- **Anterior Tibial and Posterior Tibial Arteries:** Distal branches supporting circulation beyond the knee.

Venous Drainage

- **Popliteal Vein:** Accompanies the popliteal artery, draining blood from the lower limb.
- **Superficial Venous System** (Great saphenous and small saphenous veins): Vital for collateral circulation in cases of traumatic injury.

Nervous Structures

- **Sciatic Nerve:** Divides into the tibial nerve (posterior compartment innervation) and the common peroneal nerve (lateral compartment innervation).
- **Saphenous Nerve:** Provides sensory innervation to the anteromedial knee and lower leg.
- **Popliteal Plexus:** A network of sensory nerves regulating pain response in trauma cases.

Neurovascular Trauma Considerations in Gunshot Injuries

- **Posterior knee injuries** are high risk due to the proximity of the popliteal artery and vein.
- **Lateral knee wounds** may impact the common peroneal nerve, leading to foot drop.
- **Medial knee injuries** can affect the saphenous nerve, causing sensory deficits.
- **Bullet trajectories sparing neurovascular structures** may still disrupt blood flow due to localized oedema or soft tissue trauma.

Review of Literature

Biomechanics of Gunshot Wounds to the Knee:

Ballistic trauma mechanics vary based on projectile characteristics, impacting musculoskeletal integrity. Studies by Fackler (1987) describe temporary cavitation effects, which influence joint disruption, even in cases where neurovascular compromise is absent. Bowyer & Cooper (1997) discuss the role of imaging in diagnosing intra-articular involvement in ballistic injuries. [9,14]

Management and Rehabilitation: Orthopaedic approaches to firearm-related knee trauma include early fixation strategies (Peck, 2012) and biologic reconstruction methods aimed at restoring joint function. Post-injury rehabilitation is critical to mitigating stiffness and preventing long-term arthritis. Current guidelines suggest early weight-bearing rehabilitation in cases of joint preservation. [13]

Forensic and Legal Considerations in Police Encounters:

The forensic reconstruction of knee GSWs is essential in legal proceedings. Studies by Karger et al. (2008) highlight wound ballistics and trajectory analysis in police-involved shootings. [18] Further research underscores the importance of medico-legal documentation and expert testimony in determining justification in law enforcement firearm discharges. [19,20]

Ballistic Trajectory Analysis

- **Entry wound location vs. exit wound patterns:** Determines bullet trajectory.
- **Close-range vs. long-distance shooting:** Evaluates kinetic force impact.

Police Use-of-Force Investigation

- **Medical records and forensic imaging:** Establishing intent and justification of firearm use.
- **Neurovascular sparing injuries:** Indicating incapacitation strategy rather than lethal targeting.

Case Series: Clinical Presentation and Management

Case 1: Low-Velocity Gunshot wound with no bony injury

Patient: 23-year-old male injured during police pursuit while attempting to escape custody.

Presentation: Single entry wound over anteromedial aspect of knee with inverted margin and exit wound with everted irregularly circular margins at the posteromedial aspect of left upper calf.

Neurovascular Assessment: Intact popliteal artery, tibial nerve unaffected.

Imaging Findings:

- X-ray revealed no bony injury/no foreign body of metallic density.
- CT scan confirmed no vascular compromise.



Figure 1: Image showing entry and exit wounds (Case 1)



Figure 2: X-Ray of Knee (Case 1)

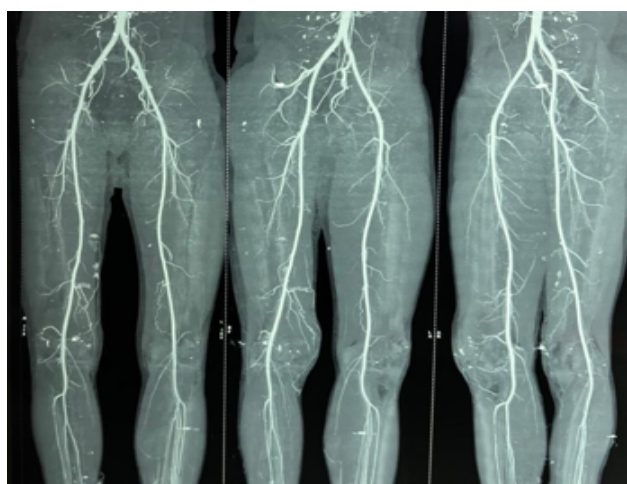


Figure 3: CT-Angiography showing no vascular injury (Case 1)

Management Approach:

- **Surgical intervention:** wound debridement and serial sterile dressings.
- **Antibiotic therapy:** Prevention of bone infection.

- **Physical therapy:** Gradual mobilization to prevent quadriceps atrophy. Post-discharge rehabilitation therapy was affected due to logistical issues as the patient was incarcerated in prison.
- **Outcome:** Full weight-bearing achieved at 4 weeks; minimal functional impairment.

Case 2: High-velocity gunshot wound with patellar fracture

Patient: 42-year-old male injured during police encounter while attempting to escape custody.

Presentation: Anterior centrally placed entry wound over right knee with inverted margins and tattooing, and an exit wound in the middle of popliteal fossa with irregular everted margins.

Neurovascular Assessment: No clinical sign of neuro-vascular damage.

Imaging Findings:

- X-ray revealed a displaced transverse two-part fracture of the right patella. No retained bullet fragment was visible, suggesting complete exit of the projectile.
- CT angiography scan revealed no vascular injury
- MRI ruled out ligamentous injury.



Figure 4: Image showing entry and exit wounds (Case 2)

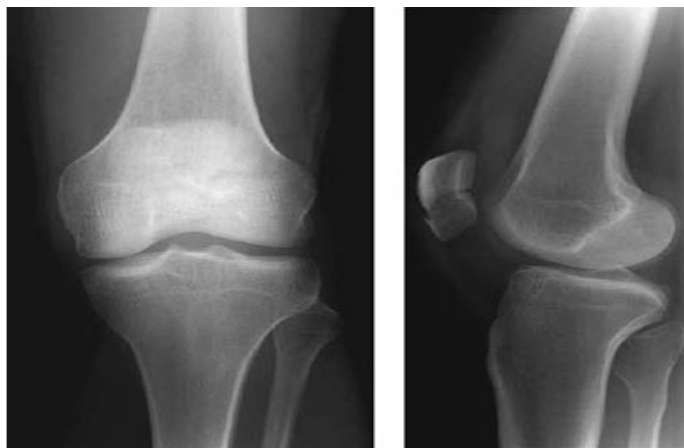


Figure 5: X-Ray of Knee showing transverse fracture of patella (Case 2)

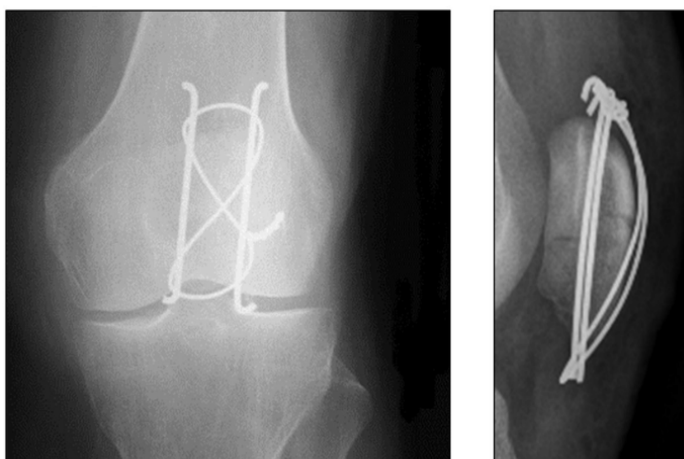


Figure 6: X-Ray of Knee (Case 2-Post-Op)



Figure 7: CT-Angiography showing no vascular injury (Case 2)

Management Approach:

- **Surgical fixation:** Wound debridement, open reduction, and tension-band wiring was done for fracture stabilization.
- **Pain management:** Intravenous NSAIDs for two days followed by oral NSAIDs for 2 weeks.
- **Infection control:** Wound irrigation and prophylactic antibiotics.
- **Physical therapy:** initiated after 10 days. Post-discharge rehabilitation therapy was affected due to logistical issues as the patient was incarcerated in prison.
- **Outcome:** Partial weight-bearing at 4 weeks; return to normal activity at 4 months.

Case 3: High-velocity gunshot wound with patellar fracture

Patient: 35-year-old male injured during police encounter while attempting to break through police barricading.

Presentation: Anterior centrally placed entry wound over right knee with inverted margins and tattooing, and an exit wound in the middle of popliteal fossa with irregular everted margins.

Neurovascular Assessment: No clinical sign of neuro-vascular damage.

Imaging Findings:

- X-ray revealed a stellate fracture of the right patella. No retained bullet fragment was visible, suggesting complete exit of the projectile.
- CT angiography scan ruled out vascular injury.
- MRI ruled out ligamentous injury.

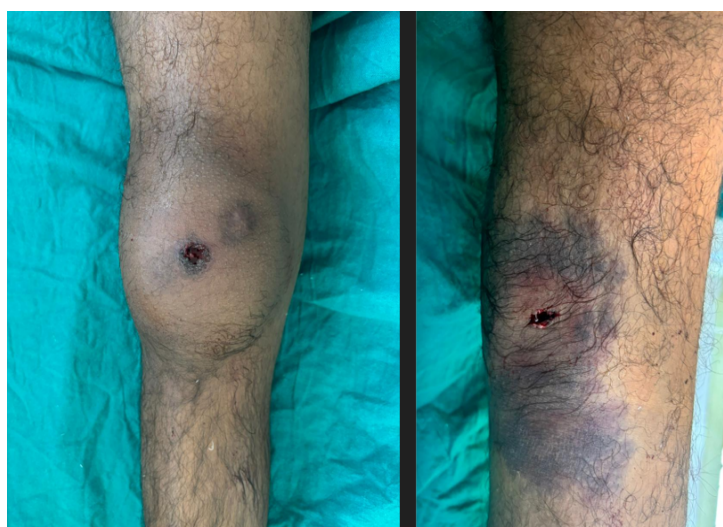


Figure 8: Image showing entry and exit wounds (Case 3)

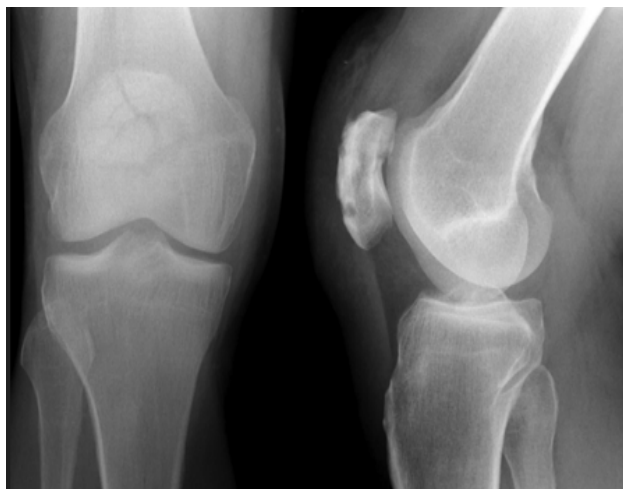


Figure 9: X-Ray of Knee showing stellate fracture of patella (Case 3)

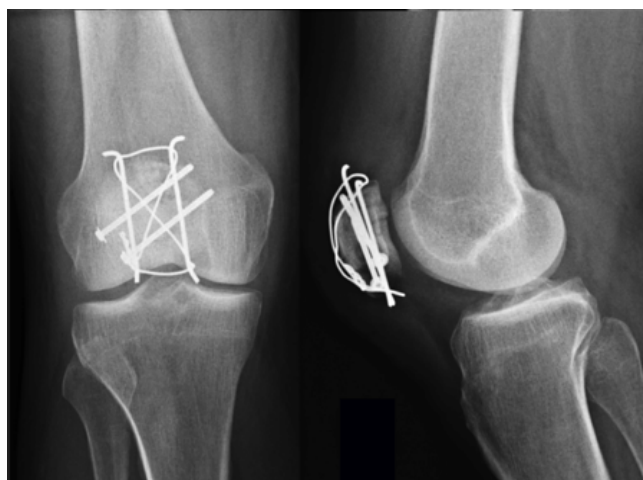


Figure 10: X-Ray of Knee (Case 3-Post-Op)

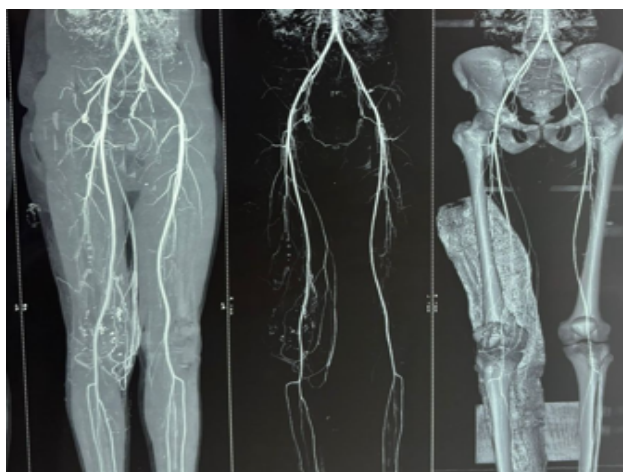


Figure 11: CT-Angiography showing no vascular injury (Case 3)

Management Approach:

- **Surgical fixation:** Wound debridement, open reduction and internal fixation with two screws and tension-band wiring was done for fracture stabilization.
- **Pain management:** Intravenous NSAIDs for two days followed by oral NSAIDs for 2 weeks
- **Infection control:** Wound irrigation and prophylactic antibiotics.
- **Physical therapy:** initiated after 2 weeks. Post-discharge rehabilitation therapy was affected due to logistical issues as the patient was incarcerated in prison.
- **Outcome:** Partial weight-bearing at 4 weeks; return to normal activity at 6 months.

Discussion

Biomechanics and Clinical Implications: The ballistic behaviour of projectiles in knee injuries depends on velocity, calibre, and trajectory. Low-velocity wounds often cause localized fractures without joint destruction, whereas high-velocity injuries lead to extensive bone fragmentation. The absence of neurovascular damage allows for a more favourable prognosis but does not eliminate the risk of complications such as joint stiffness, osteomyelitis, or post-traumatic arthritis.

Forensic Analysis in Law Enforcement Cases: Gunshot wounds sustained during police encounters necessitate forensic evaluation to determine intent, ballistic trajectory, and injury severity. Key forensic aspects include:

- **Ballistic trajectory reconstruction:** Determining angle and range of fire.
- **Wound pattern analysis:** Entry vs. exit characteristics in relation to firearm type.
- **Toxicology screening:** Evaluating the role of substance use in the event.

Legal and Ethical Considerations: Police firearm discharges aimed at extremities are often assessed in legal proceedings. Documentation, wound analysis, and medical expert testimony play a role in determining whether the use of force was justified or excessive.

Conclusion

Knee firearm injuries without neurovascular compromise represent a distinct clinical challenge, requiring careful orthopaedic and forensic evaluation. This case series and literature review highlight the complexities of knee firearm injuries without neurovascular involvement.

As law enforcement encounters continue to pose ethical and medical dilemmas, understanding the biomechanics and management of such injuries can improve patient care and investigative accuracy. While patient outcomes are generally favourable with appropriate orthopaedic intervention, forensic and legal assessments remain crucial in law enforcement cases.

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