Gun Shot Wound to the Knee

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Case Report
A 30-year-old black male sustained a single gunshot wound to the right knee. A single wound surrounded by a powderburn was located over the inferior anterolateral portion of the knee. On physical examination, the right knee was swollen and tender with a large effusion. Range of motion was limited secondary to pain. X-ray evaluation revealed a comminuted right patellar fracture with intra-articular bullet fragments (Fig. 1). The patient was treated by irrigation and debridement, evacuation of the hematoma, removal of the bullet fragments, placement of a suction drain intra-articularly for 1 day, and IV antibiotic coverage for 3 days. The right knee retinaculum was essentially intact and the patellar fracture was minimally displaced, therefore, the patella was not internally fixed. Postoperatively, the patient was placed in a Jones dressing which was changed to a right cylinder cast before discharge.

Discussion
The extent of the soft tissue damage caused by a bullet is dependent upon the mass and velocity of the bullet, as well as size, shape, and tumbling characteristics. The most important factors, mass and velocity, are related to the extent of the injury by the formula \( E = \frac{1}{2} m v^2 \) which represents the kinetic energy of the bullet dissipated to the surrounding tissues. The mass of a bullet varies insignificantly between high and low velocity firearms, i.e., a .38 caliber civilian bullet and a .30 caliber high velocity military firearm weigh almost the same. However, the military firearm has a muzzle velocity approximately three times that of the civilian firearm. Therefore, when the velocities are squared, the military bullet has nine times greater energy than the low velocity civilian firearm. The average civilian firearm muzzle velocities are approximately 275 M/sec to 350 M/sec compared to military firearm’s average muzzle velocities of 610 M/sec to 765 M/sec. Military firearms have the potential to produce explosive type injuries with secondary shock waves and temporary cavitation which exceeds the expanding capacities of the surrounding tissues and, therefore, causes significant injuries. Cavitation occurs when muzzle velocities are greater than 305 M/sec. Thus, most civilian firearms result in minimal or no cavitation and insignificant tissue necrosis away from the immediate bullet track. It is generally accepted that civilian gunshot wounds to the extremities do not require extensive debridement. Howland and Ritchey evaluated 72 patients with fractures resulting from civilian gunshot wounds. Forty-two patients were initially

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treated as outpatients, eight of which later required a surgical procedure for removal of a retained missile; the primary indication was pain. Thirty patients were initially hospitalized; 18 were admitted for parenteral antibiotics and/or observation, 12 patients were admitted and underwent immediate surgery. Six of the operated patients underwent superficial debridement only, and six had major surgical procedures. These included two patellectomies, one IM radius and ulna nailing, one exploratory arthroscopy, one wound exploration and debridement for a femoral fracture, and one finger amputation. Only two out of the original 12 operative patients received antibiotics, and nine of the 18 observed hospitalized patients received antibiotics. Of the 72 patients reviewed, only two patients developed wound infections which were both reported as superficial.

Similar conclusions were reported by Freeark et al after reviewing 100 extremity fractures. Hampton et al stated that the presence of a fracture did not necessitate major surgical debridement of a civilian extremity gunshot wound. Morgan et al, after reviewing 105 patients, also demonstrated that antibiotic coverage combined with superficial debridement is sufficient treatment.

The critical issue of this case is the intra-articular lead foreign body and whether this will cause short- or long-term morbidity. Historically, Lewin reported in 1911 that toxic symptoms were described secondary to lead missiles used in the Roman wars. He also reported an incident of a man who died of lead poisoning 45 years after the Battle of Trafalgar in which he sustained a gunshot wound to the humerus.

In 1974, Ashby discussed seven cases in which the
patient had a knee joint violated by a bullet. He concluded that all joints should be surgically explored, even if the bullet is lodged extra-articularly. He felt that bullets can cause osteocartilaginous fragments which will not be evident on routine x-rays, but can cause mechanical dysfunction and impede normal joint motion. Ashby also concluded that preoperative and intraoperative x-rays should be taken to better plan surgical incisions and to check for acute shifts in the position of bullet fragments. Additionally, multiple surgical incisions may be required, especially if the fragment is located in the posterior compartment. Ashby emphasized that the primary indication to operate was to remove foreign bodies, both lead and osteochondral, not for septic prophylaxis.

In 1982, Parisien and Esformes reported on the role of arthroscopy in managing low velocity gunshot wounds to the knee joint. Of the eight cases examined, five patients underwent limited arthrotomies following arthroscopy, which accurately located the bullet; two patients underwent arthroscopy to evaluate the joint cartilage; and one patient required internal fixation of a medial femoral condyle chondral fracture via an arthrotomy using Smillie nails. It should be noted that five patients had intra-articular damage and retained foreign bodies, including denim and metallic particles, as well as osteochondral fragments. The advantages of arthroscopy include: no immediate preoperative x-rays, osteochondral and lead fragments can frequently be manipulated out of the joint via the arthroscope, rapid recovery with rapid increased range of motion in the injured knee compared to arthrotomies, rare infections, the synovium and articular surfaces of the knee can be examined without large exploratory incisions which can lead to iatrogenic soft tissue damage, the anterior and posterior compartments can be explored easily, and the arthrotomy incisions can be precisely located.

In 1960, Leonard reported on the pathophysiology of lead solubility. Lead was found to be more soluble in synovial fluid where it dissolves and then diffuses through the synovial membrane via dialysis. Once in a serous environment, the lead precipitates out into the subsynovial layer causing periarticular fibrosis and chondrolysis and can lead to hypertrophic arthritis.

Intra-articular knee injuries resulting from low velocity gunshot wounds should be routinely explored either by arthotomy or arthroscopy. The major indication is to remove mechanical impediments in the joint and to remove a source of possible chronic synovitis. The surgical procedure does not need to be done immediately, however it should be accomplished within several days following injury.

References


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