Handgun Injuries to the Foot: Treatment of Low-Velocity, High-Energy Wound Types

The authors present several cases of gunshot injury to the foot. Classification of wounds according to weapon type and caliber is discussed, as well as treatment rationale. Emphasis is placed on the need for detailed wound history and classification as precursors to adequate therapy. The low-velocity, high-energy wound type is introduced, and its variation from the current low- and high-velocity classifications discussed.

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Gunshot wounds present an unique management challenge because of their diversity. Variability comes not only from the multiplicity of firearms but also from the circumstances of tissue penetration by the missile. Weapon caliber; bullet type; range, angle, and area of impact; and foot coverings are some of the variables affecting the makeup of a gunshot wound.

As podiatrists become involved with patient management in large medical institutions and acute trauma settings, our exposure to such foot injuries increases. Early podiatric literature is understandably lacking in information on this important topic. Recently, several articles in the podiatric literature have detailed the management and pathophysiology of gunshot wounds (1–3), thus signaling this increase in exposure. As emphasized in these papers, proper management of gunshot wounds requires thorough knowledge of ballistics as well as surgical technique. In this manuscript, the authors present a series of gunshot injuries treated at Kaiser Permanente Medical Center, Santa Clara, California, and discuss their treatment rationale. Highlighted is the concept of the low-velocity, high-energy handgun wound, which only recently has been described (4).

Case Reports

Case 1. A 25-year-old man was admitted several hours after being shot in the right foot with a .38-caliber pistol at close range (5 to 10 feet). The bullet entered the distal aspect of the foot, through shoes and socks, after it apparently ricocheted off the pavement.

The patient arrived at the emergency department in stable condition. Medical history was noncontributory. Vital signs were stable, and systemic physical examination was unremarkable.

Right lower extremity examination revealed a moderately edematous right forefoot (Fig. 1 *A* and *B*). Dorsalis pedis and posterior tibial pulses were 2/4 to the right foot. Subpapillary venous plexus filling time was 3 sec. to toes one, two, three and five. The fourth right toe was severely pulverized from the bullet entrance site, making the toe ischemic, ruberous, and cold. Neurologic status to the right foot was intact with the exception of the fourth toe, which lacked light touch and sharp sensations.

The bullet's entrance at the distal fourth right toe and third interspace caused a transverse laceration of the fourth toe into dorsal and plantar segments. There was also a distal medial open fracture to the distal phalanx of the fifth toe and a superficial laceration to the distal lateral third digit tuft. There was no exit wound.

Anteroposterior (Fig. 1*C*), medial oblique, and lateral x-ray films of the right foot revealed one large and several small metal fragments within the third interspace and along the fourth metatarsal shaft. The base of the proximal phalanx and fourth metatarsal shafts were severely comminuted and pulverized. The distal head of the right third metatarsal was fractured and slightly displaced medially. A large fragment of the fourth metatarsal head was noticeably displaced medially near the third metatarsal head, probably acting as a secondary missile and causing the third metatarsal head fracture.

The patient was taken to the operating room directly from the emergency department, and the following procedure was performed. After successful induction of

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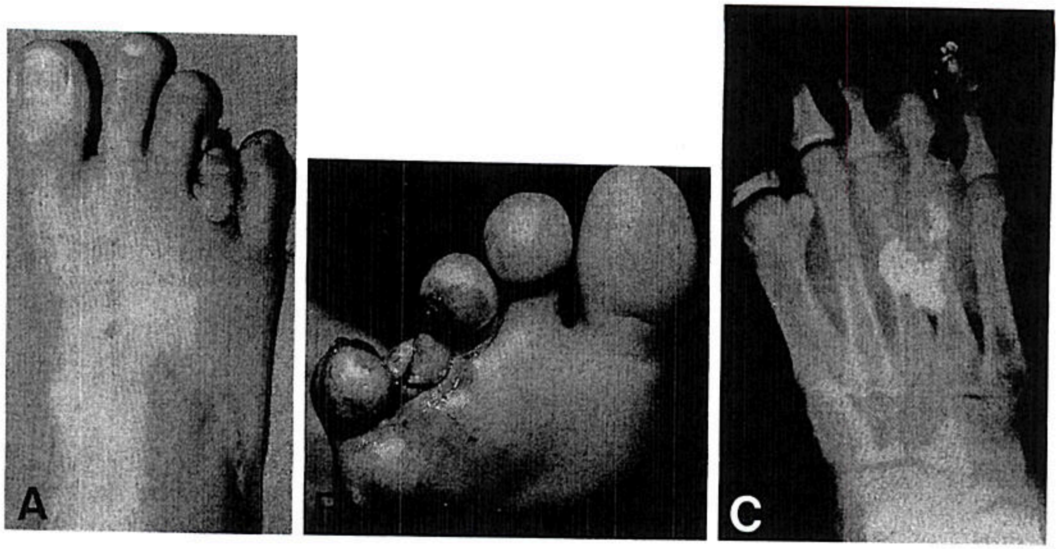

Figure 1. *A* and *B*, photographs show clinical appearance several hours after close-range .38-caliber handgun injury; *C*, anteroposterior x-ray view shows third metatarsal neck fracture from indirect mechanism.

general anesthesia, the leg was prepared below the knee using povidone-iodine and sterile draping. The lacerations of the distal third and fifth toes were debrided of necrotic tissue and foreign particulate matter as necessary (Fig. 2*A*). The entrance wound through the fourth toe and third interspace was examined, but this portal produced inadequate exposure for debridement. A dorsolinear incision was made, centered over the third right interspace and deepened by sharp and blunt dissection. Three large pieces of lead were freed from surrounding tissue (Fig. 2*B*) and removed from the wound, avoiding damage to vital structures. Other particulate foreign debris and necrotic tissue were removed when observed.

The wound was then copiously irrigated with 1 liter of normal saline solution. Small, detached bony fragments of the comminuted fourth metatarsal were removed, and the remaining larger fragments were delicately manipulated into anatomical position, as far as was possible, taking care not to further disrupt any intact periosteum. The fourth metatarsal head was displaced medially into the third interspace, approximating the third metatarsal head. The articular surface was intact. This fragment was manipulated into a position that approximated the fourth metatarsophalangeal joint. No salvageable capsular tissue was identified.

The tourniquet was released, and hemostasis was achieved. Intraoperative x-ray films were taken to ensure adequate removal of the larger lead particles. This was achieved. The wounds were again irrigated, then closed using 5-0 nylon sutures for the digital lacerations. The third interspace laceration was left open and the dorsal incision was left open centrally, for approximately 80% of the wound. A small drain was placed in

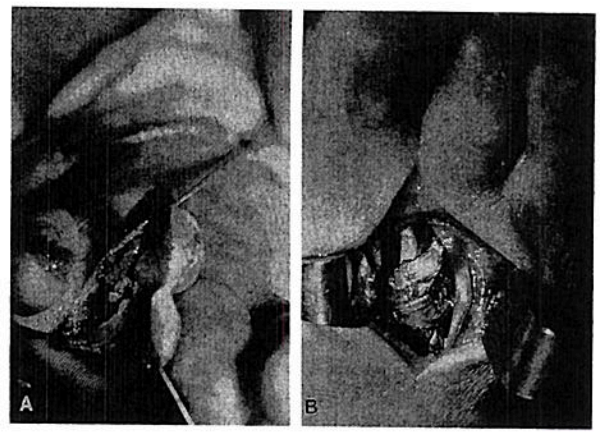

Figure 2. *A*, initial photographs at surgical debridement show damage to fourth toe and metatarsophalangeal joint as well as *B*, bullet position.

the wound before dressing application. Vascular status to the fourth toe remained compromised, dusky in appearance, and cool to the touch. There was a prolonged subpapillary venous plexus filling time to the fourth toe.

The patient was followed as an inpatient and received intravenous antibiotics (first-generation cephalosporin) and local wound management daily. Vascular status to the fourth toe progressively worsened, with gangrenous and necrotic changes revealing its nonviability (Fig. 3).

After 7 days, the patient returned to the operating room, at which time a partial fourth ray resection was performed to the right foot using general anesthesia (Fig. 4). The patient tolerated the procedure with no complications. The wound healed uneventfully (Fig. 5) and the patient regained a normal weightbearing and

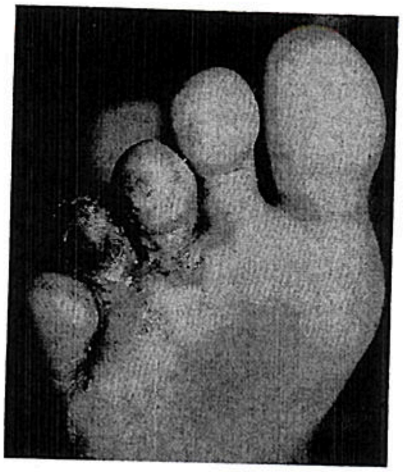

Figure 3. Photograph shows clinical appearance with post-traumatic necrosis several days following initial debridement.

Figure 4. Photograph shows clinical status after partial fourth ray resection.

ambulatory status, with normal shoes and no sequelae. At 1-year follow-up, the patient had continued to be employed as a machinist and had no limitations to his activity or shoes.

Case 2. A 21-year-old man arrived at the emergency department several hours following a self-inflicted .22-caliber, hollow-point gunshot wound to the right second toe. Because the patient was intoxicated, it was necessary to obtain past and present medical history, which was noncontributory, from a family member. Vital signs were stable and systemic physical examination was normal.

Attention was directed to the right foot, which was covered with a tennis shoe. A bullet was lodged in the sole of the shoe. There was slow hemorrhagic oozing from a small regular dorsal wound and large irregular plantar wound on the second toe (Fig. 6 *A* and *B*). The toe was warm, pink, and had normal capillary fill. An x-ray film showed severely comminuted fracture of the proximal phalangeal head (Fig. 6*C*).

The toe was anesthesized locally and probed. Several small foreign bodies as well as small bone chips were removed. The wound was then irrigated with sterile saline solution, and sterile dressing was applied. Because of his intoxication, the patient could not care for himself at home, and was admitted to the hospital for observation.

While in the hospital, the patient received prophylactic antibiotics in the form of a first-generation cephalosporin. The dressing was changed at 24 hr, and the toe was again noted to be warm, pink, and to have normal capillary fill. The patient was discharged, and was seen 3 days later in the outpatient clinic, and had dressings changed. Vascular status remained intact and there were no signs of infection. The patient returned

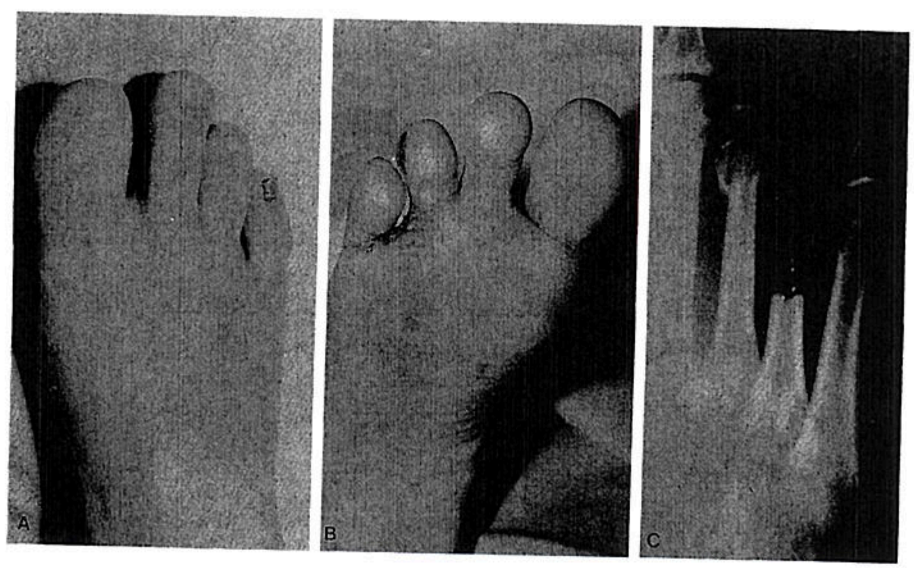

Figure 5. *A* and *B*, photographs show clinical recovery; *C*, anteroposterior x-ray view 8 weeks following initial injury.

at 10 days (Fig. 7) and the wounds were closed. At 1 month following the injury, the wounds had healed and sutures were removed. An x-ray film showed healing of the proximal phalangeal fracture. The patient was subsequently unavailable for follow-up.

Case 3. A 33-year-old man arrived at the emergency department, approximately one half hour after suffering a close-range, low-velocity, high-energy gunshot injury to the left heel while cleaning his 357-Magnum. The bullet entered and exited the left heel through tennis shoes and socks, and lodged into the wood floor.

The patient was in stable condition and in no acute distress. He had significant hemorrhagic oozing from the entrance and exit wounds, which was adequately controlled with compression dressing and elevation. Medical history was noncontributory, and systemic physical examination was unremarkable.

A lower extremity examination revealed an approximately 1-cm. entrance wound at the posterior medial aspect of the left heel, immediately medial and approximately 5 cm. superior to the Achilles tendon insertion, and posterior to the neurovascular bundle (Fig. 8 *A* and *B*). There was an approximately 1-cm. exit wound at the posterior plantar lateral aspect of the left heel. The dorsalis pedis and posterior tibial pulses were 3/4 in the left foot. Toes one through five were pink, warm, and sensate with no neurologic deficits identified to the left foot.

Radiographic examination revealed a severely comminuted and nondisplaced posterior body of the calcaneus fracture with no intraarticular involvement (Fig. 8 *C* and *D*). There was a relatively radiolucent tract at the posterior calcaneus directed from posterosuperior medially to anteroinferior laterally, depicting the course of the missile. Metallic fragments were present within the confines of this tract and extended deeply into the subcutaneous tissue to the exit wound.

The patient was taken to the operating room for

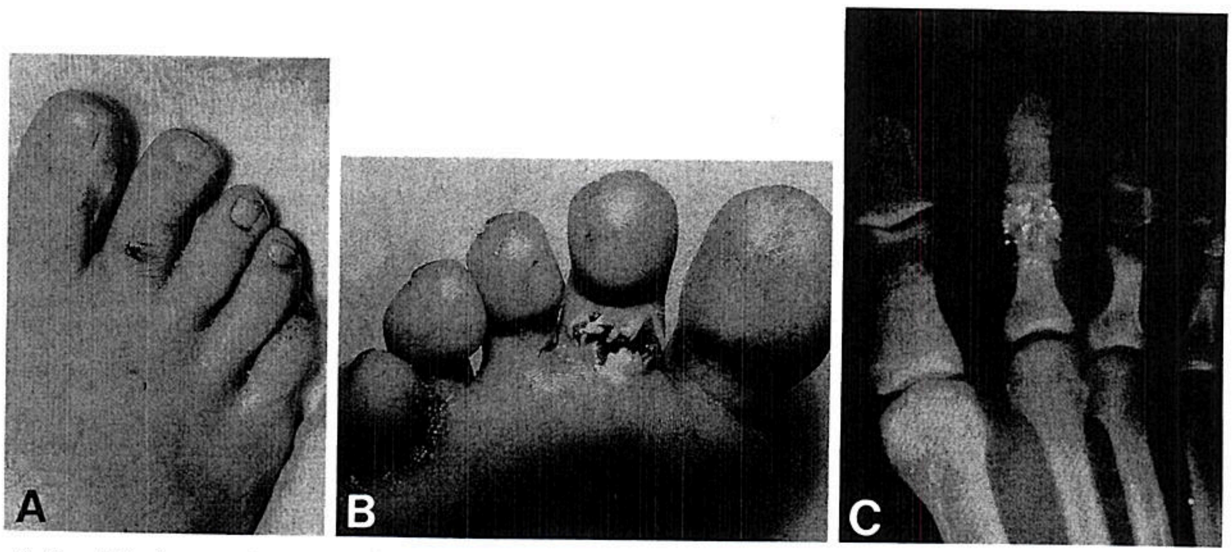

Figure 6. *A* and *B*, photographs show clinical appearance; *C*, anteroposterior x-ray view several hours following injury at close range with .22-caliber handgun with hollow-point bullet.

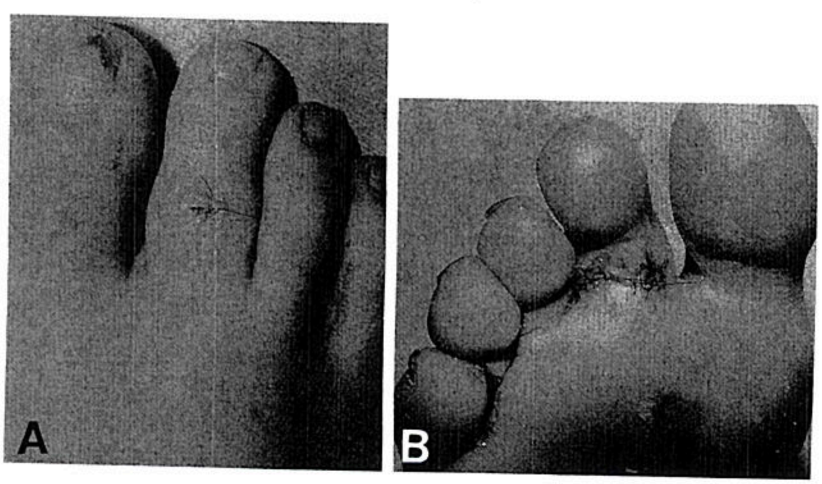

Figure 7. *A* and *B*, photographs show clinical appearance following delayed closure at 10 days.

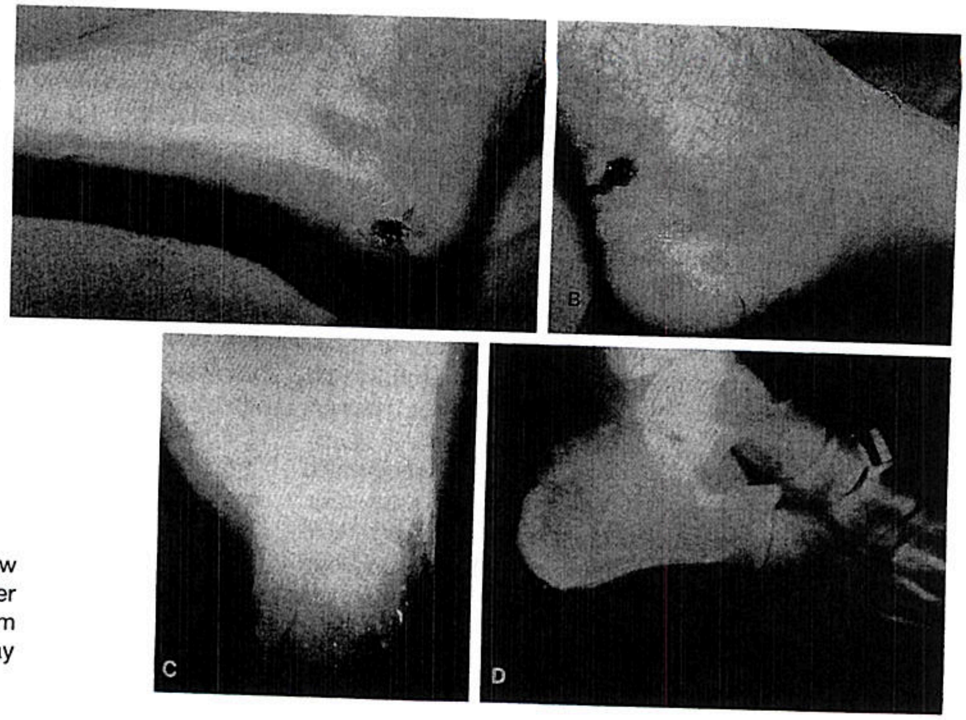

Figure 8. *A* and *B*, photographs show clinical status several hours after close-range injury with 357-Magnum handgun; *C*, axial and *D*, lateral x-ray views.

surgical debridement and irrigation. He was placed on the operating table in a supine position and general anesthesia was achieved. A sterile below-the-knee preparation and drape was performed to the left leg and foot. Hemostasis was achieved by means of a pneumatic tourniquet placed on the left thigh, inflated to 350 mm. Hg.

Attention was directed to the medial aspect of the left heel, where necrotic skin and subcutaneous tissue from the entrance wound was debrided. Some foreign particulate matter, rubber and cloth from shoes and socks, was also removed when observed. A bone curette was then placed through the missile tract in the calcaneus from the entrance to the exit wounds, to ensure a clear passage for irrigation. The exit wound at the posteroinferior lateral aspect of the heel was then debrided of necrotic skin, tissue, and foreign debris.

Four liters of normal saline solution with 1 gm./liter of kanamycin were used to irrigate the wound and missile tract through a jet lavage pulsatile irrigation system. Three to four small, loose, cancellous bone fragments were expressed through the exit wound during irrigation. Both wounds were then inspected for any remaining foreign debris in necrotic tissue and none was present.

The pneumatic thigh tourniquet was deflated and the wound was inspected for any bleeding vessels. Hemostasis was achieved using electrocautery. The posterior tibial and dorsalis pedis pulses were evaluated, and were within normal limits. Reperfusion proceeded to the toes of the left foot. The wound was packed using $\frac{1}{4}$-inch iodoform gauze packing and dressed.

The patient tolerated the procedure and anesthesia well and left the operating room in satisfactory condition with vital signs stable. He remained in the hospital for several days postoperatively, for intravenous antibiotics (first generation cephalosporin) and local wound care. On the fifth postoperative day, a removable fiberglass, short-leg nonweightbearing cast was applied.

The patient was discharged home and remained nonweightbearing for approximately 8 weeks, doing daily nonweightbearing range-of-motion exercises and changing wound dressings. Exercises consisted of passive range-of-motion of the ankle and subtalor joints.

He was followed on an outpatient basis with no sequelae. The wounds healed (Fig. 9*A*), as did the fracture (Fig. 9 *B* and *C*), and he returned to weightbearing activity at 10 weeks. Follow-up x-rays at 3 months showed filling of the calcaneal defect and osteophyte production at the bullet's entrance to the bone, which were not noted to be associated with pain or other symptoms. At 8 months, the patient was walking and working without limitation, although he noted minor discomfort in the plantar aspect of the heel while walking barefoot.

Case 4. A 15-year-old boy suffered a gunshot injury to the right forefoot from a .22 caliber pistol. According to the patient, the gun was fired from approximately a 3- to 4-foot range, entering and exiting his right foot through shoes and socks. The patient presented to the podiatry clinic approximately 8 hr. after injury, in moderate pain and with no acute systemic distress. His medical history was noncontributory, and results of a physical examination were unremarkable.

Lower extremity examination revealed an approximately 0.5-cm gunshot entrance wound, medial to the dorsal mid-third interspace, and an approximately 0.5-cm exit wound at the distal plantar third interspace between the third and fourth metatarsal heads (Fig. 10 *A* and *B*). Vascular examination revealed dorsalis pedis and posterior tibial pulses of 2/4 to the right foot, and a subpapillary venous plexus filling time at 3 sec. to toes one through five of the right foot. There was no major hemorrhage through the wounds. Neurologic examination was normal. There was notable fluctuant soft tissue swelling over the dorsal third interspace, suggesting hematoma formation.

Radiographic examination of the right foot revealed a comminuted middistal third metatarsal shaft (Fig. 10*C*). There was slight lateral angulation of the third metarsal head, neck, and shaft, distal to the fracture in the transverse plane. No shortening of the metatarsal parabola occurred, as the intact transverse metatarsal ligament held the third metatarsal to length. There was no sagittal or frontal plane displacement. Multiple small, metal fragments were identified at the fracture site, and in the area of the distal third metatarsal head and shaft. A larger metal fragment, lateral to the second proximal phalanx and neck of the right foot, did not correlate with a separate entrance site at the second toe, but was the result of a deflected fragment from the primary wound tract.

The patient was admitted and taken to the operating room, where the following procedure was performed. He was placed on the operating table in the supine position, and general anesthesia was achieved by the anesthesiologist. The right foot and leg were prepared and draped in the usual sterile manner. No tourniquets were used for hemostasis.

Attention was directed to the dorsal aspect of the right foot, where a dorsolinear incision was placed over the third interspace at the bullet entrance site. The incision was deepened through the skin and subcutaneous tissue, and dissected bluntly to express a subcutaneous hematoma. The wound was inspected for shoe, sock, or foreign particulate debris and bullet fragments.

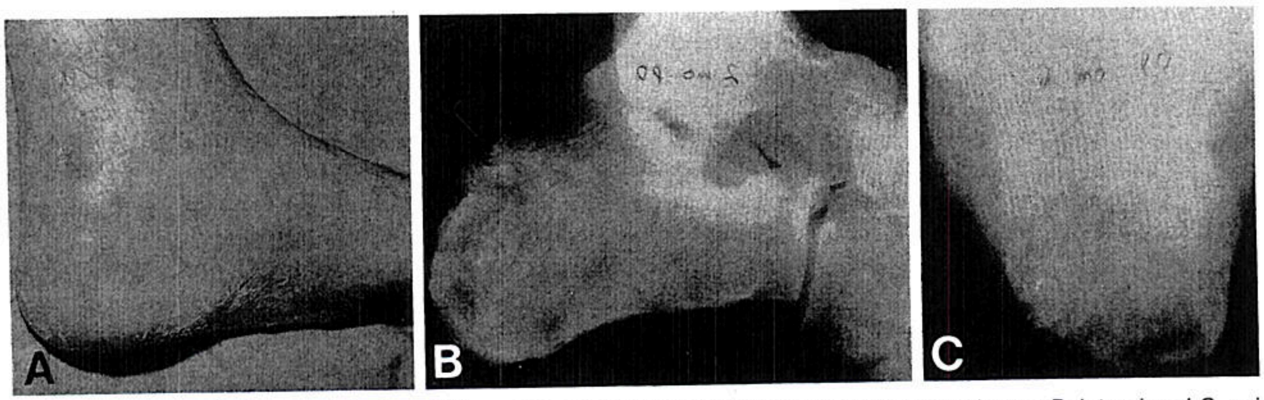

Figure 9. *A*, photograph shows clinical result 2 months after local debridement and local wound care; *B*, lateral and *C*, axial x-ray views show fracture healing with bony prominence at entrance and exit sites.

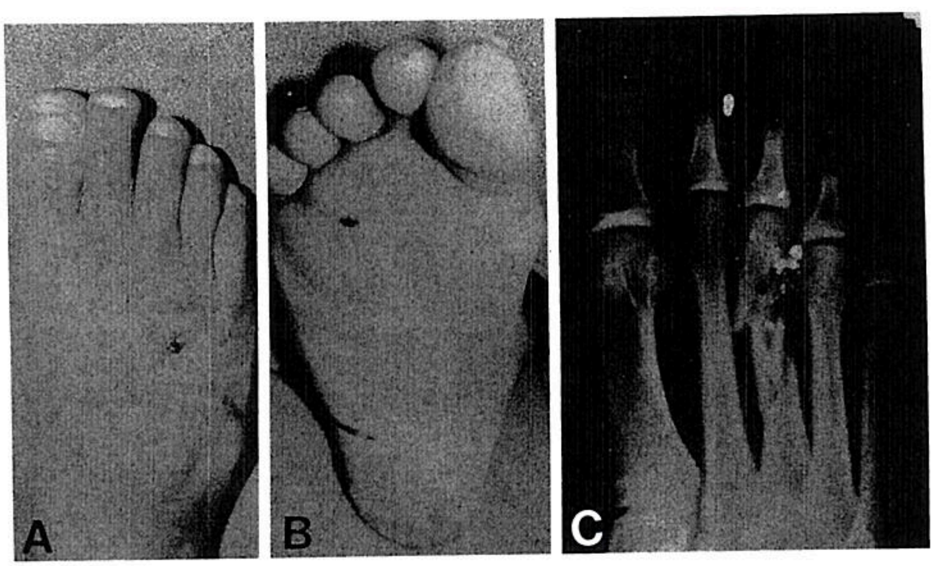

Figure 10. *A* and *B*, photographs show clinical appearance several hours following close-range .22-caliber handgun injury; *C*, note secondary missile fragment at second digit proximal interphalangeal joint on anteroposterior x-ray view.

No obvious foreign particles were present. The wound was not aggressively dissected, and care was taken to maintain the periosteum deep in the wound and viable tissue intact, thereby avoiding further trauma. After debridement of obvious necrotic tissue, the wound was copiously irrigated with 4 liters of normal saline and kanamycin solution (1 gm. kanamycin/liter), using a pulsatile irrigation system.

Attention was directed to the midlateral aspect of the second toe, where a small stab incision was placed over the area proximal to the proximal interphalangeal joint. The incision was bluntly dissected to the level of the bullet fragment present in the subcutaneous tissue (Fig. 11). The fragment was removed and sent to the pathology department for gross examination. The wound was then irrigated with normal saline kanamycin solution, and closed using 5-0 nylon simple interrupted sutures.

At this time, the third toe was distracted distally and the head and neck of the third metatarsal were manipulated to attempt closed reduction of the fracture into a more anatomic position. Intraoperative x-ray films were taken and the metatarsal was noted to be in a slightly more anatomic position that still displaced slightly in the transverse plane.

The wound was again irrigated with normal saline kanamycin solution and closed using 5-0 nylon simple interrupted sutures. The wound was dressed using povidone-iodine-soaked nonadhesive dressing interface, povidone-iodine-soaked 4 × 4 and 2 × 2 gauze, gauze fluff, cast padding, and a posterior short-leg plaster splint was applied.

The patient tolerated the procedure and anesthesia well and left the operating room in apparent satisfactory condition. Vital signs were stable and vascular status was intact.

The patient was admitted to the hospital and placed on a first-generation cephalosporin as prophylaxis, and observed for approximately 3 days. He was discharged home, nonweightbearing, with a short-leg plaster cast. Healing of the fractures was noted at 2 months, and the patient returned to full weightbearing. The patient had a complaint of numbness on the dorsal portion of the foot, immediately distal to the wound site, with decreased sharp/dull sensation. At 6-month follow-up, the numbness remained, although the patient had returned to regular activities without pain or limitation.

Figure 11. Photograph shows clinical appearance at time of debridement and removal of secondary missile fragment.

Discussion

The cases presented illustrate the basic management principles of gunshot wounds. The authors stress that before treatment can commence, a detailed history must be obtained, with particular attention provided to the type of firearm involved, caliber, range, and bullet design. This is absolutely necessary for adequate therapy. Great differences are expected between high- and low-velocity wounds (4–6). Similarly, there are specific guidelines for treating each type of wound; *i.e.*, treating a high-velocity wound, in which one expects extensive temporary cavitation, wide zone of necrosis, and high potential for neurovascular compromise and infection, with minimal local debridement and primary closure, is inadequate. Similarly, treating a low-velocity wound with extensive hospitalization and operative exploration or prolonged antibiosis is wrong. Of course, within each group there is variability, and each case needs individual attention. Nevertheless, adherence to principles stated here and in previous articles will allow the practitioner to manage a multitude of injuries in a logical and expeditious manner.

In general, low-velocity missiles have a muzzle velocity of 610 m./sec. (2000 feet/sec. (fps.)) or less (6, 7), with lower kinetic energies and, therefore, lower wounding powers (5). High-velocity missiles, or those with muzzle velocities greater than 610 m./sec. (2000 fps.) have greater ability to damage tissue at impact. Temporary cavitation has been indicated as the factor responsible for these findings in high-velocity wounds (7, 8). The explosive force from bullet impact in the tissue causes cavity formation for a fraction of a second (8). Shock waves produced during cavitation cause damage distant from the bullet contact area. It is because of this process that necrotic tissue can be found at a distance from the bullet, and fractures of bone have been noted without direct bullet contact (9). Secondary missiles can be liberated from bone or bullet fragments and cause damage along separate wound tracts (8).

Another type of wound that is, in the authors' experience, a frequent civilian injury affecting the foot is from high-caliber, low-velocity handguns. Although these guns have muzzle velocities in the <610 m./sec. (2000 fps.) category, the combination of high caliber (large bullet size) and close range produce a high-energy wound with many of the characteristics of a high-velocity wound (4). This type of wound corresponded to the .38- and .357-caliber handgun injuries in our series. Also of concern in gunshot injuries in the foot, and adding to the complexity of management, is presence of open fracture. The authors have treated these wounds more aggressively than low-velocity wounds because of increased tissue necrosis, extensive open fracture, and extensive foreign materials. Although radical debridement of muscle and fascia has not been necessary, operative debridement has proved to expedite soft tissue and fracture management.

Also of great importance is the type of projectile. A hollow-point bullet expands or mushrooms at impact, increasing transfer of kinetic energy from the bullet to the tissue and hence increasing damage within the wound. It has been shown that a hollow-point bullet leaves an exit wound 27 times larger than the entry due to this expansion (5). Fully jacketed bullets, on the other hand, transfer less energy during travel through the tissue; therefore, less posttraumatic direct and indirect tissue damage is expected. Bullet tumbling, which can occur during missile flight and be accomplished with special weaponry, also affects the wound makeup. All bullets, regardless of their composition, are considered contaminated, because firing does not effect sterilization (4).

Shotgun wounds are a special group of injuries that vary from single pellet wounds to large explosion wounds from close-range blasts. Although these weapons, like low-velocity, high-energy handguns, have velocities of <610 m./sec. (2000 fps.) and therefore can be defined as low velocity, their kinetic energies (wounding powers) are dramatic at close range. This is largely caused by the combined mass of the shot or slug mass. At long range, pellets act as individual missiles, not as a single unit as is true with close-range injuries. Sherman and Parrish (10) classified shotgun injuries into three groups: type one are those long-range injuries which penetrate subcutaneous tissue and deep fascia, type two penetrate below deep fascia from a close range, and type three are point-blank injuries producing extensive damage.

Tissue density directly affects the pathophysiology of gunshot wounds (9). Higher-density tissues, such as bone and muscle, absorb more of the projectile's kinetic energy and therefore are damaged to a greater extent than low-density tissues such as fat. Skin, although it has relatively dense composition, has high elasticity and therefore suffers much less posttraumatic necrosis than the underlying fascia and other structures.

Prompt surgical wound attention is the cornerstone of all gunshot wound therapy (6–10). In low-velocity wounds, this takes the form of superficial debridement, lavage, fracture management, and, in certain instances, primary closure. High-velocity wounds require more extensive surgical exploration, debridement, and delayed closure. Low-velocity, high-energy handgun and shotgun wounds must be carefully evaluated and individualized. Removal of the bullet from the wound is necessary only it its position poses a local threat or is intra-articular. Lead intoxication is unusual because of fibrous encapsulation that isolates the bullet from the systemic circulation (6). Multiple debridements are necessary in cases in which there is extensive temporary cavitation, as the full extent of necrosis may not be evident. Muscle and deep fascia should be widely excised in the case of high-energy wounds. Muscle damage is determined by direct visualization of muscle color, vascularity, fiber consistency, and contractility (9).

The need for routine prophylactic antibiotics recently has been questioned, and several groups (11, 12) advocate wound care alone as the primary prevention of infection, especially in low-velocity wounds. High-velocity wounds, with their extensive necrotic tissues and prolonged open wounds or open fractures, require routine prophylactic antibiosis. In both instances, however, debridement and meticulous wound toilet are paramount to achieving an aseptic, healed wound. Open fracture, which is present in many gunshot wounds in the foot, complicates this effort.

Generally stated, fractures are stabilized at the earliest possible opportunity, either by closed or open reduction, using a minimum of internal fixation. Stabilization is important for pain relief and to provide an adequate environment for neurovascular healing. Most commonly, external fixation is advocated (6), although internal fixation is acceptable in the case of intra-articular fractures and those near vascular repairs. Debridement of bone is limited to those fragments far from their origin, those obviously necrotic, and those no longer having soft tissue attachments. Periosteum, other than portions severely contaminated, is left intact. Determination of the full extent of tissue necrosis may not be possible at the acute debridement. Often it is prudent to do limited debridement of all obvious necrotic tissue acutely, and to return for addition debridement and definitive fixation in several days.

Neurovascular compromise is determined through careful clinical examination and confirmed through direct visualization at the time of exploration. Repair of damaged vessels and nerves is made at the time of initial debridement. Angiography has been said to have no indication in gunshot wounds in the extremities because the indications for angiogram usually constitute indications for surgical attention (13, 14). Close monitoring is important in extremity gunshot wounds because of the potential for compartment syndrome.

Wound closure, varying from primary closure at acute presentation to delayed primary closure several days to weeks following an extensive injury, is attempted when the wound is free of necrotic and infectious material. In general, attempts should be made to use existing skin flaps for closure. As previously stated, skin need not be extensively debrided because its high elasticity makes it resistant to necrosis. With this consideration in mind, routine debridement of skin edges should not be attempted because potentially viable skin may be removed, necessitating skin grafting or other closure methods. In cases in which large skin defects are present, appropriate grafting techniques apply. Fluorescent dye injection has been used to test skin flap viability when primary closure is desired. In most instances, however, observation over time is sufficient.

Conclusion

The authors present a series of gunshot injuries seen by the podiatric surgery division. Highlighted is a group of injuries designated as low-velocity, high-energy wounds. Treatment guidelines for these and other gunshot wounds are discussed.

References

1. Hurst, J. M., Rybczynski, J., Wertheimer, S. J. The physics, pathophysiology, and management of high velocity gunshot wounds. J. Foot Surg. 25:440–9, 1986
2. Newman, P., Hugar, D. W. Gunshot wound to the foot: early management and pathophysiology of projectile wounds. J. Foot Surg. 23:203–6, 1984.
3. Ziv, I., London, E., Wishnie, P. A. One-stage treatment of gunshot wounds. J. Foot Surg. 28:255–8, 1989.
4. Dugas, R., D'Ambrosia, R. Civilian gunshot wounds. Orthopedics 8:1121–5, 1985.
5. DeMuth, W. E., Jr. Bullet velocity and design as determinants of wounding capability: an experimental study. J. Trauma 6:222–32, 1966.
6. Russotti, G. M., Sim, F. H. Missile wounds of the extremities: current concepts review. Orthopedics 8:1106–16, 1985.
7. Hampton, O. P., Jr. The indications for debridement of gun shot (bullet) wounds of the extremities in civilian practice. J Trauma 1:368–72, 1961.
8. Amato, J. J., Billy, L. J., Lawson, N. S., Rich, N. M. High velocity missile injury: an experimental study of the retentive forces of tissue. Am. J. Surg. 127:454–9, 1974.
9. DeMuth, W. E., Jr., Smith, J. M. High-velocity bullet wounds of muscle and bone: the basis of rational early treatment. J. Trauma 6:744–55, 1966.
10. Sherman, R. T., Parrish, R. A. Management of shotgun injuries: a review of 152 cases. J. Trauma 3:76–86, 1963.
11. Dickey, R. L., Barnes, B. C., Kearns, R. J., Tullos, H. S. Efficacy of antibiotics in low-velocity gunshot fractures. J. Orthop. Trauma 3:6–10, 1989.
12. Hartl, W. H., Klammer, H. L. Gunshot and blast injuries to the extremities. Acta Chir. Scand. 154:495–9, 1988.
13. Boyd, N. A. A military surgical team in Belfast. Ann. R. Coll. Surg. Engl. 56:15–25, 1975.
14. Luce, E. A., Griffen, W. O. Shotgun injuries of the upper extremity. J. Trauma 18:487–92, 1978.