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Removal of the wadding from the wound in shotgun-pellet injuries

Av tüfeği yaralanmalarında tapanın çıkartılması

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Amaç: Düşük hızlı mermilerin yol açtığı ateşli silah yaralanmalarında kavitasyon ve devitalizasyonun daha az olması nedeniyle, yumuşak doku yaralanması daha hafiftir. Damar yaralanması ve merminin giriş açısına bağlı olarak kırık oluşabilir. Mermiler ve saçma taneleri yumuşak doku içine gömülürler. Kolayca belirlenebilenler ve önemli yerleşim gösterenler dışında, yaradaki saçma ve mermi parçalarının çıkartılması önerilmez. Bununla birlikte, av tüfeği fişeğinin bir parçası olan, plastik veya mantardan yapılan tapanın enfeksiyon riski nedeniyle çıkarılması önerilmektedir.

Çalışma planı: Av tüfeği yaralanması nedeniyle getirilen 41 hastanın sekizinde saptanan tapa çıkartıldı.

Sonuçlar: Bir hastadan mantar, yedi hastadan plastik tapa çıkartıldı. Öykü ve yaranın özelliklerine ek olarak, radyografilerde saçma tanelerinin kümelenmiş şekilde bulunması, radyolojik olarak görüntü vermeyen plastik tapaların dolaylı tanınma bulgusu olarak değerlendirildi. Altı hastada yaralanmanın olduğu ekstremitede kırık saptandı. Hastaların hiçbirinde başlangıç yarasına bağlı enfeksiyon gelişmedi.

Çıkarımlar: Yerini saptamak bazen zor olmakla beraber, av tüfeği fişeğinin bir bölümünü oluşturan tapanın bakteriyel bulaşmaya/enfeksiyona zemin oluşturma riski nedeniyle çıkartılması gerekmektedir.

Anahtar sözcükler: Kol yaralanmaları/etyoloji/komplikasyon/tedavi; sefazolin/terapötik kullanım; kırık/etyoloji; bacak yaralanmaları/etyoloji/komplikasyon/tedavi; yumuşak doku yaralanmaları/etyoloji; yaralanma, ateşli silah/tanı/komplikasyon/tedavi.

Objectives: Most of the gunshot injuries are caused by low-velocity bullets and shotgun pellets, resulting in mild soft tissue damage. They are sometimes associated with vascular involvement and fractures depending on the angle of entry. Bullets and especially pellets usually lodge in soft tissues. For those that are not easily detected, surgical exploration is not recommended unless they are of vital localizations. However, the removal of wadding, which may incite a local inflammatory response and harbor bacterial contaminants, is strongly recommended.

Methods: Of forty-one patients with shotgun injuries, eight patients were found to bear waddings that required removal.

Results: Waddings made of cork and plastic were removed from one and seven patients, respectively. In addition to patients' histories and wound-related features, radiolucent plastic waddings were predicted by the presence of a cluster of pellets on radiographs. Fractures were encountered in the injured extremity in six patients. No infections developed related to the primary wound.

Conclusion: Although it is often difficult to locate a lodged wadding in the body, its removal is necessary because it can incite a local inflammatory response and harbor bacterial contaminants.

Key words: Arm injuries/etiology/complications/therapy; cefazolin/therapeutic use; fractures/etiology; leg injuries/etiology/complications/therapy; soft tissue injuries/etiology; wounds, gunshot/diagnosis/complications/therapy.

The increase in use of gunshot and consequent injuries within our society requires the evaluation of the cases with an effective approach and treatment plan in orthopedics and traumatology.

Because the distance between the assailant (the shooter) and the victim is usually close-range (short distance), the velocity of the bullet in exit of the barrel and striking velocity are close too.[1] The destruc-

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tive force of the bullet (the missile) is directly proportional to the amount of kinetic energy transferred to the surrounding tissues.[1-4] Kinetic energy is defined by the formula $1/2mv^2$ (m indicates the mass of the bullet, v indicates the velocity).[1,2,4] Guns are divided into three groups according to the velocity of missile at the time it leaves the barrel. Low-velocity: traveling less than 1000 ft/sec (1 foot= 30.479 cm, as with most handguns and civil shotguns); medium-velocity: traveling 1000 to 2000 ft/sec (as with magnum type handguns and shotguns); high-velocity: traveling more than 2000 ft/sec (as with high-powered rifles and military weapons).[1] Some authors divide this classification as low-velocity (less than 1000 or 2000 ft/sec) and high-velocity (greater than 2000 ft/sec) shotgun injuries.[2,4] Civil shotguns are classified as low-velocity shotguns.[1,3-5]

The three factors used to determine the injury of the tissues caused by the bullet are, (i) laceration and crashing, (ii) shock waves and (iii) cavitations.[4] Three zones are defined for injuries caused by bullet: (1) a primary wound tract and permanent cavity; (2) a contusion zone (in muscles adjacent to the bullet tract); and (3) a concussion zone (variable outside congestion).[1,2,4]

The total weight of pellets in a cylindrical cardboard or plastic sheath (shotgun shell), which is commonly called cartridge, is approximately 30 grams in shotguns, which are low- and medium-velocity guns.[1,3-5] The size of pellets, the shape of the wadding and its wings vary according to type of the animal to be hunted by these shotguns. Cartridge includes, from proximal to distal, a capsule (percussion capsule), gunpowder, compressed cloth, a cork or a plastic wadding (bung) and pellets most distally.[6] The wadding, which is stiffed and generally made of organic material, provides the ejection of pellets from the shotgun barrel (Figures 1a, 1b).[6,7] When the capsule is shot, the spark fires the gunpowder; and the pellets are ejected to the target by the pressure of gunpowder gas. The pellets, leaving the barrel, dispersed conically after moving together for 95 cm. This dispersion becomes approximately 50-60 cm in diameter at 12 meters.[6] Wadding moves with the pellets for few feet, after leaving the barrel and then it falls to the ground. In close-range gunshot wounds, wadding and its remnants may enter the wound.[7] Wadding causes bacterial contamination by affecting and triggering the local inflammatory response.[7,8] Because of this, if any wadding is detected inside the injured area, it should be extracted immediately.[2,7-9]

In this study, we presented our experiences in extraction of the wadding, which are made of various materials like cloth, plastic or cork; provide forward motion of the pellets and stay inside the tissue in close-range (short distance) shots; are hard to detect radiologically; cause infections when remained inside the tissue.

Materials and methods

41 patients were included in this study who presented to our clinic between the dates December 1997 and March 2001 because of shotgun injuries. After the examination of vital and general conditions, radiological evaluations were done. Surgical treatment was decided following the evaluation of histories, wounds and radiographs. Wound debride-

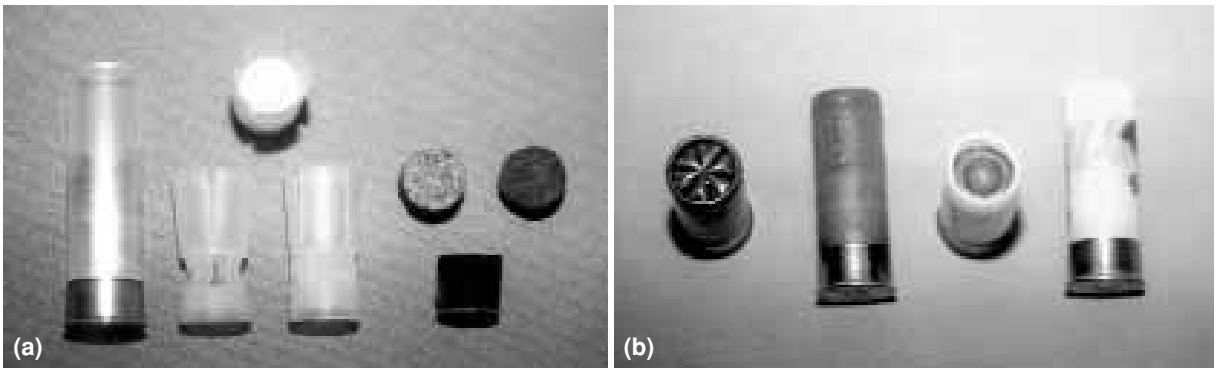

Figure 1. (a) Empty cartridge and its capsule, and waddings made of plastic and cork. Plastic waddings have the wings to provide the dispersion of the pellets in disered diameter as it moves towards the target. **(b)** Different kinds of cartridges where the pellets or bullets is put.

ments and mechanical irrigation were performed on required cases. Wadding was searched, in contemplation of remaining inside, for cases which were close-range shots and do not had an exit. Appropriate osteosynthesis methods were performed to the fractures associated with the injury, according to fracture types and extremity regions. The fixation methods used in fractures and fracture healing methods were not evaluated because they were not the subject of study.

Results

Of eight patients, who detected densely clustered cork wadding or pellets, seven plastic waddings (Figures 2, 3 and 4) and a cork wadding (Figure 5) were extracted during debridements. The entrance diameter of the bullet holes were varying between 2-8 cm. Embedded waddings inside the soft tissues were detected and extracted from the injured areas including shoulder, thigh and proximal thigh/hip

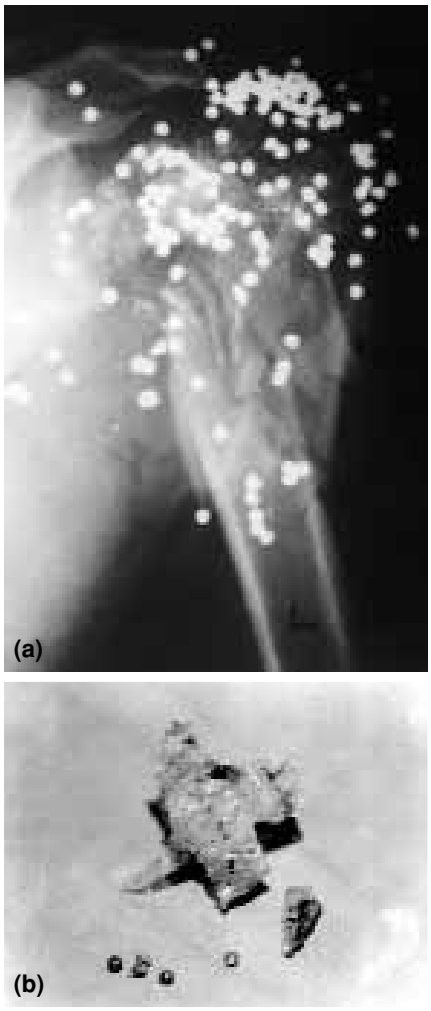

Figure 2. **(a)** Left shoulder AP radiograph of a 19-year-old male patient who had gunshot injury. The clustered pellets can be seen in the region lateral of the acromion. **(b)** Pellets and extracted plastic wadding which is broken up and wings are completely opened.

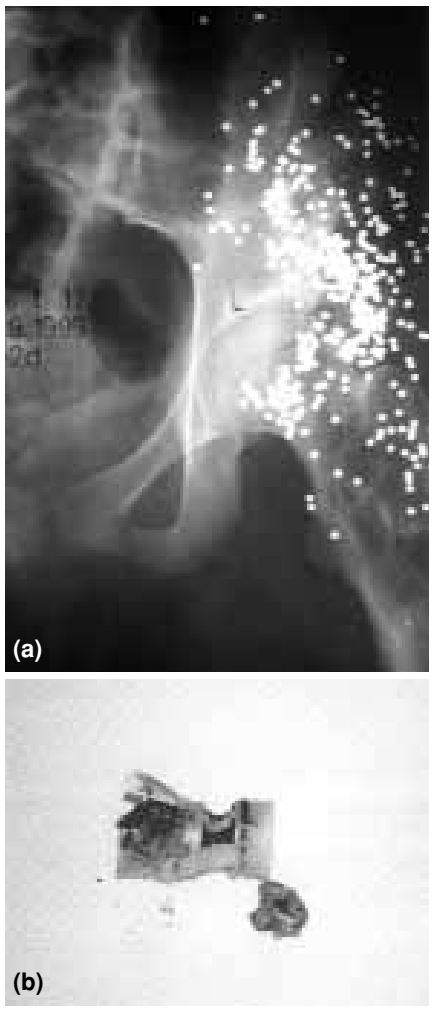

Figure 3. **(a)** Left hip AP radiograph of a 17-year-old female patients, two days after the injury. Clustered pellets can be seen in the superior part of trachanter major. **(b)** Wings of the plastic wadding is not completely opened and includes pellets with soft tissue remnants.

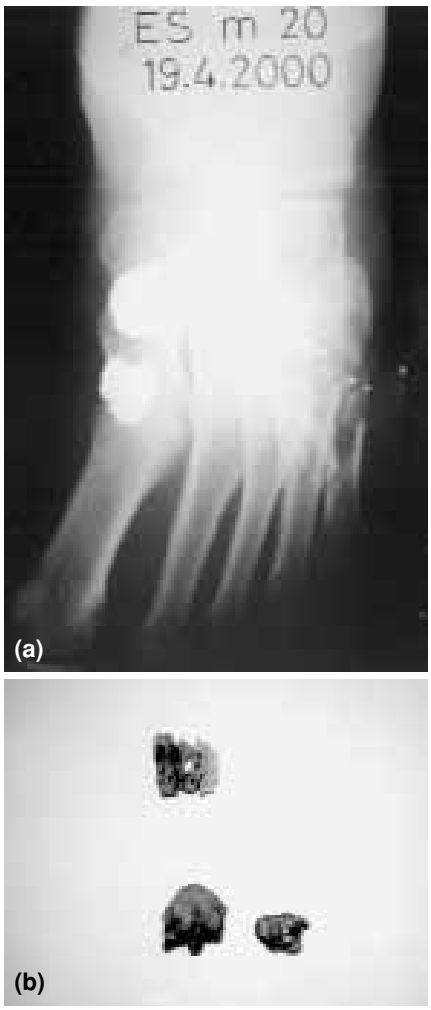

Figure 4. **(a)** AP radiograph of the left foot of a 20-year-old male patients. Two fragments of a bullet are present in medial part of the foot. **(b)** The wadding whose wings are completely destroyed (broken) and the bullet which is diveded in to two main fragments

Table 1. The properties of 8 patients who had extracted waddings

No	Age	Sex	Location of the injury	Associating fracture, injury
1	19	M	Left shoulder	Left humerus proximal comminuted fracture
2	21	M	Left arm	Left humerus comminuted fracture, thorax injury
3	69	M	Right elbow, forearm	Soft tissue injury
4	17	F	Left hip	Left ilac wing fracture
5	39	M	Left thigh	Left femur comminuted fracture of diaphysis
6	20	M	Left foot	Left foot 4th and 5th metatarsal bases fracture
7	31	M	Right knee, proximal crus	Soft tissue injury
8	15	F	Left knee, distal femur and proximal crus	Left femur distal comminuted, intraarticular fracture, left patella and left tibia proximal comminuted fracture

joint especially. Pellets and soft tissue remnants were seen inside the plastic waddings with undamaged extracted wings (Figure 3b). Intraarticular (as in two cases) and palpated pellets in debridement were extracted (Figures 2b, 3b, and 4b). It's not strived for the detection of pellets. In contemplation of the cloth remnants inside the wound of patients, who were wearing clothes during the injury, foreign body search was done, but none was detected. Following the wound debridement, appropriate osteosynthesis methods were performed according to the type of fractures and extremity regions for the associating fractures in six patients. An extra incision was not done for this process in wadding extracted patients. Wounds were not closed primarily. The characteristics of the patients and injuries are stated in Table 1.

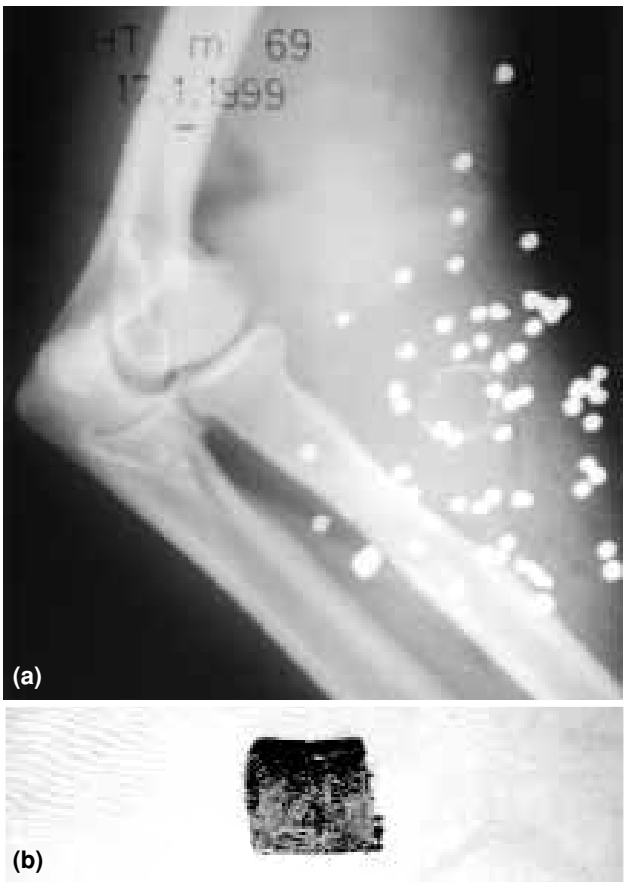

Figure 5. (a) The oblique radiologic view of the gunshot injury including the right elbow and the proximal part of the forearm in a 69-year-old male patient. The circular cross section of the cork wadding is seen between the skin and the radius, in the centre of pellets. **(b)** The extracted cork wadding.

In the oblique radiography of a patient with shotgun injury in his left elbow (cubital region) and proximal fore-arm region, a foreign body compatible with circular cross section of the cork wadding was obvious (Figure 5a). Cork waddings were detectable according to their position within the body, whereas plastic ones were not showing any image. However, plastic waddings were extracted from the suspected regions where the pellets caused dense and clustered images (Figures 2a, and 3a). A different kind of single bullet was put inside the wadding in a patient. In this patient, an entrance hole of 2 cm in diameter and fractures in the bases of the forth and fifth metatarsal bones were present on the lateral side of the left foot. Pellets and wadding were extracted from the plantar region on medial side (Figure 4). It's seen that the wings of some of the extracted waddings were opened and broken up (Figures 2b, and 4b). Because the wings of the wadding would open as the shooting distance increases, the extracted waddings were not including too many pellets (Figure 2b). Because reliable information was not available to take from the patients, shooting distances were not stated in this article. All

of the cases were evaluated as close-range (mean of 1-1,5 m) gunshot injuries. No waddings were detected in debridements of the patients who had long distance injuries and having an entrance hole of 1,5-2 cm or less. As the shooting distance increases, pellets dispersedly entered the body and caused more superficial injuries.

After the tetanus prophylaxis and in postoperative period, the antibiotic treatment with first generation cephalosporin (cefazolin) and aminoglycoside mixture was applied for five days to the cases with only soft tissue injuries; for 7-10 days to the cases who had additional fractures and applied osteosynthesis. No infection was developed during wound healing period of the wadding extracted patients.

Discussion

High-velocity bullets (missiles) cause soft tissue injuries distant from the bullet hole as a result of their cavitation forming effects and they also carry the risk of vascular injury and comminuted fractures. They carry the risk of infection by absorption of infected or contaminated material inside the wound.[1,3,4,10] Cavitation and devitalization ratios are less in injuries with low-velocity bullets, so the soft tissue injury is less complex, however vascular lesions can be seen.[4,5,10] The bullets have the risk of causing fractures proportional to its entrance angle. Cavitation and suction occur in gunshot injuries with 1000 ft/sec velocity.[1] The heat, created by firing is inadequate for the sterilization of the bullet. The non-sterile bullet may cause infections by pulling clothes, skin flora and various foreign bodies inside the wound with its vacuum effect.[1-3,5,10-12] The injuries caused by large pellets (buckshots) are treated as multiple, low-velocity (low-energy) injuries; however, close-range (short distance) shotgun injuries should be treated as high-velocity injuries. Soft tissue injury, which is increasing according to decrease in the gunshot distance and probability of existence of wadding inside the wound, increases the bacterial contamination risk.[2,10] Many radiologically detectable pellets, except for easily palpable ones, can be neglected initially.[13] Bullets, especially pellets are embedded inside the soft tissue; the surgical approach for hardly detectible ones causes more tissue injury than the pellets embedded inside.[8] Bullets and pellets in the soft tissues are covered by an avascular scar tissue in a short time; so, usually preventing migration and perhaps reducing uptake of lead by the body.[1] In addition to this, intraarticular or synovial ones, the ones which have the probability of damaging vascular and neural structures and the ones extending to subarachnoid region should be extracted.[1,8,13-15] The foreign bodies, which are made of organic materials especially, are recommended to be extracted.[2,7-9] The cavities, recesses, fissures and clefts of the foreign bodies provide a shelter for pathogenic microorganisms and their spores.[8] Especially organic oriented foreign bodies trigger inflammatory response.[7,8] Because it is hard to evaluate the injuries without an exit hole, it's reported that additional dissections can be performed to extract the wadding.[8]

We performed surgery in patients who have clustered pellets in their radiograms, in contemplation of the existence of wadding. According to our observations, in close-range gunshot injuries to 1-1,5 m, wadding and pellets move together. Because the wings on the edges of wadding are not completely opened, wadding and pellets enter the wound as one and the pellets are seen closer in radiological evaluations (Figures 2a, 3a). During this process, palpable and detected intraarticular pellets were extracted too (Figures 2b, 3b, 4b). An extra dissection for the extraction of the waddings was not required.

Some authors reported that the soft tissue injury would be least and debridement is not required in low-velocity gunshot injuries.[2,4] Antibiotic application and period is still the subject under discussion. Commonly cefazolin is recommended for one or three days according to postoperative additional ostesynthesis.[1,4,7-9] Besides this, after application of single dose, long-acting intramuscular cephalosporin, oral cephalosporin for 7-10 days,[11] 2 gram of ceftriaxone per day,[7] intravenous Keflin for three days[3] or in articular injuries intravenous Ancef and gentamicin[14] applications are recommended. We performed debridement and mechanical irrigation following the tetanus prophylaxis. We applied our cefazolin and aminoglycoside combination treatment protocol, preoperatively and postoperatively, for five days to the patients having soft tissue injuries only, for 7-10 days to the patients who had osteosynthesis because of associating fractures. A special kind of surgery is not recommended for

extraction of pellets in shotgun injuries, however, extraction of the wadding made of organic material, is recommended.[2,7-9] No infection is seen in the healing period of the cases who we extracted waddings.

In conclusion, pellets can be detected radiologically, however, the waddings, which are made of organic materials like clothes, cork or plastic and which may cause bacterial contaminations, should be kept in mind, detected and extracted in close-range (short distance) gunshot injuries, especially.

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