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Soft Tissue Pseudocysts Associated with Retained Bullets: a Series of 4 Cases

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Abstract

Aside from assuring adequate wound debridement and antibiotic coverage, it is not necessary to remove most bullets retained in soft-tissue except for in instances of joint space involvement which carries an increased risk of lead poisoning and on-going joint disruption. However, fluid-filled cysts, often with synovial-like surface linings, may slowly eventuate around retained bullets. The development of a pseudocyst indicates increased breakdown of bullet fragments which may put patients at greater risk for lead poisoning. Surgical excision and drainage of the pseudocyst is the recommended treatment. The present report investigates the resulting pathology of pseudocyst formation around retained bullets in four cases, two of which showed features of synovial metaplasia.

Keywords: Pseudocyst; Retained bullet; Hyaluronic acid; Lead poisoning; Synovial metaplasia

Introduction

According to data from the Centers for Disease Control and Prevention (CDC), 70% of annual firearm injuries in the United States are non-fatal [1]. Depending on where bullets become lodged in the body they are not always removed. Most bullets shot from civilian firearms that are retained in soft tissue or muscles are from low velocity weapons, i.e., handguns, and need only be removed if problems arise once acute soft tissue swelling has subsided [2]. The four cases in this report with pseudocysts have an average 10-year history of bullet retention. Original traumatic tissue plane disruption, in situ motion of the foreign object, and bullet dissolution may each contribute to the formation of pseudo-cysts. Patients may live for years with a retained bullet before the cysts become symptomatic, e.g., with weather-related discomfort, painful swelling, distal paresthesias, or shoulder impingement syndrome. Two of the four pseudocysts herein reported had synovial-like linings (synovial metaplastic cysts or SMCs). Although the prevalence of SMCs is unknown, their omission from a 2011 American Academy of Orthopaedic Surgeons monograph on gunshot wounds [3] points to the infrequency in which they are encountered.

Cases

A summary of clinical data, missile type and size, and cyst characteristics are summarized for the following four cases in Table 1.

Case 1

Under undisclosed circumstances, a 25-year-old male received a gunshot wound to the left thigh that fractured his femur; an intramedullary rod was inserted. The fracture healed with mild angulation and excessive callus. Over the succeeding 10 years, progressive painful swelling of the anterior thigh increasingly impeded ambulation. Forty milliliters of milky white to tan watery fluid aspirated from the thigh cyst was submitted for cytologic analysis. It contained occasional histiocytes and acellular, amorphous granular material with fibrin strands with no indication of cellular inflammation or neoplasm. At surgery, the cystic abnormality (Figure 1A) was opened and drained of 2-3 liters of milky white fluid under pressure. Two solid metallic foreign bodies embedded in the cavity wall were excised and had a combined weight of 12.77g (197 grains) representing a 3.0 x 1.2 x 0.1 mm deformed copper jacket and 2.6 x 2.2 x 0.4 mm flattened lead core of a non-hollow point .45 caliber bullet (Figure 1B). The flat dull, chalk-white wall of the cyst was excised and submitted for pathologic study. Superficial, grossly plate-like 5-10 mm rounded, brittle white chalky deposits lining the cavity like miniature flag-stones, are composed of a combination of lead corrosion products and dystrophic mineralization. The cyst wall demonstrated a palisaded layer of mesenchymal cells (synovial metaplasia) underlain by a few histiocytes and giant cells (Figure 1C). The synovial-like lining cells labeled for vimentin (Figure 1D), without reactivity for cytokeratin. Immunohistologic CD 68 reactivity (Figure 1E) and positive alcian blue staining (Figure 1F), mirrored both normal and hyperplastic synovium.

Case 2

A 21 year-old male with a retained bullet in the volar aspect of his right wrist presented with fourth and fifth finger paresthesias. Plain film radiographs showed a healed indentation of radial cortex with metallic fragments in overlying soft tissue (Figure 2A). At operation, with tendons moved aside, a large white bulging mass was firmly attached to the flexor carpi ulnaris tendon and loosely attached to the sublimis tendon. Yellow fibrinous material and bullet fragments were found within a 2.5-cm diameter sac 5-cm proximal to and independent of the wrist joint; it was dissected down to the wrist capsule and removed. The deformed 11 x 8 x 7-mm fragment of gray metal (sans copper jacket) had a 42.8 grain weight that exceeds the common rim fire .22 caliber bullet (16 - 30 grains) with basal diameter of 5.58 mm (Figure 2B) consistent with .25 automatic colt pistol (ACP). A small amount of necrotic gray-tan fibrous tissue was attached to the irregular surface of the missile. The pink-tan internally glistening 2.6 x 2.2 x 1.3-cm, 1-3 mm, thick, sac-like specimen demonstrated microscopic evidence of some fibrin on the inner surface. Internal papillary areas had vimentin-positive palisaded surface cells (Figure 2C and D) that resembled synovium (Figure 2E and F).

Case 3

12 years prior to surgery, a 38 year-old male was the victim of a drive by, ricochet gunshot wound to his right lower leg. He noticed slight swelling at the site 8 years after injury and remarked that it bothered him in cold weather. A plain film displayed a group of irregular bullet fragments beside tibia and fibula (Figure 3A). At surgery, the swelling was accounted for by a cyst-like space containing 2-3 cc of thin white fluid within which two flattened gray metal bullet fragments 4 and 9 mm in greatest diameter. A cluster of at least 20 additional flattened metallic fragments 7 mm in aggregate maximal diameter were very near the anterolateral midtibia without evidence of bone damage. Absence of copper jacket material and bullet fragmentation precluded specific identification of caliber and missile construction. Clumps of fibrin without inflammatory cells occurred on the surface of the dense, fibrous hyalinized wall of the pseudocyst without inflammatory cells and no synovial-like lining (Figure 3B). Microscopic particles of granular, translucent, gray, and weakly birefringent corrosion products coated irregular, opaque, black, angular metallic centers within the fibrous wall of the pseudocyst without foreign body reaction (Figure

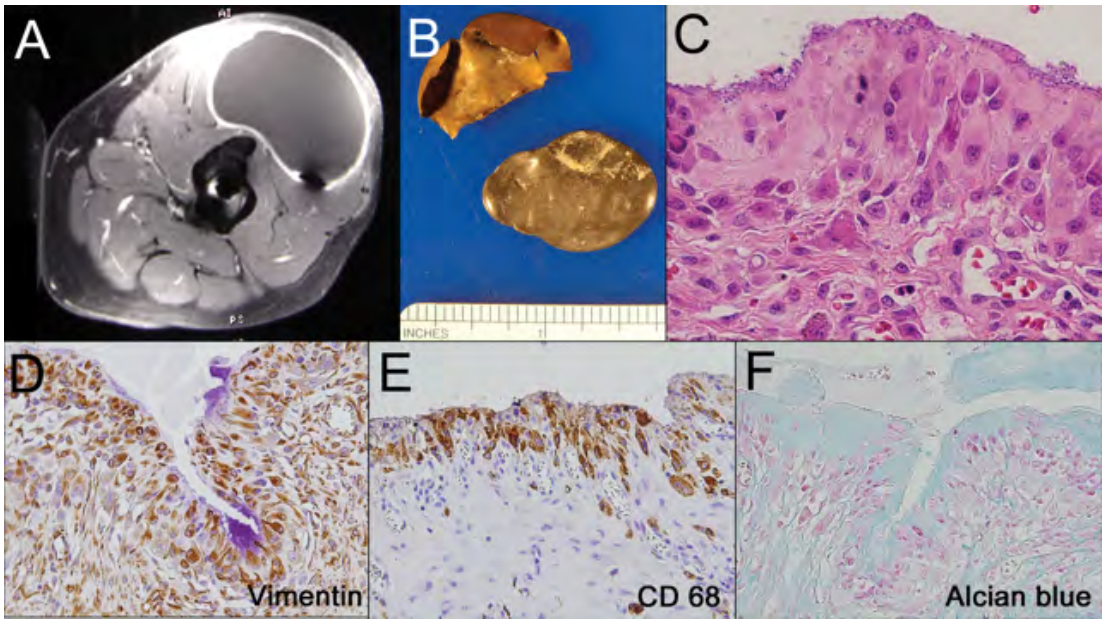

Figure 1: A. The thin hypervascular rim around the 15-cm diameter fluid-filled pseudocyst enhances in a pre-operative MRI. The low signal (black) object interrupting the contrast-enhanced MRI signal in the lower right corner of the cyst is the lead core of the responsible missile.

B. The lead core and copper jacket of the retained bullet, separated at impact, were separately lodged in the cyst wall.

C. The intimal lining of the cyst has prominent diluted thin-walled vascular channels. Synovial-like cellular lining is focally interrupted by basophilic mineral deposits (H&E, x400).

D. Vimentin (x200).

E. CD68 (x400).

F. Alcian blue (x200).

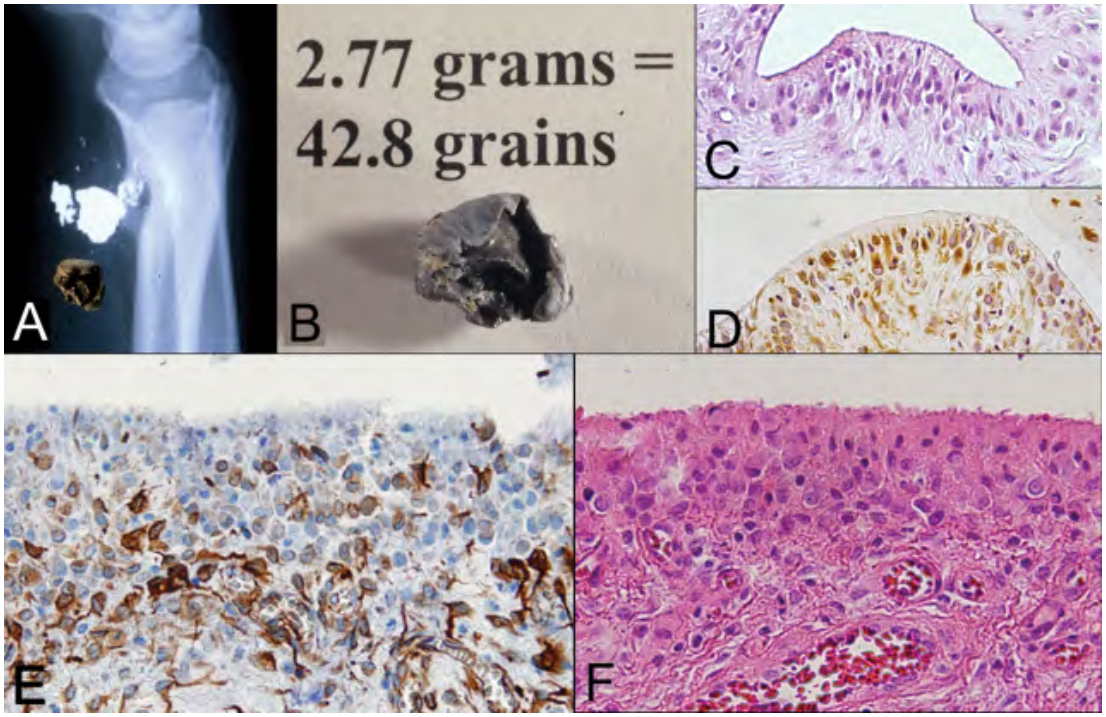

Figure 2 (Case 2): A. The white shadows of distorted and minute fragments of lead missile lies beside distal forearm bones. Photograph taken with largest missile fragment overlying plain film.

B. Close-up of the largest excised missile fragment.

C. Lining of the cystic cavity (H&E, x400)

D. Lining of the cystic cavity (vimentin reaction, x 400).

E. Normal synovium (vimentin reaction, x 200).

F. Normal synovium (H&E, x 200).

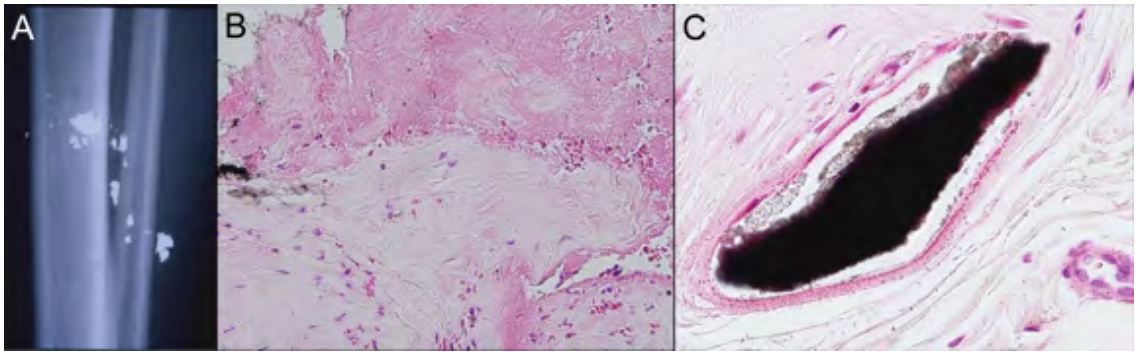

Figure 3 (Case 3): A. Multiple irregular metallic fragments are radiologically displayed beside lower leg bones.

B. Fibrin rests upon the uninflamed fibrous wall of the cyst (H&E, x200).

C. Glassy translucent corrosion products coat an irregular lead fragment (H&E, x400)

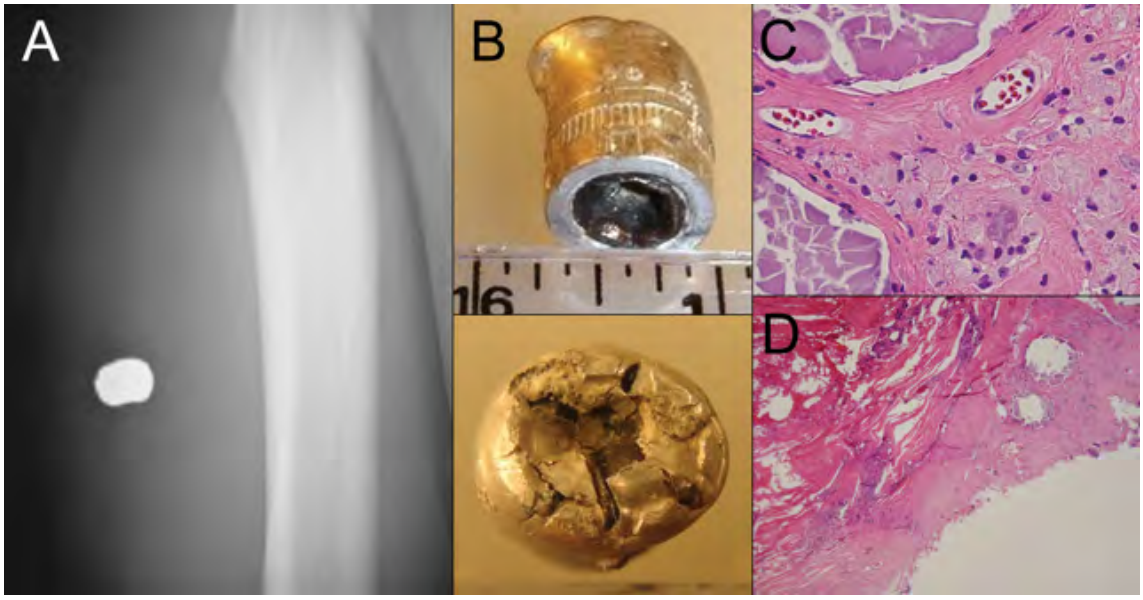

Figure 4 (Case 4): A. A radio-opaque, intact bullet lies in soft-tissue beside the humerus.

B. The retrieved .380 Silvertip® bullet did not expand. Rather, the nose caved in implying it struck with low velocity or hit some solid intermediary target first.

C. Histiocytes with finely particulate gray-staining cytoplasm and basophilic coloration of altered collagen fibers resemble the effects of aluminum chloride hemostatic treatment of a biopsy site (x400).

D. The fibrous walls of the pseudocyst had no synovial-like lining (x100).

3C). The milky white color of the cyst fluid is attributed to lead corrosion products.

Case 4

A 32 year-old male sustained a gunshot to the right arm 8 years before presenting with right arm pain localized to the site of a metallic foreign body (Figure 4A). Initial exam and symptoms were consistent with a right shoulder impingement syndrome. A 10 x 9-mm, 85.5 grain, .380 caliber, aluminum clad, "Silvertip®" hollow point handgun slug [4-6] was excised within a cystic structure with walls of red-maroon to pale-tan firm tissue. The nose of the bullet had collapsed inward in rather than expanding (Figure 4B), implying some non-fluid intermediary target [6]. In the wall of the chamber were microscopic metallic fragments bordered by puddles of clear glassy and amorphous basophilic aluminum corrosion products and histiocytes with copious granular cytoplasm (Figure 4C). The expanded gray cytoplasm of mural histiocytes resembled "Drysol cells," as commonly found after aluminum chloride hemostatic treatment, suggesting a local toxic effect of aluminum corrosion products [5]. The perhaps in consequence of this cytotoxic effect, the innermost layer that faced the missile was hypocellular without synovial metaplasia (Figure 4D).

Discussion

Handgun and rifle bullets alike impart momentum and radial acceleration to tissue. Temporary cavitation becomes substantial only with impact velocities above 304.8 m/sec (1,000 ft/sec) [7]. Radial displacement of tissue creates a temporary fusiform or conical cavity reaching a maximum in size 2-4 milliseconds after the projectile has passed [8] causing rapid compression and stretching of surrounding tissue. Temporary cavity formation is a dynamic, 10 milliseconds process. The water vapor filled space expands partly along planes of least resistance such as beside facial sheets, resulting in an asymmetric cavity with shear forces with the abrupt lytic efficiency of a scalpel. Tissue elasticity allows the cavity to collapse immediately. All four prospectively collected cases were instances of handgun injury. A rifle round is more likely to exit the body than to be retained because it posses a greater amount of kinetic energy.

The delayed appearance of an encompassing cyst is a very rare complication of a retained bullet that has been previously described [9] and is known to occur in both bone and soft tissue [10]. Unlike a stab wound, temporary cavity formation likely sets the stage for pseudocyst formation by weakening and frankly opening up tissue planes around the lodged bullet.

Bullets retained in bone can also invoke cyst formation. In one instance, a 9-year-old girl was treated conservatively for a bullet that lodged just below the knee and returned 17 months later with soreness and swelling [11]. Out of fear of an impending fracture, the bullet, which was freely mobile in a cystic cavity filled with yellowish fluid, was removed and her recovery was uneventful. Fluid-filled cyst formation was also found around a bullet retained for 10 years in the first metacarpal before the patient presented with one month of pain and swelling, or pseudoarthrosis, in his right thumb [12]. A seven-year-old retained bullet in the mandible of a 38-year old man presented with six months of painless swelling and was found to be surrounded by an acquired implantation-type epidermoid cyst [13].

By strict pathologic definition, a true cyst has an epithelial lining; not so in the "pseudocysts" here presented, since like normal synovium, their lining is negative for cytokeratin in immunohistochemical reactions. Two of the four specimens here reported featured mural "synovial metaplasia." Such "synovial metaplastic cysts" (SMCs) are histologically characterized by a cystic cavity lined by metaplastic cell layer resembling synovium that is often hyperplastic and can protrude into the lumen as villous structures [14]. The palisaded layer of mesenchymal cells may have a few underlying histiocytes and giant cells forming an inner layer of the cyst wall that is unrelated to the joint or other synovial elements. SMCs are most frequently found in the tissues surrounding silicone breast prostheses [15] and in healing tissue adjacent to joint prostheses [16]. Transmission electron microscopy of the lining cells in the common setting of breast prostheses confirmed their true synovial nature with the type A (macrophage-like) cells, type B (fibroblast-like) cells, and intermediate forms or type AB cells identified which lead the authors concluded that the cellular lining surrounding silicone breast implants is a true synovial membrane [17].

A review of cases of synovial metaplasia reported in the literature revealed that in most cases, and the smooth gliding surfaces of the foreign material (most commonly a silicone breast prosthesis) resists penetration by fibroblast processes. In the situation under discussion, as the fibroblasts extend their processes to bridge the gap formed by the original insult; they meet the bullet and turn along its surface in an attempt to find another area to bridge [15,18]. If it is unsuccessful, the fibroblasts send out additional processes, which meet the same fate resulting in intertwining of processes creating the mimicry of a synovial membrane. Whether the surface ends up smooth or papillary may depend on the properties of the surface against which the metaplasia forms in addition to other factors involved in the repair process [19].

SMCs have also been described in skin and soft tissues, most frequently in healing or healed traumatic or surgical wounds [15]. The normal synovial positivity for the histocyte marker CD68 has been inconsistently reported in this setting [20], and is positive in present Case 1 (Figure 1E). Extensive synovial metaplasia has been reported in a recurrent lipoma [21] as well as in the infrazygomatic region following injection with non-animal stabilized hyaluronic acid [22].

SMCs of the skin refers to a cyst lined by a membrane resembling hyperplastic synovial villi that clinically appears as a tender subcutaneous nodule often misdiagnosed as a suture granuloma particularly following biopsy. Projections from the cyst wall may attain significant size and give the intraoperative impression of a "bag of worms." [23] Cutaneous SMC is also a potential complication after surgical treatment of male gynecomastia [24] and has been reported in a child with Ehlers-Danlos syndrome [25]. Cutaneous fragility and anomalous scarring typical of Ehlers-Danlos syndrome may be related to the development of this pseudocyst [26]. Recurrence of synovial metaplasia at the same site following excision of an epidermoid cyst is reported [27].

SMCs presenting as cystic nodules localized on the thumb and great toes of two patients with rheumatoid arthritis without history of trauma or surgical procedures led the authors to hypothesize that constant pressure on the great toe, repeated manipulation of the finger, and chronic inflammation around the affected joints may have played roles in the pathogenesis of the lesions [19]. SMCs can also occur as a histopathologic variant of the oral mucocele that exhibit a papillary cystic growth pattern [24].

Depending on location, retained lead bullet fragments are associated with a variety of delayed systemic and local complications, namely lead intoxication. After a bullet is embedded in soft tissue, it becomes enveloped in a fibrous scar and only slowly corrodes. Such retained bullets and missiles are usually innocuous and do not require surgical removal. Despite the absence of symptoms in the majority of patients carrying lead bullet fragments in their bodies [28], there needs to be an awareness of the possible signs and symptoms of lead intoxication when bullets are lodged in large joints like knees, hips, shoulders [29], and even the spine [30]. Elevated levels of lead in the blood can result in neurologic symptoms and even death from lead poisoning [7]. Most bullets retained in soft-tissue may be observed, however, if the joint space is involved it is recommended bullets be removed immediately to prevent joint destruction and lead poisoning [31]. None of the four patients reported here had serum lead levels assessed. Interestingly, calcinosis following a wound, as in the thin plate-like mineralization along the surface of the cyst in Case 1, is rarely reported and requires a great deal of time to develop after injury [32,33].

The increased hazard in bone and joint location is due to the presence of hyaluronic acid in synovial fluid [34] which corrodes lead at roughly four times the rate of saltwater [35]. This may occur without the formation of an SMC as illustrated by a case of a bullet retained in the wrist for a period of 24 years that dissolved and migrated into a synovial recess resulting in reactive focal synovitis and a soft tissue mass [34]. The white color of the fluid found in cases 1-3 is likely due to lead corrosion products, i.e., lead carbonate [36]. Lead fragments dissolved by synovial fluid are then systemically absorbed. Of note, lead may also be dissolved and absorbed from bursae, lung tissue, abscesses, and intervertebral disc spaces [37].

Abundant Alcian blue-positive material in and around synovial metaplasia membranes as demonstrated in Case 1 (Figure 1F) fits the deposition of acid mucosubstances including hyaluronic acid [21]. This finding is significant as it reveals the environment of SMCs is chemically similar to the interior of native joint capsules lined by synovial membrane and filled with lubricating glycoproteins and molecules, which include hyaluronic acid.

Take Home Message

Although SMCs take years to develop, once a retained bullet is encapsulated by an SMC the amount of subsequent corrosion it experiences dramatically increases due to hyaluronic acid supplied by the fibroblasts lining the lumen of the SMC. Since the formation of a pseudocyst indicates increased breakdown of bullet fragments these patients may also be at risk of lead poisoning. Therefore the recommended treatment for pseudocyst formation around retained bullets is surgical excision and drainage.

References

1. Gotsch KE, Annest JL, Mercy JA, Ryan GW. Surveillance for fatal and nonfatal firearm-related injuries: United States 1993-1998. Center for Disease Control MMWR Surveillance Summaries. 2001; 50(SS02):1-32.

2. Rhee JM, Martin R. The management of retained bullets in the limbs. Injury. 1997; 28:23-28.

3. Dougherty PJ. Gunshot Wounds (AAOS Monograph, 44). Rosemont IL: American Academy of Orthopaedic Surgery; 2011.

4. Elston, DM, Bergfeld WF, McMahon JT. Aluminum tattoo: a phenomenon that resemble parasitized histiocytes. J Cutan Pathol. 1993; 20:326-329.

5. Barr, RJ, Alpern JS, Jay S. Histiocytic reaction associated with topical aluminum chloride (Drysol reaction). J Dermatol Surg Oncol. 1993; 19:1017-1021.
6. Ragsdale BD, Josselson AR. Winchester Silvertip ammunition: a study in ordnance gelatin. J Forensic Sci. l986; 3l:855-68.
7. Ragsdale BD. Gunshot wounds: a historical perspective. Military Med. 1984; 149:301-15.
8. Karger B. Chapter 9: Forensic ballistics. In Tsokos M, Ed. Forensic Pathology Reviews. 2008; 5:142.
9. Weinrich DM, Stickel AE, Diaz LK. Soft tissue cyst secondary to bullet retention. Arch Pathol Lab Med. 2001; 125:1391.
10. Lai CC. Delayed appearance of popliteal cyst caused by a bullet. J Trauma. 1977; 17:144–50.
11. Brogdon BG, Cottrell WC, Nimityongskul P, Takhtani D. A bullet-sired bone cyst. Skeletal Radiol. 2006; 35:959-63.
12. Jensen SP, Richardson ML, Conrad EU, Lazerte GD. Case report 608. Skeletal Radiology. 1990; 19:233-5.
13. Noffke CEE. Implantation-type epidermoid cyst of the mandible. Dentomaxillofacial Radiology. 1999; 28:383-85.
14. Bhawan J, Dayal Y, Gonzales-Serva A, Eisen R. Cutaneous metaplastic synovial cyst. J Cutan Pathol. 1990; 17:22-6.
15. Fowler MR, Nathan CO, Abreo A. Synovial metaplasia, a specialized form of repair. Arch Pathol Lab Med. 2002; 126:727-30.
16. Athanasou NA. The pathology of joint replacement. Current Diagnostic Pathol. 2002; 8:26-32.
17. Del Rosario AD, Bui HX, Petrocine S, Sheehan C, Pastore J, Singh J, et al. True synovial metaplasia of breast implant capsules: a light and electron microscopic study. Ultrastruct Pathol. 1995; 19:83-93.
18. Chi AC, Haigney RJ 2nd, Spagnoli DB, Neville BW, Richardson MS. Papillary synovial metaplasia-like change in oral mucoceles: a rare and previously undescribed histopathologic variant of a common oral lesion. Oral Surg Med Pathol Radiol Endod. 2010; 109:268-73.
19. Choonhakarn C, Tang S. Cutaneous metaplastic synovial cyst. J Dermatol. 2003; 30:480-4.
20. Beham A, Fletcher CDM, Feichtinger J, Zelger B, Schmid C, Humer U. Synovial metaplasia of the skin. Virchows Arch A Pathol Anat Histopathol. 1993; 423:315-18.
21. Michal M, Zámecník M. Synovial metaplasia in lipoma. Am J Dermatopathol. 1998; 20:285-9.
22. Inchingolo F, Tatullo M, Abenavoli FM, Marrelli M, Inchingolo AD, Servili A, et al. A hypothetical correlation between hyaluronic acid gel and development of cutaneous metaplastic synovial cyst. Head Face Med. 2010; 6:13.
23. Lin YC, Tsai TF. Cutaneous metaplastic synovial cyst: unusual presentation with “a bag of worms”. Dermatol Surg. 2003; 29:198-200.
24. Ramdial PK, Singh Y, Singh B. Metaplastic synovial cyst in male breast. Ann Diagn Pathol. 2005; 9:219-22.
25. Guala A, Viglio S, Ottinetti A, Angeli G, Canova G, Colombo E, et al. Cutaneous metaplastic synovial cyst in Ehlers-Danlos syndrome: report of a second case. J Dermatopathol. 2008; 30:59-61.
26. Nieto S, Buezo GF, Jones-Caballero M, Fraga J. Cutaneous metaplastic synovial cyst in an Ehlers-Danlos patient. Am J Dermatopathol. 1997; 19:407-10.
27. Chakravarthy KM, Lavery KM, Barrett AW. Recurrent cutaneous metaplastic synovial cyst. Oral Surg Med Pathol Radiol Endod. 2007; 103:e42-4.
28. Slavin RE, Swedo J, Cartwright J Jr, Viegas S, Custer EM. Lead arthritis and lead poisoning following bullet wounds: a clinicopathologic, ultrastructural, and microanalytic study of two cases. Hum Pathol. 1988; 19:223-35.
29. De Madureira PR, De Capitani EM, Vieira RJ. Lead poisoning alter gunshot wound. Sao Paulo Med J. 2000; 118:78-80.
30. Conway JE, Crofford TW, Terry AF, Protzman RR. Cauda equina syndrome occurring nine years after a gunshot injury to the spine. A case report. Am J Bone Joint Surg. 1993; 75:760-3.
31. Peh WC, Reinus WR. Lead arthropathy: a cause of delayed onset lead poisoning. Skeletal Radiol 1995; 24:357-60.
32. Ratte J, Faugeras P, Gondy B. [Calcinosis of the anteroexternal bed of the right leg forty years after a war wound.] Mem Acad Chir (Paris). 1959; 85(4-5):146-8. French.
33. Sorrel E. [Calcinosis of the calf following a wound acquired thirty three years before.] Acta Orthop Belg. 1952; 18:184-90. Flemish.
34. Janzen DL, Tirman PFJ, Rabassa AF, Kumar S. Lead “bursogram” and focal synovitis secondary to a retained intraarticular bullet fragment. Skeletal Radiol. 1995; 24:142-4.
35. Manton WI, Thanl ER. Lead poisoning from retained missiles, an experimental study. Ann Surg. 1986; 204:594-9.
36. Wiberg E, Wiberg N, Holleman AF. Inorganic Chemistry. Academic Press: San Diego, CA; 2001; p.915.
37. Grogan DP, Bucholz RW. Acute lead intoxication from a bullet in an intervertebral disc space. J Bone Joint Surg. 1981; 63:292-3.