Use of Ultrasound in the Diagnosis of Soft Tissue Foreign Bodies. Case Report and Review of the Literature.

McHaney, A.M., Biller, D.S. and Klocke, E.

Kansas State University Veterinary Health Center, Manhattan, USA.

* **Address correspondences to:** Prof. David S. Biller, Kansas State University Veterinary Health Center 1800 Dennison Ave. Manhattan, KS 66506; biller@vet.k-state.edu; Phone: +01-785-532-5690

ABSTRACT

The diagnosis of retained subcutaneous, muscular, and deep soft tissue foreign bodies can be challenging from both a clinical and imaging perspective. The main challenges lie in identification and localization of the foreign body within soft tissues. Retained foreign bodies present a variety of potentially serious complications, so prompt diagnosis and removal is necessary to avoid poor outcomes. An eight-year-old intact male pointer presented to the Veterinary Health Center for two years of intermittent lameness after exercise. On physical examination, a small non-painful swelling was palpated in the distal antebrachium. Ultrasound revealed a 20x2 mm hyperechoic linear foreign body surrounded by a well circumscribed hypoechoic region. The foreign body was surgically removed. While radiography is usually the first imaging modality used for diagnosing foreign bodies, it has significant limitations in that not all foreign bodies are radiopaque and localization can be imprecise. Ultrasound is an excellent adjunct or primary imaging modality for diagnosing retained foreign bodies. Ultrasound is extremely sensitive and specific for identifying even extremely small foreign bodies present in the soft tissues. Ultrasound is also extremely useful to demonstrate the exact location, orientation, and depth of a retained foreign body, as well as adjacent or surrounding complications, allowing for more targeted surgical removal with less iatrogenic tissue damage.

Keywords: Ultrasound; Soft Tissue; Foreign Bodies; Superficial; Diagnosis.

INTRODUCTION

Retained or migrating foreign bodies in the subcutaneous, musculoskeletal and deep soft tissues can be difficult to diagnose, from both a clinical and imaging perspective. The primary challenges lie in the identification and localization of the foreign body within the tissues. Often, patients with retained foreign bodies have vague clinical signs, without a definitive history of puncture wound or exposure to foreign material (1-5). In these particular cases, a retained foreign body may not be on the differential list for the clinician. Studies in human medicine have shown that approximately 38% of retained foreign bodies are missed on the initial doctor or hospital visit (1, 3, 4). If those foreign bodies are found, they may be incompletely removed, leaving small fragments within the tissues and predisposing the patient to complications (2, 5).

Complications related to retained and migrating foreign bodies are varied. Human studies have shown that approximately one out of four patients with retained foreign bodies present with some kind of complication (4). The most common complications in humans and animals are an inflammatory response by the body or infection (cellulitis, abscess formation, draining tracts, pyogranulomas, osteomyelitis, etc.) (3-11). Plant material foreign bodies are especially prone to developing infection because bacteria are present on their surface and grow readily (4, 8). Other complications are dependent on the foreign body location and its migration path. These include neurologic (4, 8, 9), respiratory (8, 9), and joint disease (4, 12), in addition to severe pain (8, 9). Glass (4), porcupine quills (12), and plant material foreign bodies have all demonstrated distant migration. Uncommon and severe complications include sepsis (8, 12), disseminated intravascular coagulation (12), sudden death (12) and endocarditis (12). Additional complications are caused by the frequent surgeries that patients with retained foreign bodies may undergo in order to identify the foreign body and/or manage the complications (5, 7, 11). Additional surgeries are time consuming for the practitioner, costly for clients, pose an infection risk to the patient and cause an unnecessary iatrogenic wound and tissue damage (3, 7, 9, 11). Ultimately, since the complications of retained foreign bodies can be severe, their prompt diagnosis and complete removal is necessary for a good prognosis (6, 9, 10). Missed-diagnosed foreign bodies are the second leading cause of lawsuits to emergency medicine physicians in human medicine (3, 11).

CASE DESCRIPTION

An eight-year-old male intact pointer presented to the Kansas State University Veterinary Health Center with a two-year history of intermittent lameness. The patient had been previously utilized as a hunting dog. The lameness was worse after significant activity, such as hunting, running, or jumping. Non-steroidal anti-inflammatory medications only provided minimal relief. On physical examination, a small, non-painful swelling was palpated on the distal and caudolateral aspects of the right antebrachium. The patient was also holding this limb up while sitting in the examination room. The remainder of the physical examination was within normal limits. Per the owner's verbal history, radiographs taken of the limb were unremarkable. In light of the long duration of clinical signs and lack of pain elicited on physical exam, ultrasound was elected to further characterize the swelling.

Sonographic evaluation (Toshiba Aplio500, 14Hz linear transducer) of the distal antebrachium revealed a 20 mm by 2 mm linear foreign body. On short axis, the foreign body appeared as a very small, circular, hyperechoic focus surrounded by a well circumscribed hypoechoic region, which aided in its visualization (Figure 1). On long axis, the foreign body was much easier to visualize and was characterized by a hyperechoic surface echo and incomplete, mild acoustic shadowing. On long axis, a well circumscribed hypoechoic region was also visualized surrounding the foreign body (Figure 2A).

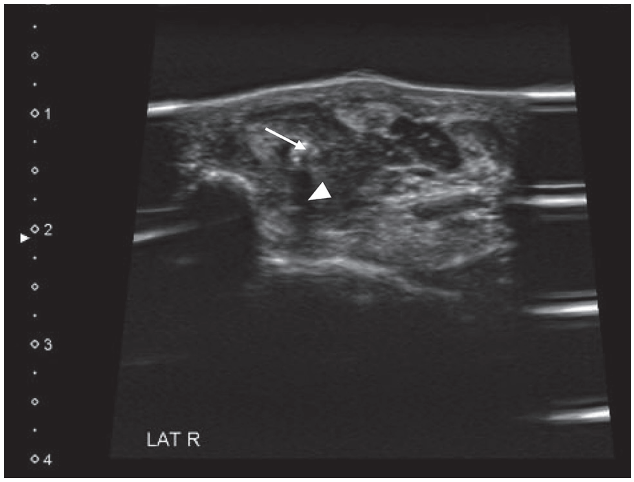

Figure 1: Short axis image of the hyperechoic foreign body present within the distal right antebrachium. Note the well-defined hypoechoic rim (arrow) and acoustic shadow (arrowhead).

The patient re-presented three months after initial diagnosis to pursue surgery, and the limb was imaged again to ensure the foreign body was still present in the same location, and that no significant soft tissue changes had occurred. Other than subjectively decreased echogenicity associated with the foreign body, there was no significant change in the appearance or location of the foreign body within the antebrachial soft tissues (Figure 2B).

Surgery was performed approximately three months after the initial presentation. The patient was premediated with acepromazine 0.02 mg/kg and methadone 0.5 mg/kg, induced with propofol 3.1 mg/kg, and maintained under general anesthesia with isoflurane gas. A 4 cm incision was made immediately over the swelling (Fig 3A). The fibrous capsule containing the foreign body was bluntly dissected from the antebrachium, and the foreign body and its associated capsule were removed (Fig 3B, Fig 3C). The incision was closed, and the patient recovered uneventfully from anesthesia. Aerobic and anaerobic samples were taken of the area immediately associated with the foreign body and were submitted for culture and sensitivity. The fibrous capsule was opened and the foreign body removed and examined.

Further examination indicated that the foreign body was likely a thorn from a locust tree (*Gleditsia triacanthos*) (Fig 3D). The following organisms were cultured from the tissue: *Enterobacter sp.*, *Enterococcus casseliflavus*, *Streptococcus gallolyticus*, unidentified gram positive, *Clostridium subterminale*. The patient was discharged after a short hospital stay on analgesics and amoxicillin/clavulanic acid, pending sensitivity

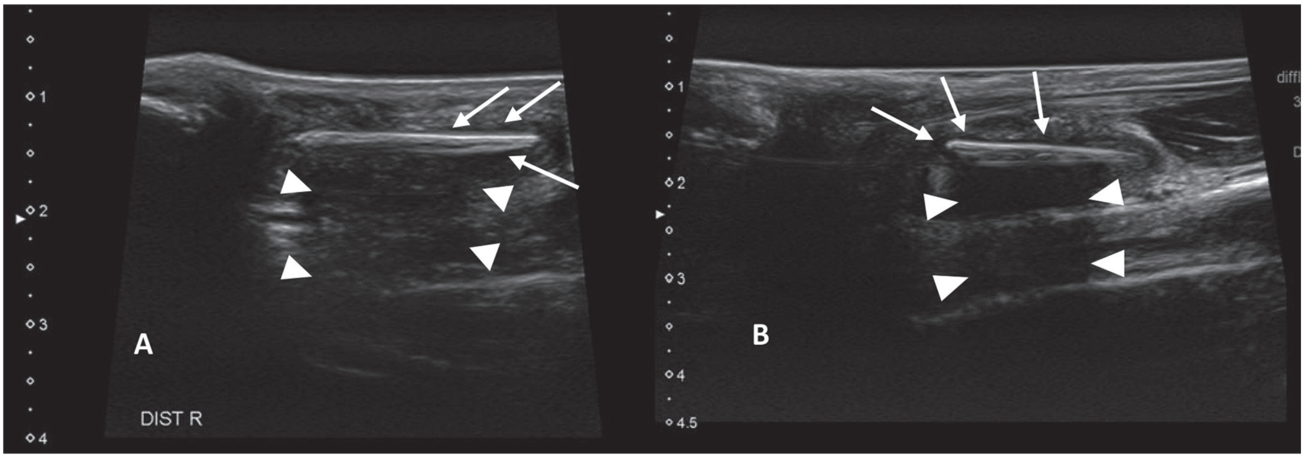

Figure 2: Long axis image of the hyperechoic foreign body present within the distal right antebrachium. (A) At initial presentation. (B) Three months after initial presentation. Note that the surface echo of B is slightly less intense than that of A. Note the hypoechoic rim around the foreign material (arrows), and the acoustic shadowing (arrow heads) which in this case happens to be better appreciated in A.

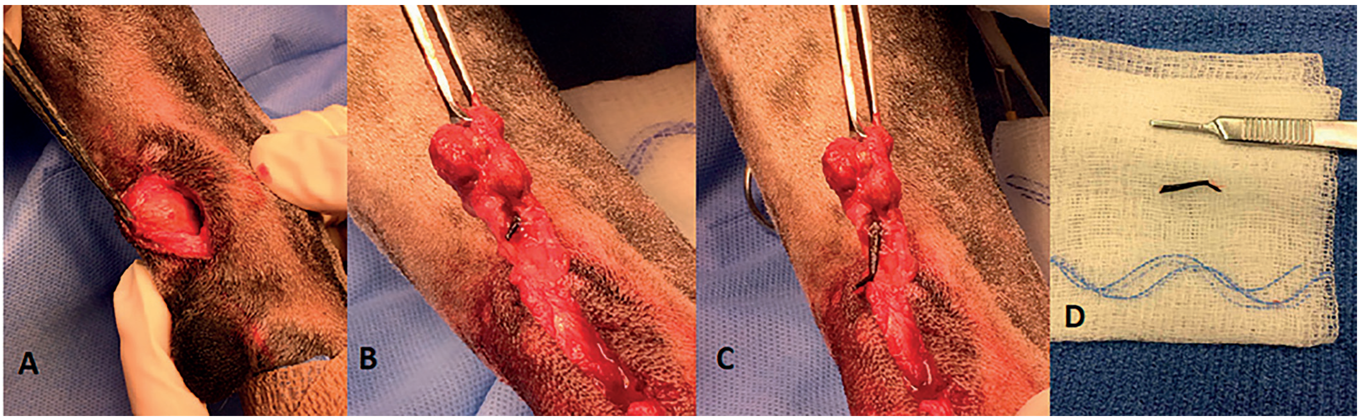

Figure 3: Intraoperative images of foreign body removal from the distal antebrachium. Initial incision (A). Capsule dissection and removal of the foreign body (B and C). Foreign body isolation and identification as a thorn (D).

results. The patient was lost to follow-up immediately after discharge.

DISCUSSION

This case demonstrates the use of ultrasound as an imaging modality to help alleviate the problems of identification and localization of retained and migrating foreign bodies in the subcutaneous, muscular, and deep soft tissues of the body. Radiographs have been the typical screening method for identifying foreign bodies (4, 5, 10, 13, 14); however, they lack sensitivity. One of the primary disadvantages of radiography is that not all foreign objects are radiopaque (2-5, 10, 13). Radiolucent foreign bodies, such as wood, plant material, and plastic are not uncommon, and since these have densities similar to that of soft tissues in the body, they are not visible radiographically (1-5, 13, 14) (Figure 4A). Studies in human medicine have shown that only about 15% of wooden foreign bodies are identified radiographically (1, 11). Small foreign bodies, such as small shards of glass (4), can also be difficult to appreciate radiographically. Other imaging modalities (CT, MRI, and fistulograms) can be used to diagnose retained foreign bodies, but these also have significant drawbacks. CT can be an excellent modality for the diagnosis of large foreign objects, but it is less accurate when used to diagnose small foreign bodies (1, 2). CT also exposes the patient to ionizing radiation, can be expensive and may require general anesthesia for veterinary patients (1, 11). CT may also only be available at teaching and specialty hospitals. Fistulograms can be difficult to interpret and can have many false positives and negatives due to incomplete or artifactual filling defects (5).

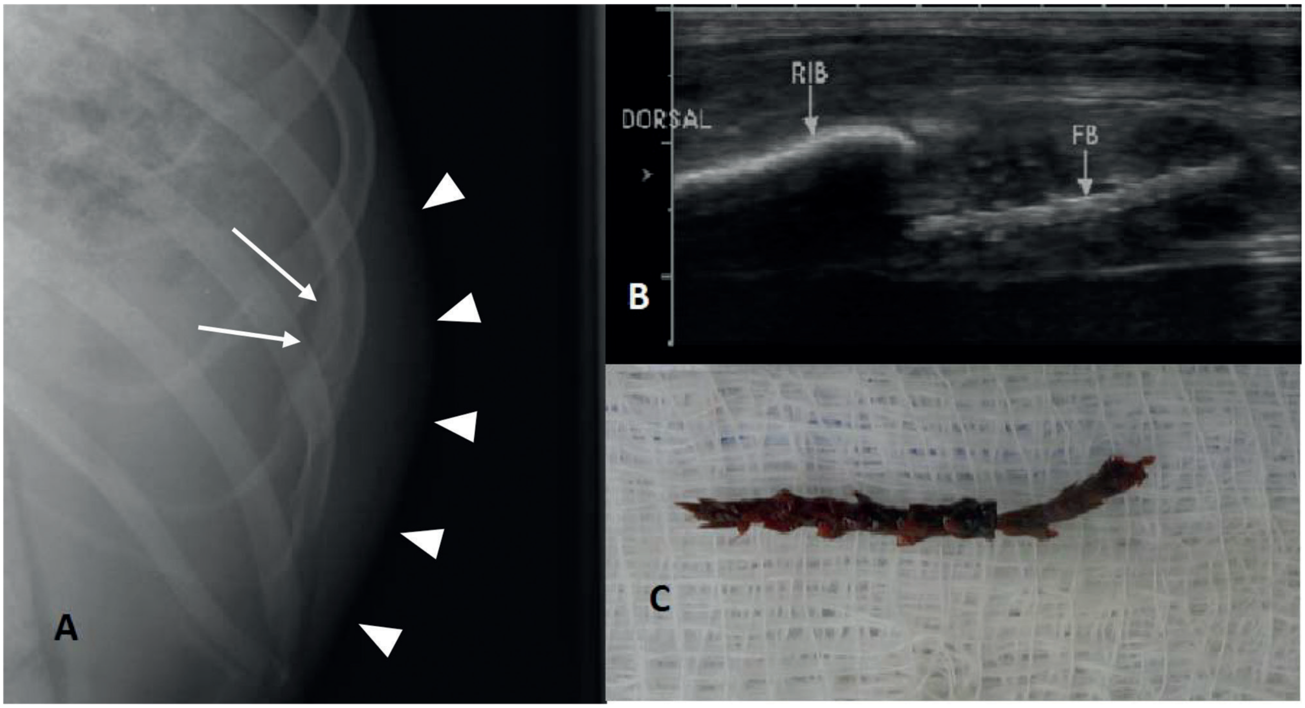

Figure 4: Radiograph (A), ultrasound (B), and gross specimen (C) of a plant foreign body from a different patient. Note in radiographs how plant foreign material is not visible. Instead, soft tissue swelling (arrow head) and periosteal reaction along the rib (arrow) indicate that a foreign body may have been present. On ultrasound, the foreign body is visible adjacent to a rib. Note also how similar the sonographic appearance of the foreign body is compared to the gross specimen.

Ultrasound is an excellent imaging modality for diagnosing foreign bodies of all sizes (1, 4, 11, 14). High frequency transducers are necessary, as these allow for enough detail through superior resolution to see even extremely small foreign objects in the body (1, 3). Ultrasound has been reported to be accurate in identifying foreign material as small as about 2.5 mm (1, 11, 14), and will also identify small foreign bodies that may have been missed on evaluation with other imaging modalities (2, 10). It is the mainstay diagnosis of subcutaneous foreign material in horses (5), and has been widely used in human and small animal patients (5). Wooden foreign bodies can be identified with around 92% accuracy (1), and the sensitivity and specificity for the diagnosis of all foreign material is between 94-98% and 89% respectively (1, 3, 11). Frequently, tissue reactions and ultrasound artifacts help to identify foreign material (1-3, 5, 11, 13), and hypoechoic draining tracts can often be followed to foreign material (5).

As a cross sectional imaging modality, ultrasound can very accurately determine the exact location of a foreign body in relation to surrounding tissues (3, 5, 11). Radiographs offer imprecise localization (1, 14), even if orthogonal views are taken, and can, for the most part, only relate the location of foreign material to the surrounding bony structures (1) (Fig 4A). Using ultrasound, the operator can identify the exact foreign body location, size, depth, orientation, and relationship to other structures, which can allow it to be removed with minimal disruption of normal tissues (3, 5, 9, 11, 13, 14) (Fig 4B). Doppler can be used to identify vessels near the foreign object and present within the surgical plane so that they can be avoided if necessary (1, 5). Ultrasound can also determine the extent of fistulous tracts so that abnormal or infected tissues can be removed with minimal damage to adjacent, normal tissue (5, 13).

The sonographic appearance of a variety of different foreign bodies has been extensively reported in the literature (5, 13, 14), and the use of ultrasound to diagnose and describe foreign material has been well documented in veterinary and human medical literature (5, 8, 9, 13, 14). Although at first glance, many foreign bodies may appear similar, differences in reverberation, acoustic shadowing, and surface echo intensity have been reported (5, 13, 14). The surface echo of a material depends on the material's density (5, 14). Even the most low-density foreign materials will reflect enough sound to be hyperechoic, and highly detectable (4, 13, 14), but the intensity of the echo will vary (5, 14). Acoustic shadowing is the artifact that occurs when sound waves are reflected and absorbed after encountering a highly attenuating material (9). Changes in reverberation are dependent on the surface characteristics of the foreign body (4, 13). Smooth and flat surfaces are more likely to exhibit reverberation artifact, and irregular or curved surfaces are more likely to have clean shadowing (4, 13). Additionally, it has been well documented that foreign bodies within the soft tissues of the body are generally surrounded by a rim of hypoechoic material, which is usually indicative of an inflammatory response (4, 5, 13, 15). The hypoechoic material also highlights the hyperechoic surface echo and makes the foreign body more visible (5, 13, 15).

Wood and plant foreign objects are one of the most common foreign bodies found in the distal extremities in dogs (7), and in general make up the majority of reported foreign bodies seen in veterinary medicine (7). Wooden foreign bodies generally have moderately hyperechoic, linear interfaces (5, 7, 11, 13, 14). This surface echo becomes less intense with chronicity due to the foreign body's absorption by local inflammatory reactions (7). Large, acute, and hard wooden foreign bodies are most likely to have intense acoustic shadowing (13, 14), while small and/or thin wooden foreign bodies may not shadow at all (5, 9, 11). Again, chronicity will decrease the acoustic shadow due to fluid uptake and enzyme degradation of the material, causing decreased attenuation of sound waves (9). Grass awns are becoming an increasingly recognized migrating foreign body, especially in younger hunting and working breed dogs (8, 9, 15). Grass awns exhibit hyperechoic surface echoes that are linear and spindle shaped with two to three parallel interfaces (7, 8, 15). Due to their small size and decreased density, grass awns may (8, 9) or may not present with acoustic shadowing (7, 9, 15). Other common foreign bodies that have been described include glass, metal, porcupine quills, gravel/stone and plastics (12-14).

Besides its use in diagnosing, localizing, and describing various foreign bodies, ultrasound can also be used to aid in the removal of foreign material from the subcutaneous and musculoskeletal soft tissues. Multiple techniques have been reported in the literature regarding foreign body removal with ultrasound guidance (8, 10, 16-18). Some techniques will also utilize ultrasound to visualize the removal of the foreign material in real time (8, 16-18), others do not (10, 17). Most techniques start with the placement of a guide needle (8, 10, 16-18) or some kind of external marker using ultrasound to ensure proper localization before a small incision is made (17, 18). Small hemostats or forceps are then introduced into the incision or needle tract and the tissues are bluntly dissected under ultrasound guidance until the instrument is adjacent to the foreign material (8, 16-18). Ultrasound is used to visualize both the instrument's jaws closing around the foreign body and its subsequent removal (8, 16-18). Alternatively, after the guide needle is placed, and incision can be made and the tissues bluntly dissected along the guide needle until the foreign material can be visualized and removed (10). Multiple human publications report high levels of success and rapid removal using these techniques (10, 16-18). Ultimately, ultrasound allows for targeted removal of the foreign body with minimal disruption to normal tissues (8, 10, 18).

In conclusion, ultrasound is an excellent imaging modality that effectively addresses both the problems of foreign body identification and localization in the subcutaneous, musculoskeletal, and deep soft tissues of the body. Ultrasound allows foreign material to be removed from the body with as little disruption to normal tissues as is possible, and can be used to visualize foreign body removal in real time.

REFERENCES

1. Budhram, G.R. and Schmunk, J.C.P.: Bedside ultrasound aids identification and removal of cutaneous foreign bodies: A case series. J. Emerg. Med. 47:e43-e48, 2014.
2. Dumarey, A., De Maeseneer, M. and Ernst, C.: Large wooden foreign body in the hand: recognition of occult fragments with ultrasound. Emerg. Radiol. 10:337-339, 2004.
3. Dean, A.J., Gronczewski, C.A. and Costantino, T.G.: Technique for emergency medicine bedside ultrasound identification of a radiolucent foreign body. J. Emerg. Med. 24:303-308, 2003.
4. Jarraya, M., Hayashi, D., De Villiers, R. V., Roemer, F.W., Murakami, A.M., Cossi, A. and Guermazi, A.: Multimodality imaging of foreign bodies of the musculoskeletal system. Am. J. Roentgenol. 203:92-102, 2014.
5. Armbrust, L.J., Biller, D., Radlinsky, M.G. and Hoskinson, J.J.: Ultrasonographic Diagnosis of Foreign Bodies Associated with Chronic Draining Tracts and Abscesses in Dogs. Vet. Radiol. Ultrasound. 44:66-70, 2003.
6. Jones, J.C. and Ober, C.P.: Computed Tomographic Diagnosis of Nongastrointestinal Foreign Bodies in Dogs. J. Am. Anim. Hosp. Assoc. 43:99-111, 2007.
7. Ober, C.P., Jones, J.C., Larson, M.M., Lanz, O.I. and Were, S.R.: Comparison of ultrasound, computed tomography, and magnetic

resonance imaging in detection of acute wooden foreign bodies in the canine manus. Vet. Radiol. Ultrasound. 49:411-418, 2008.
8. Birettoni, F., Caivano, D., Rishniw, M., Moretti, G., Porciello, F., Giorgi, M.E., Crovace, A., Bianchini, E. and Bufalari, A.: Preoperative and intraoperative ultrasound aids removal of migrating plant material causing iliopsoas myositis via ventral midline laparotomy: A study of 22 dogs. Acta. Vet. Scand. 59:1-9, 2017.
9. Staudte, K.L., Hopper, B.J., Gibson, N.R. and Read, R.A.: Use of ultrasonography to facilitate surgical removal of non-enteric foreign bodies in 17 dogs. J. Small Anim. Pract. 45:395-400, 2004.
10. Nwawka, K.O., Kabutey, N.K., Locke, C.M., Castro-Aragon, I. and Kim, D.: Ultrasound-guided needle localization to aid foreign body removal in pediatric patients. J. Foot Ankle Surg. 53:67-70, 2014.
11. Graham, D.D.: Ultrasound in the emergency department: Detection of wooden foreign bodies in the soft tissues. J. Emerg. Med. 22:75-79, 2002.
12. Brisson, B.A., Bersenas, A. and Etue, S.M.: Ultrasonographic diagnosis of septic arthritis secondary to porcupine quill migration in a dog. J. Am. Vet. Med. Assoc. 224:1467-1470, 2004.
13. Horton, L.K., Jacobson, J.A., Powell, A., Fessell, D.P. and Hayes, C.W.: Sonography and radiography of soft-tissue foreign bodies. Am. J Roentgenol. 176:1155-1159, 2001.
14. Shah, Z.R., Crass, J.R., Oravec, D.C. and Bellon, E.M.: Ultrasonographic Detection of Foreign-Bodies in Soft-Tissues Using Turkey Muscle As a Model. Vet. Radiol. Ultrasound. 33:94-100, 1992.
15. Gnudi, G., Volta, A., Bonazzi, M., Gazzola, M. and Bertoni, G.: Ultrasonographic features of grass awn migration in the dog. Vet. Radiol. Ultrasound. 46:423-426, 2005.
16. McArthur, T., Abell, B.A. and Levsky, M.E.: A procedure for soft tissue foreign body removal under real-time ultrasound guidance. Mil. Med. 172:858-859, 2007.
17. Bradley, M.: Image Guided Soft Tissue Foreign Body Extraction Success and Pitfalls. Clin. Radiol. 67:531-534, 2012.
18. Shiels, W.E., Babcock, D.S., Wilson, J.L. and Burch, R.A.: Localization and guided removal of soft-tissue foreign bodies with sonography. Am. J. Roentgenol. 155:1277-81, 1990.