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PICTORIAL ESSAY

Ultrasonographic Findings of Suspected Retained Foreign Body in Soft Tissue Following Penetrating Injury

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ABSTRACT

A suspected retained foreign body in soft tissue following penetrating injury presents a diagnostic challenge to clinicians. A retained foreign body can be radiolucent and is prone to be missed, leading to serious complications. Ultrasonography is a reliable tool to detect, localise, and guide removal of a foreign body, and also to diagnose injury-related conditions in cases where no foreign body is detected. This pictorial essay illustrates the spectrum of findings encountered during ultrasonographic examination for suspected foreign bodies. Familiarisation with these findings may help in diagnosis and guide further management.

Key Words: *Complications; Foreign-body reaction; Soft tissue injuries; Ultrasonography*

中文摘要

穿透性損傷後疑似異物入體的超聲波檢查

農智行、李嘉樂、伍永鴻

在穿透性損傷後，診斷疑似異物滯留於軟組織有時較為困難。放射線可以穿透滯留的異物而導致漏診，有時導致嚴重的併發症。超聲波是一種可靠的工具來檢測、定位和引導異物取出，能在沒有檢測到異物的情況下可以診斷損傷相關的改變。本圖文回顧闡釋異物體內滯留的超聲波檢查表現。熟悉這些檢查表現有助於診斷和引導進一步的治療。

INTRODUCTION

A suspected retained foreign body in soft tissue after penetrating injury presents a diagnostic challenge to clinicians. In some cases, patients who sense the presence of a foreign body may be unable to recall a definite history of penetrating injury, or the time or mechanism of injury. Previous studies have shown that 38% of retained foreign bodies in soft tissue are overlooked at initial examination. This may lead to serious complications including infection and foreign body reaction.[1] Common radiolucent foreign bodies, such as wood, thorn or bamboo, are prone to be missed. Only up to 15% of wood is detected on radiographs,[1] and these organic foreign bodies are more likely to cause infection or inflammation.[2] Ultrasonography (US) has been increasingly used to detect these radiolucent foreign bodies,[3] and is now considered a reliable imaging technique.[4,5] The reported sensitivity ranges

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from 75% to 100%, whereas the reported specificity ranges from 59% to 100%.[5-10] US is superior to radiographs in detecting radiolucent foreign bodies,[11,12] and plain and soft-tissue radiographs are now suggested to be redundant provided US is available.[12] For radio-opaque foreign bodies, US is useful for localisation and removal.[13,14]

In our experience, localised symptoms at and around the site of a previous penetrating injury may not always be related to an in-situ foreign body. This is in keeping with a study where only 15% of 437 suspected cases were found to have retained foreign bodies.[15] US is helpful in the detection or exclusion of a foreign body and related complications and can guide further management.[16] In this pictorial assay, we illustrate the spectrum of sonographic findings encountered during scanning for suspected foreign bodies following penetrating injuries.

TECHNIQUE

Before scanning, it is crucial to ask the patient about the type, size, direction of implantation, and likelihood of a foreign body. Time since the injury is also important as it affects the amount of soft tissue reaction against the foreign body, particularly for organic foreign bodies. A high frequency (7.5 MHz or above) linear array probe should be used and the examined area should include the area around the site of penetration and beyond, particularly along the direction of implantation, to maximise the chance of detection. Once a suspicious foreign body is identified, the probe should be aligned parallel to it in order to determine its size and shape. Scanning in another plane at right angles is also helpful to confirm its presence. The surrounding area can then be assessed for any soft tissue inflammation, granulation tissue, or hyperaemia. Associated complications in the adjacent soft tissue such as infection, neurovascular, or tendon injury also need to be determined. It is important to repeat an US scan 1 week later if the initial finding is equivocal and the first scan was performed shortly after the injury. This allows some time for foreign body reaction and granulation tissue to form around the foreign body. Echogenic foci at the site of injury can be due to gas introduced from a skin wound or recent exploration, and will usually resolve in a follow-up scan.[10]

FOREIGN BODY

Wood

Wood, usually in the form of a wooden or bamboo splint, is the most common radiolucent foreign body implanted in soft tissue. They are seen as elongated echogenic structures and / or posterior artefact (reverberation / comet-tail artefact) [Figures 1-3]. If left in situ for enough time, there is often a soft tissue reaction to these organic foreign bodies, seen as a hypoechoic rim around the foreign body, representing inflammatory / granulation tissue. Surrounding hyperaemia may be present. When superimposed with infection, complications such as cellulitis, focal collection (Figure 2b) or tenosynovitis (Figure 3) may also be seen.

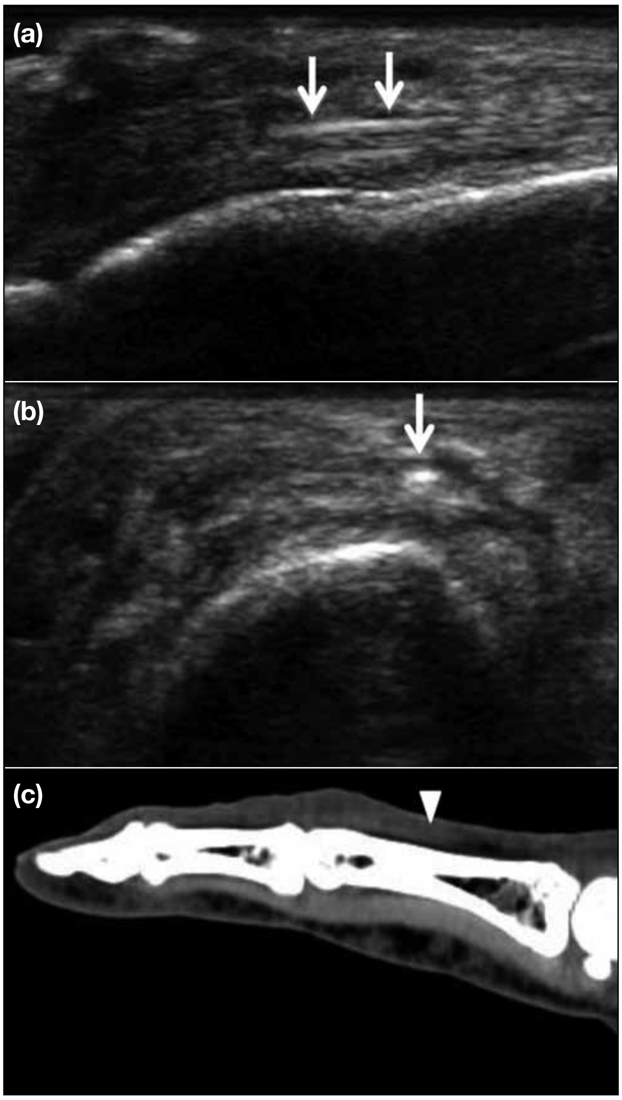

Figure 1. (a) Longitudinal ultrasonography (US) showing a linear echogenic structure (arrows) in the dorsal index finger at the level of proximal phalanx. (b) Transverse US showing an echogenic focus (arrow) and the presence of a foreign body. (c) Computed tomography showing the foreign body in the corresponding region (arrowhead). Operation confirmed an implanted wooden splint.

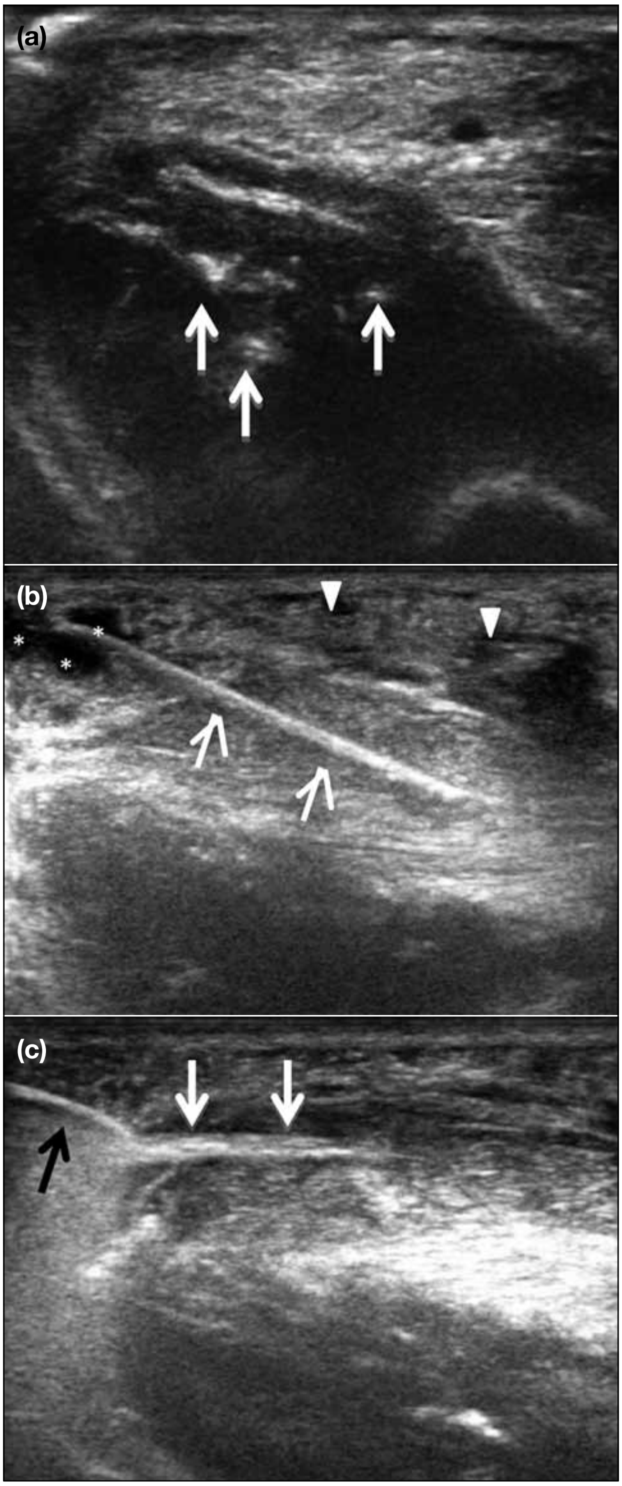

Figure 2. (a) Tranverse ultrasonography (US) following surgical exploration showing multiple echogenic foci (arrows) within the thenar muscles representing gas. No definite foreign body can be identified. (b) Follow-up US 4 days later showing a wooden splint (arrows) implanted in the thenar muscle, with cellulitis (arrowheads) and a focal collection (asterisks) at one end of the splint. (c) US-guided removal of the wooden splint (white arrows) is performed using forceps (black arrow).

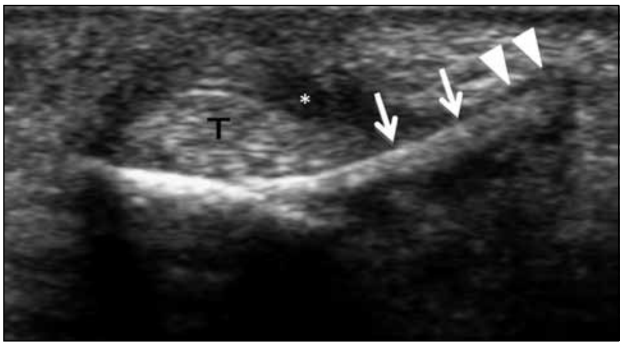

Figure 3. Transverse section ultrasonography showing a wooden splint (arrows) in the palmar aspect of finger, implanted deep to the flexor tendon (T). A small rim of granulation tissue around the foreign body (arrowheads) and mild thickening of tendon sheath (asterisk) suggestive of early tenosynovitis.

Glass

Glass is often radio-opaque and can usually be identified on a plain radiograph (Figure 4). Nonetheless, for small pieces of glass, detection may not always be easy. Computed tomography (Figure 4c) can readily detect even small pieces of glass but involves ionising radiation and is not cost-effective. US is a reliable and readily available tool to detect glass fragments that are seen as an echogenic focus with sharp edges. Glass tends to be intermediate between metallic and organic material in causing foreign body reaction, which is usually mild to moderate. The presence of a surrounding hypoechoic rim of inflammatory or granulation tissue helps to localise small pieces of glass. Like wooden foreign bodies, complications of a superimposed reaction can occur when there is contamination (Figure 4b).

Metallic Foreign Body

A metallic foreign body is mostly detected by plain radiograph alone (Figure 5). The role of US lies in accurate localisation and guiding removal. Metallic foreign bodies, commonly in the form of needles or small metallic fragments implanted with high velocity during industrial accidents, are echogenic with strong posterior acoustic shadowing on US. They can remain inert for years and the surrounding inflammatory / granulation tissue can be absent or minimal although detection is usually easy due to the high echogenicity against a background of soft tissue and the aid of plain radiographs. US can accurately localise the foreign body in terms of its depth and soft tissue plane, as well as indicate the proximity of any vital structures such as a neurovascular bundle. This provides crucial information for surgical planning and minimising soft tissue trauma during exploration. For a superficially located foreign body, removal can be performed using artery forceps under real-time US guidance with local anaesthesia (Figure 5d).

FOREIGN BODY REACTION

Granuloma

Granuloma is formed by histiocytes attempting to wall off substances that are perceived as foreign but that cannot be eliminated (Figure 6). Presence of a foreign body is a cause of granuloma formation, but other aetiologies such as infection (commonly mycobacterial or fungal infection) and granulomatous inflammation may also be responsible.[17] Granuloma is seen on US as a well-circumscribed isoechoic to mildly echogenic nodular lesion, usually with a surrounding rim of hypoechogenicity and hyperaemia. Presence of a granuloma at the site of a penetrating injury prompts a vigorous search for a foreign body. Nonetheless, there are occasions where a foreign body cannot be identified, either due to its small size that escapes detection or some endogenous materials such as keratin and hair

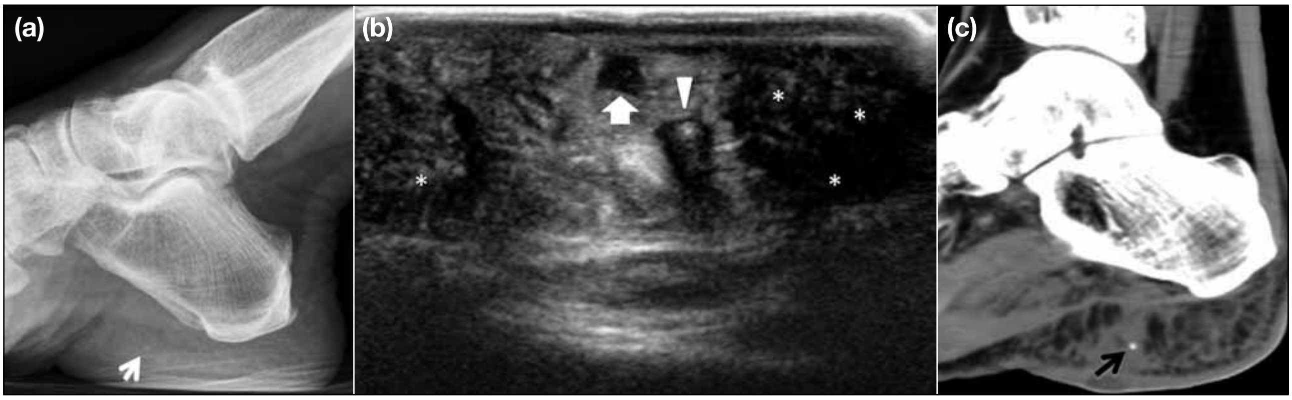

Figure 4. (a) Lateral radiograph of the ankle showing a faint radio-opacity in the subcutaneous region of the heel (white arrow) that is difficult to visualise. (b) Transverse ultrasonography of the plantar side of the heel showing an echogenic focus with reverberation artefact (arrowhead). There is cellulitis in the adjacent subcutaneous tissue (asterisks) and a small collection (block arrow). (c) Computed tomography showing a hyperdense foreign body (black arrow) that is confirmed surgically to be a small glass fragment.

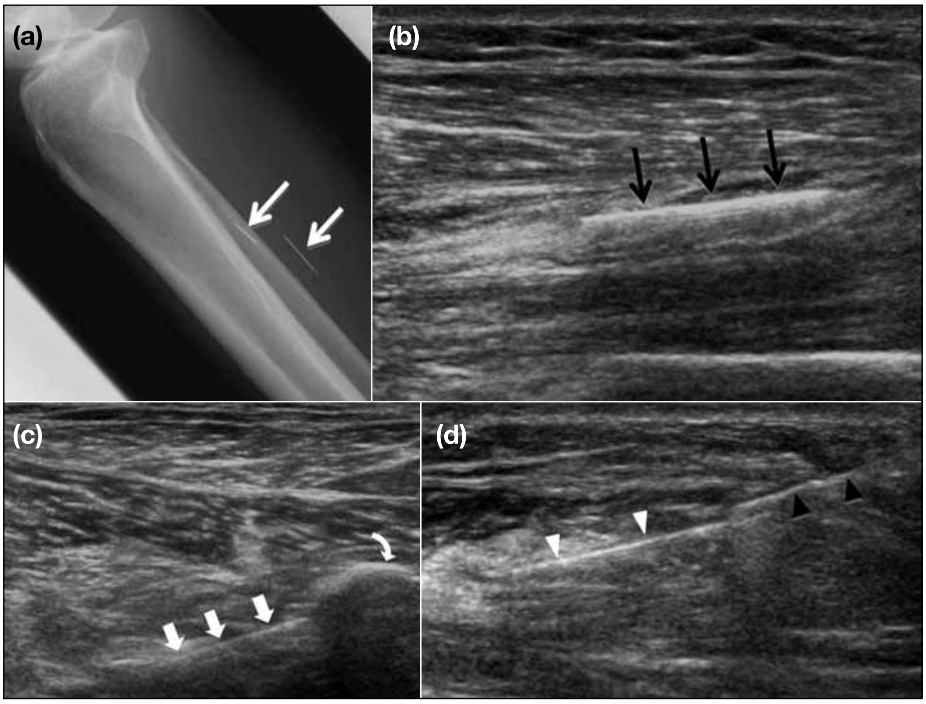

Figure 5. (a) Lateral radiograph of the leg showing two metallic needles (white arrows) in the calf region. (b) Longitudinal ultrasonography (US) showing the more superficially located needle (black arrows) with strong posterior acoustic shadowing. (c) Transverse US showing the deeper needle (block arrow) that is obliquely orientated with one end abutting the fibular shaft (curved arrow). This provides crucial information for subsequent surgical removal. (d) US-guided removal of the more superficial needle (white arrowheads) is performed with forceps (black arrowheads).

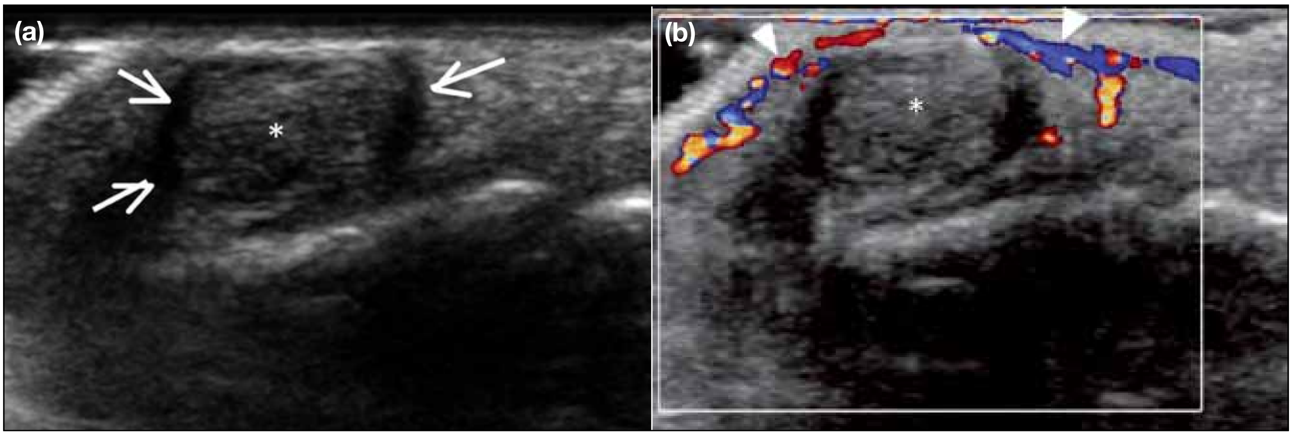

Figure 6. (a) Longitudinal ultrasonography (US) of a patient with a penetrating injury by a pencil showing a well-circumscribed isoechoic nodule (asterisk) with surrounding hypoechoic rim (arrows) in the palmar aspect of the distal phalanx, suggestive of a granuloma. No foreign body is detected. The graphite should have been removed at the time of injury. (b) Colour Doppler US showing moderate hyperaemia (arrowheads) around the granuloma (asterisk). Patient was managed conservatively and symptoms subsequently resolved.

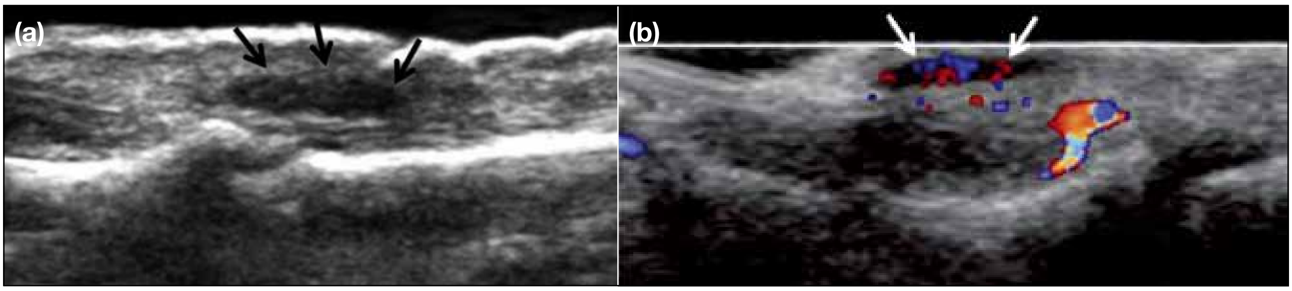

Figure 7. (a) Longitudinal ultrasonography (US) showing a thin spindle-shaped homogeneous hypoechoic lesion (black arrows) in the subcutaneous fat of finger pulp, suggestive of granulation tissue. No foreign body is identified. (b) Colour Doppler US showing vascularity (white arrows) within this granulation tissue representing increased blood flow during healing. Subsequent clinical follow-up showed resolution of symptoms.

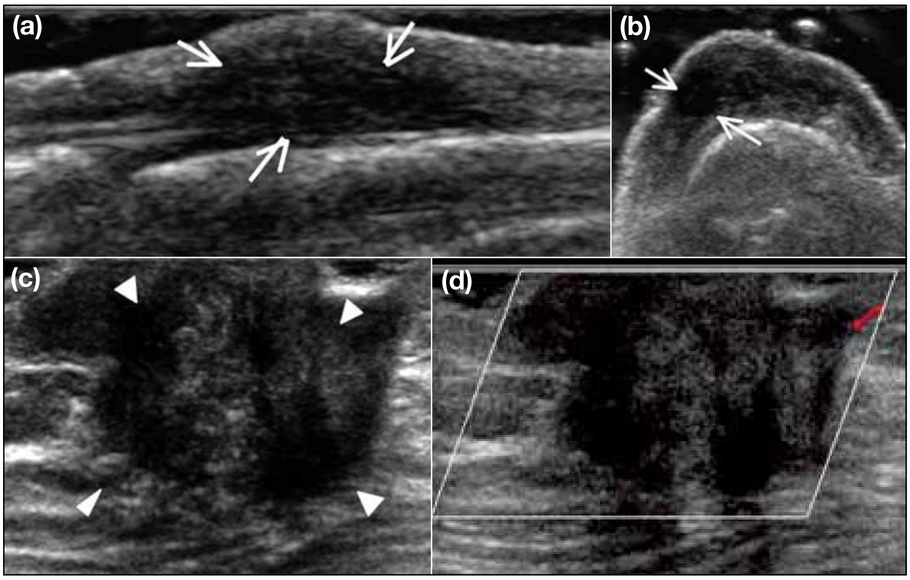

Figure 8. (a) Longitudinal and (b) transverse ultrasonography (US) of the palmar aspect of the middle phalanx showing a poorly marginated hypoechoic area (arrows) in the subcutaneous fat. No hyperaemia is seen on Doppler US (not shown). (c) Transverse US of the heel of another patient showing a focal heterogeneous hypoechoic mass (arrowheads) with indistinct border. (d) Power Doppler US showing no increased vascularity within the mass. The appearances are suggestive of fibrosis. No foreign body is identified. Both patients were treated conservatively.

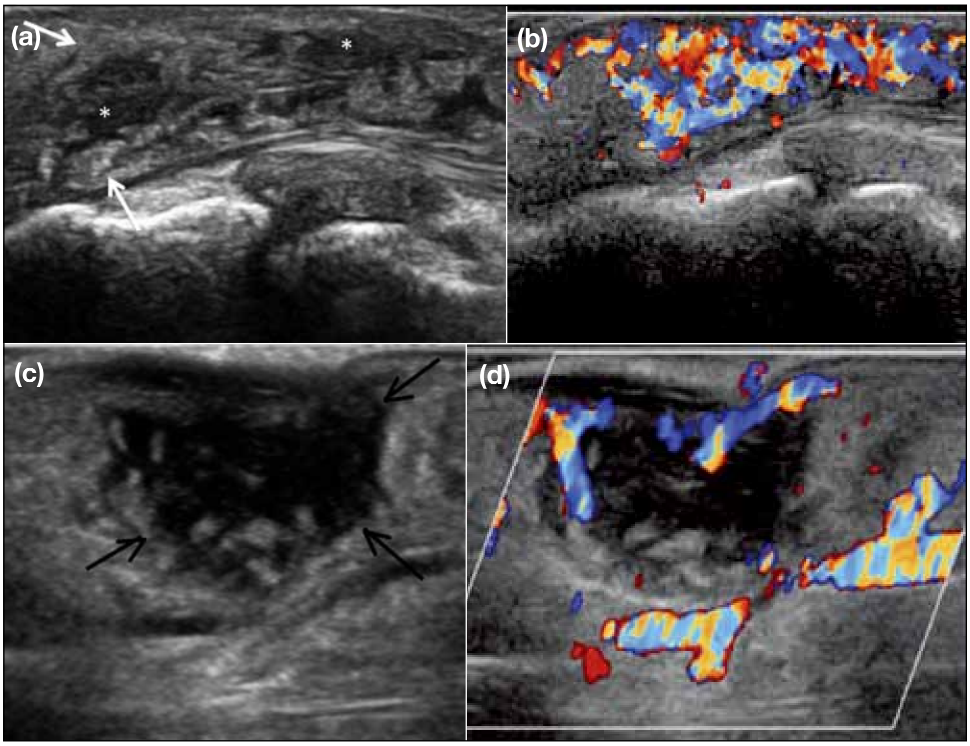

Figure 9. (a) Longitudinal ultrasonography (US) showing cellulitis in the finger as thickening and increased echogenicity of subcutaneous fat (arrows) with fluid accumulation (asterisks), giving rise to 'copple-stone' appearance. (b) Marked hyperaemia is present on colour Doppler US. (c) Transerve US of another patient showing a focal collection (black arrows) in the plantar aspect of heel following penetrating injury, suggestive of an abscess. (d) Colour Doppler US showing hyperaemia around the abscess. The abscess was subsequently drained under US guidance.

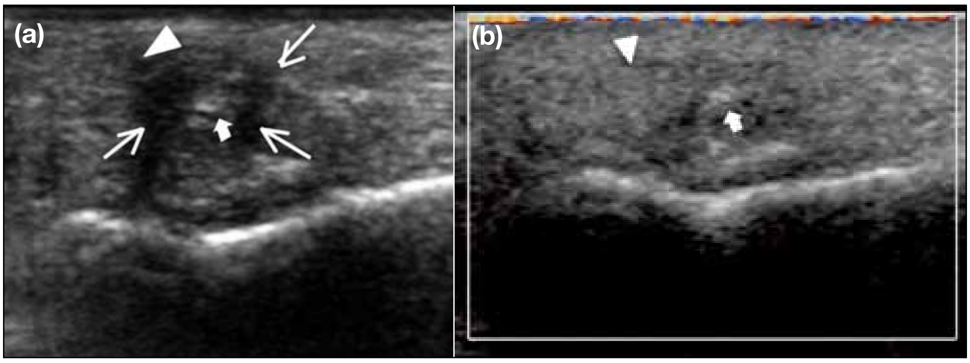

Figure 10. (a) Longitudinal and (b) colour Doppler ultrasonography showing poorly defined hypoechoic area (arrows) in the subcutaneous fat of the finger pulp. Hypoechoic stranding (arrowheads) is noted in the adjacent fat. Small echogenic foci (block arrows) within the hypoechoic area probably represents calcification. No hyperaemia is present. No foreign body is evident. The diagnosis of fat necrosis was made and the patient was managed conservatively.

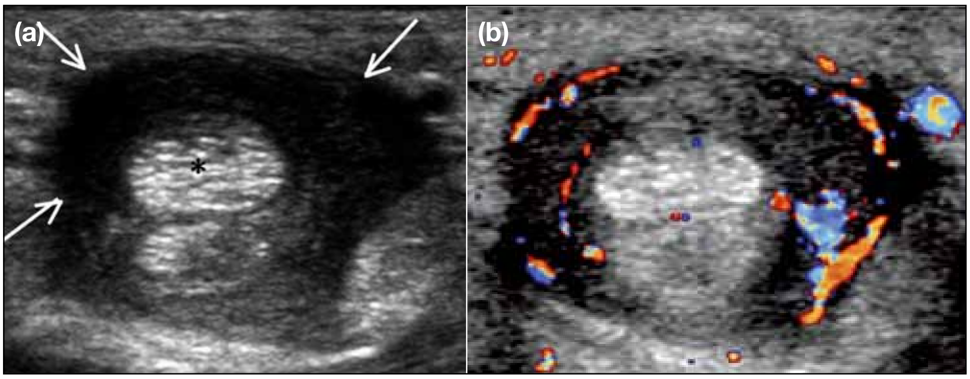

Figure 11. (a) Transverse ultrasonography (US) of a flexor tendon in a patient poked by a thorn showing thickening of the tendon sheath with effusion (arrows). The tendon (asterisk) itself is intact and no foreign body is evident. (b) Colour Doppler US showing moderate peritendinous hyperaemia. Features are compatible with tenosynovitis. Patient was subsequently confirmed to have acute pyogenic tenosynovitis with surgical debridement and drainage.

shafts that may be altered and recognised as foreign.[18] Nonetheless, if a foreign body granuloma is seen on US, even in the absence of a detectable foreign body, the patient should be referred for clinical assessment or for imaging to ensure the genuine absence of an in-situ foreign body.

Granulation Tissue

Granulation tissue refers to new connective tissue and tiny blood vessels formed around the site of injury during the healing process (Figure 7). US has been reported to be useful in assessing wound healing.[19] Granulation tissue is seen as a homogeneous hypoechoic well-defined area, which may be elongated or spindle-shaped. There is usually a mild degree of hyperaemia (Fig 7b), representing increased blood flow to the region during healing.

Fibrosis

The reparative process with fibrosis and scarring following injury and surgical exploration can present with a lump. There may also be other symptoms such as pain, vague foreign body sensation, or itchiness. US is helpful to exclude residual foreign bodies and offers reassurance to both patients and clinicians. Fibrosis is seen as poorly marginated hypoechoic areas with little mass effect and usually no significant hyperaemia (Figures 8a and b). Occasionally fibrosis can be focal and resemble a mass (Figures 8c and d).

Cellulitis and Abscess

Soft tissue infection is the most common complication of a penetrating foreign body.[1] It is mostly a clinical diagnosis, but US is useful in assessing the degree, extent, and complications such as abscess formation that may require drainage. Drainage of an abscess is also commonly performed under US guidance. Cellulitis is seen as increased thickness and echogenicity of subcutaneous tissue with fluid accumulation, giving rise to a 'cobble-stone' appearance (Figure 9). There is usually moderate-to-marked hyperaemia depending on the severity.

Fat Necrosis

Fat necrosis is a benign process secondary to aseptic saponification of fat by lipase released from blood and tissue (Figure 10), usually following trauma although a definite trauma history sometimes cannot be recalled by patients. Previous studies have shown variable sonographic appearance of fat necrosis involving the trunk and limb.[20,21] Common sonographic features include predominantly hypoechoic fat lobules with intervening hypoechoic septi and hypoechoic extrinsic stranding into the surrounding fat.[20] Pseudocapsule and calcification have been described and there is usually no hyperaemia.

Tenosynovitis

Hands are the most common site of suspected foreign body following penetrating injury. Due to the relatively thin subcutaneous tissue, injury not uncommonly involves the tendons of the fingers and occasionally toes and if there is superimposed infection, tenosynovitis occurs. US is both sensitive and specific in detecting tenosynovitis (Figure 11) and shows thickening of the tendon sheath with effusion, peritendinous oedema, and hyperaemia.

CONCLUSION

US is a valuable tool to assess patients with a suspected foreign body in soft tissue following penetrating injury. US can detect, localise, and guide removal of foreign bodies, and also diagnose a spectrum of injury-related complications. Familiarisation with these conditions may help in diagnosis and guide further management.

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