Journal of Ultrasound (2012) 15, 50—55

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Sonographic assessment of orthopedic hardware impingement on soft tissues of the limbs

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KEYWORDS
Sonography;
Soft tissues;
Orthopedic hardware.

Abstract Ultrasonography allows high-resolution imaging with real-time correlation to patients' pain, and it is an indispensable tool for assessing disorders associated with soft tissue impingement by orthopedic hardware. The sonographic examination in these cases begins with static studies, and images are then obtained during active and passive joint mobilization designed to reproduce the conflict with the orthopedic hardware. Ultrasonography is particularly useful for documenting hardware-induced injury to tendons and synovial bursae, but also those of muscles and vascular structures. The frequency of hardware-soft tissue conflict varies with the site and type of surgical procedure, but in all cases ultrasonography plays an essential role in identifying this type of conflict and assessing the soft tissue lesions it causes.

Sommario L'ecografia, per la possibilità di correlare in tempo reale il dolore del paziente con le strutture visualizzate, unitamente a un'eccellente risoluzione spaziale, si è imposta nella valutazione delle sindromi dolorose causate dal conflitto tra il materiale ortopedico e i tessuti molli limitrofi.
La tecnica di esecuzione dell'esame si basa su una prima fase statica e su un secondo tempo, mirato alla mobilizzazione attiva e passiva delle strutture, in modo di cercare di riprodurre il conflitto con il materiale ortopedico.
L'ecografia è particolarmente efficace nell'evidenziare le lesioni dei tendini e delle borse sinoviali da conflitto con materiale ortopedico, ma anche quelle di muscoli e vasi.
La frequenza dei conflitti materiale ortopedico/tessuti molli adiacenti varia a seconda della sede e del tipo di intervento operatorio, in tutti i casi l'ecografia gioca un ruolo essenziale nell'identificazione del conflitto e nella valutazione delle alterazioni patologiche secondarie dei tessuti molli.

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1971-3495/$ - see front matter
doi:10.1016/j.jus.2012.01.001

Introduction

Orthopedic hardware (OH) used for osteosynthesis or in prostheses differs widely in terms of host tolerability. In patients with fractures, the persistence of symptoms after satisfactory consolidation has been achieved may be an indication for OH ablation [1,2]. Conflict between the OH and adjacent soft tissues is difficult to visualize on standard radiography owing to the presence of overlying bones [3,4], the static nature of the images, insufficient contrast for the soft tissues, and the absence of real-time correlation between the patient's pain and the structures being observed. The use of ultrasonography (US) eliminates all of these problems and offers excellent spatial resolution as well, so it is easy to see why this imaging modality has come to be regarded as an indispensable tool for assessing pain caused by OH-soft tissue conflicts.

Examination technique and US appearance of OH

The sonographic assessment begins with a detailed patient history that includes information on the temporal characteristics of the symptoms with respect to the surgical procedure, factors associated with the onset of pain, and the precise location of the pain. The initial phase of the examination includes longitudinal and axial scans aimed at visualizing the entire orthopedic device. If the patient reports focal pain, pressure can be exerted on different structures under real-time ultrasound monitoring to reproduce the symptoms described. The fact that the elicited pain can be correlated with the images being visualized is a fundamental advantage of the sonographic approach. Later in the examination, dynamic imaging can be used during active and passive mobilization of the structures designed to reproduce the OH impingement.

The OH is typically hyperechoic with a characteristic posterior reverberation artifact. In vivo and in vitro studies of the tips of surgical screws show that this artifact increases with the angle of incidence of the US beam (Fig. 1). When doubts arrive, visualization of the tip of the screw can improved by inclining the transducer so that the angle between the US beam and the screw is as close as possible to 90°.

Lesions of the tendons and synovial bursa secondary to conflict with OH

Inside their osseofibrous tunnels, the tendons (particularly those of the wrist and ankle) are in close contact with the bone plane. For this reason, they are highly vulnerable to trauma during surgical procedures and thereafter, as a result of OH impingement during muscle contraction [4—6]. A tendon that has been damaged by chronic conflict of this type displays local hyperemia on color Doppler imaging and in some cases there is also evidence of tenosynovitis. The latter is manifested by the presence of synovial effusion or hypertrophy of the tendon sheath (Fig. 2). Persistent impingement can result in partial tearing of the tendon, which is reflected by longitudinal fissuring or thinning of the tendon. The final stage consists of complete rupture of the tendon, which may be associated with retraction (sometimes quite marked) of the proximal stump [7]. The main objective of the sonographic examination is to make sure that the tendon is not entrapped beneath the plate or within the fracture itself [8], although this complication can usually be avoided by

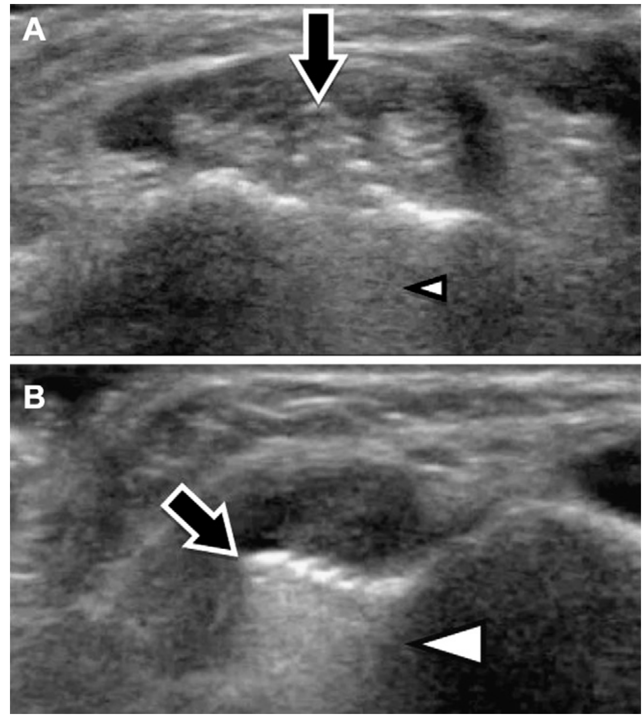

Figure 1 A. The tip of a screw (arrow) can be seen protruding into the extensor compartment of the wrist. Note the moderately evident posterior reverberation artifact (arrowhead). B. The artifact becomes more obvious when the transducer is inclined.

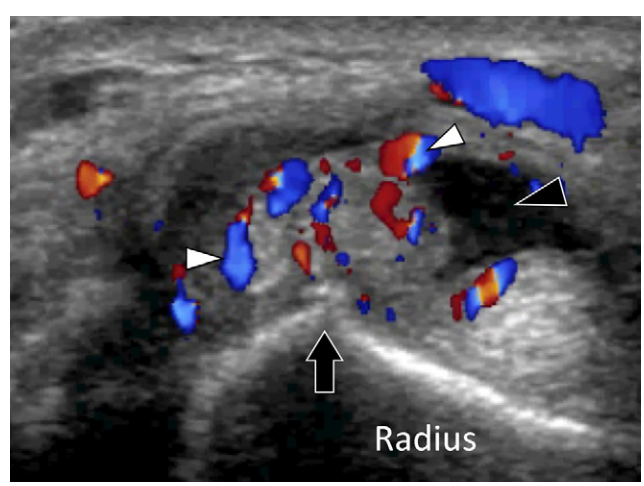

Figure 2 The protruding tip of this screw is the cause of tenosynovitis of the extensor carpi radialis tendons (black arrowhead). Note hypervascularization of the tendons (white arrowhead).

clinical examination during the course of surgery. Conflict between the OH and soft tissues can lead to bursitis (when there is a preexisting synovial bursa); when there is not, the conflict can cause "neobursitis", which is visualized as a local collection of fluid.

In the shoulder, anomalous protrusion of an anterograde intramedullary screw can lead to subacromial conflict [9]. This is generally explored during dynamic maneuvers of abduction/antepulsion, which tend to reproduce the conflict between OH and acromion.

At the level of the wrist, Kirschner wires used to repair fractures involving the distal radius can impinge upon the extensor pollicis longus or extensor indicis tendon [5,10]. In a series of 350 patients treated with this technique, Nonnemacher and Kempf reported two cases of complete tears and five cases of tendinopathy [4]. When volar plates are used, the tips of the screws may penetrate the dorsal cortex of the radius and cause damage to the extensor tendons of the first four compartments [7,11—14] (Figs. 1 and 2). In addition, if the distal portion of the plate is not correctly positioned, the edge can cause damage to the flexor pollicis longus [15—17], flexor carpi radialis, and the flexor digitorum superficialis or profundus tendons [17].

As for the fingers, there is a lack of consensus among orthopedic surgeons as to the type of fixation device that is least likely to injure the surrounding soft tissues [18,19]. In a series of 105 patients with phalangeal or metacarpal fractures that were treated with plates, reoperation was necessary in five cases due to anomalous protrusion of the plate ($n = 3$) or tendon tears ($n = 2$) [20].

At the level of the hip, the proximity to the trochanter major of the ileotibial tract favors its contact with the screws placed in the neck of the femur or cerclage. Plates in the ankle can impinge on tendons, and for this reason some surgeons prefer simple fixation with malleolar screws whenever possible. Lesions to the peroneal tendons are common because they are in close contact with the cortex of the lateral malleolus [21,22]. Less common lesions are those caused by screw impingement on the flexor hallucis longus tendon after repair of calcaneal fractures (Fig. 3) or by irritation of the anterior tibial tendon by the locking screws of an intramedullary tibial nail [23].

Tendon and bursal lesions caused by prostheses

Orthopedic surgeons are well aware of the risk of conflict between periarticular tendons and components of a joint prosthesis. In the knee, for example, care is taken to avoid using an excessively large prosthesis that could impinge upon periarticular tendons, the pes anserinus tendons in particular. At the level of the hip, pain after flexion of more than 90° that develops a few months after arthroplasty should raise the suspicion of conflict between the acetabular component of the prosthesis (which is usually too large in these cases) and the deep aspects of the ileopsoas muscle and tendon [24,25]. Ultrasound can confirm the existence of local impingement, and dynamic studies performed with the hip flexed will reveal the exact site of the conflict and its relation to the improper position of the acetabular component (Fig. 4a e b). There is a lack of consensus on the sonographic findings associated with this type of impingement. Fluid within the synovial bursa of the ileopsoas muscle was reported in 50% of all cases in two series investigated with computed tomography [24,26]. In our experience this can also be observed on ultrasound [27], but it seems to be less frequent, perhaps because the most distal portion of the bursa is located too deep to be readily visualized with this method. The intrabursal synovial effusion is not a specific finding: it can also be seen in the presence of an infected prosthesis [28] or loosening [29]. One of the main advantages of ultrasonography in patients with this type of impingement is that it facilitates real-time guidance of local injections of steroid-local anesthetic mixtures for therapeutic or diagnostic purposes [25]. This is easy to perform if one uses a lateral access; strict asepsis must be maintained. The fixation screws of an acetabular cup or fragments of cement can impinge on the belly of the ileopsoas muscle at a point more proximal than

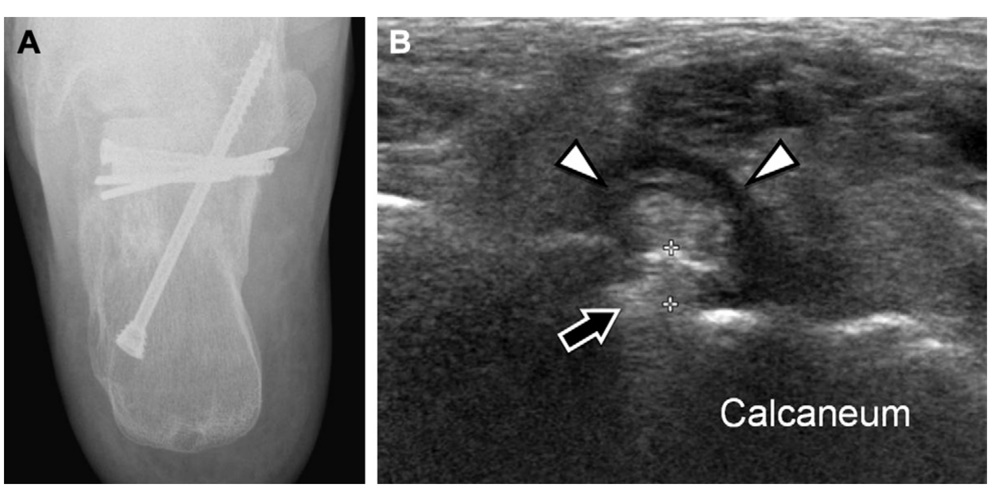

Figure 3 A. Protrusion of a screw tip from the anterior aspect of the calcaneus. B. Ultrasound confirms the existence of screw impingement on the flexor hallucis longus tendon, which presents obvious structural damage.

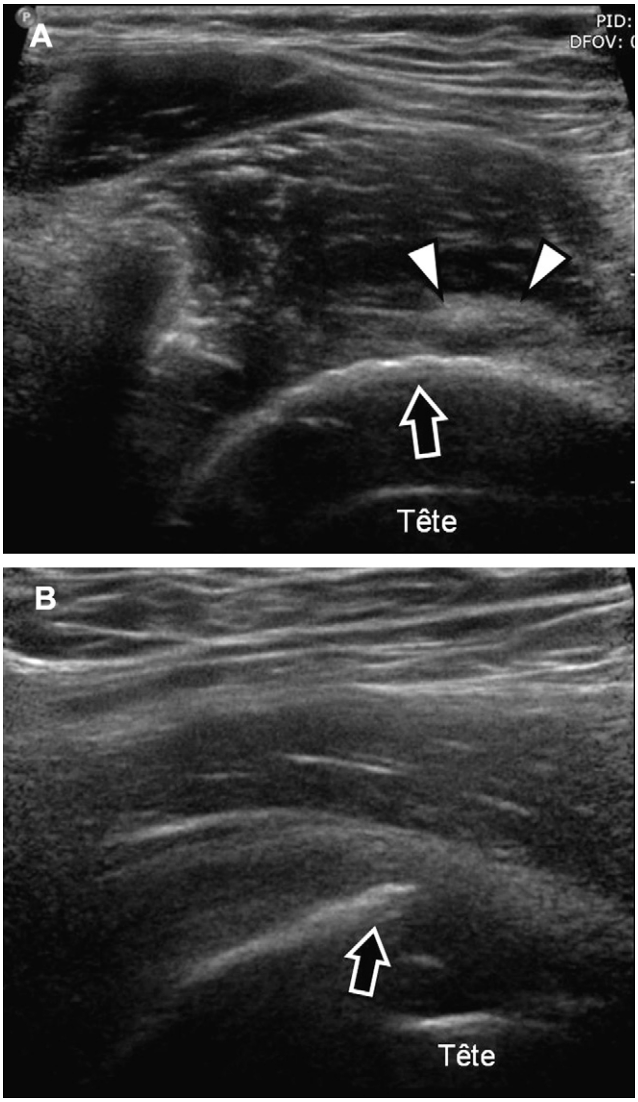

Figure 4 Identification of conflict between the dome of a hip prosthesis (arrows) and the psoas tendon (arrowheads) in transverse and sagittal planes.

that described above, and both situations can be documented with US.

Muscle lesions

The muscles, which are in close contact with the bone plane, are subject to impingement by screws protruding from fixation plates. Most of these screws are well tolerated, and very few have to be removed by the orthopedic surgeon. Ultrasound plays a major role in the assessment of this type of impingement. Simple pressure exerted over the tip of the screw (visualized sonographically) elicits complaints of pain, confirming that the screw is the cause of the patient's symptoms. Positive findings on US thus indicate that surgical removal of the impinging screw will successfully eliminate the pain. If compression does not provoke pain, the US findings must be interpreted with caution, and other causes should be sought for the pain reported by the patient (Fig. 5).

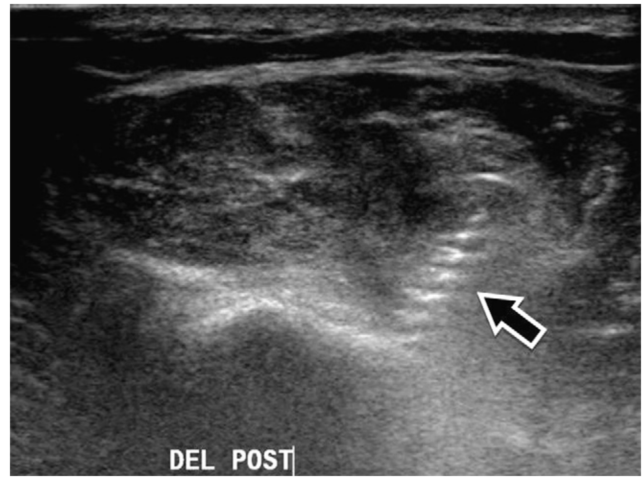

Figure 5 Protrusion of a screw tip into the posterior deltoid muscle (arrow). Pain was elicited pressure was exerted over the area with the transducer.

Vascular lesions

Because of their size and their contiguity with the bone plane, vessels and nerves at the root of the limbs can enter into conflict with OH.

Examples in the upper limb include impingement by screws used for fixation plates [30], locking screws of intramedullary nails [31], and percutaneously placed Kirschner wires [32] in the proximal humerus. The arterial damage is often acute and causes bleeding during surgery, but these lesions can also develop some time after the operation. A case of this type reported in the literature [33] involved a patient with a pseudoaneurysm of the subclavian artery complicated by arterial claudication, which developed following fixation of a clavicular fracture. Certain hip prostheses are subject to intrapelvic migration of the dome causing compression of the external iliac arteriovenous axis or of the crural nerve [34,35].

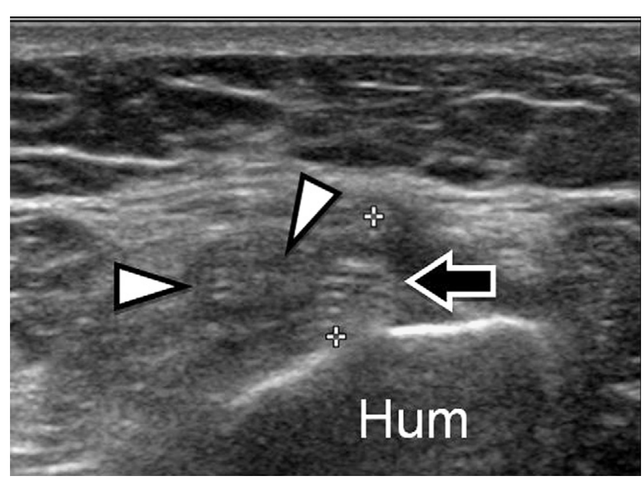

Figure 6 The radial nerve (arrowhead) appears thickened with a heterogeneous echostructure as a result of local impingement by the tip of a screw protruding from the humerus (arrow).

Like tendons, the nerves of the limbs can also be damaged during or after surgery. Examples include lesions of the superficial fibular nerve caused by the locking screws of a tibial nail [36], lesions of the radial nerve caused by contact with a humeral screw (Fig. 6), and calcaneal screw impingement on the tibial nerve.

Conclusions

The risk of conflict between OH and adjacent soft tissue varies with the site and nature of the surgical procedure. Sonography can be used for dynamic studies of the limbs and it is not limited by metal artifacts. These features make it an essential tool for identifying soft tissue/OH conflict and assessing the soft-tissue lesions it causes.

Conflict of interest

The authors have no conflicts of interest to declare.

Appendix. Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jus.2012.01.001.

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