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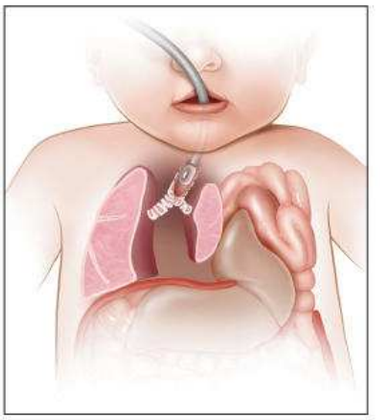

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Role of Sonography and Magnetic Resonance Imaging in Detecting Deltoideal Acromial Enthesopathy

An Early Finding in the Diagnosis of Spondyloarthritis and an Under-Recognized Cause of Posterior Shoulder Pain

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Article includes CME test

The acromial origin of the deltoid is a target structure of ankylosing spondylitis and related spondyloarthritis, which are often overlooked and underdiagnosed as causes of posterior shoulder pain. The objective of this article is to review the roles of sonography and magnetic resonance imaging in detecting deltoideal acromial enthesopathy and their importance for optimizing management in individuals with posterior shoulder pain. Adequate awareness of such enthesopathy as a potential manifestation of inflammatory rheumatic disorders is critical for early diagnosis of spondyloarthritis.

Key Words—ankylosing spondylitis; deltoid; enthesopathy; magnetic resonance imaging; musculoskeletal ultrasound; sonography; spondyloarthritis

Entheses are sites where tendons, ligaments, joint capsules, or fascia attach to bone.[1] The stress concentration at the bone–soft tissue interface makes entheses vulnerable to mechanical injuries that are well documented in a number of sports. However, the importance of entheses extends beyond this aspect, as they are also the primary targets of ankylosing spondylitis and related spondyloarthritis.[2]

Spondyloarthritis is one of the most frequent varieties of inflammatory rheumatic disorders, has a strong association with HLA-B27, and classically presents as inflammatory back pain. Other manifestations include enthesopathy, peripheral arthritis, psoriasis, acute anterior uveitis, and inflammatory bowel disease.[3] Entheseal involvement of lower limbs in spondyloarthritis has been extensively studied, especially at the Achilles tendon and plantar fascia, whereas upper limb enthesopathy often remains overlooked and underdiagnosed. The objective of this article is to review the roles of sonography and magnetic resonance imaging (MRI) in detecting deltoideal acromial enthesopathy and their importance for optimizing management in individuals with posterior shoulder pain.

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Abbreviations
MRI, magnetic resonance imaging

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Definition, Classification, and Function of Entheses

Entheses can be categorized into fibrous or fibrocartilaginous, according to the type of tissue present at the attachment place.[4] A fibrous enthesis is composed of mainly dense fibrous connective tissue and can be further classified into periosteal and bony, depending on the site of attachment. On the other hand, a fibrocartilaginous enthesis, as the name implies, shows additional zones of calcified and uncalcified fibrocartilage between connective tissue and bone.[5] Irrespective of the type, the function of entheses is to anchor soft tissues to bone, dissipate mechanical stress, and promote bone growth.[6]

Pathogenesis of Enthesopathy

Enthesopathy is characterized by an early phase involving edema, infiltration, and destructive fibrocartilage microlesions; the subsequent vascular proliferation in the fibrocartilage and subchondral bone determines bone erosions, reactive sclerosis, and reactivation of endochondral ossification, leading to enthesophytes.[7]

Anatomy of Deltoideal Entheses

The deltoid muscle originates from the clavicle, acromion, and spine of the scapula. From this extensive origin, the fibers converge toward their insertion on the deltoid tuberosity of the humerus to provide abduction, flexion, and extension of the shoulder. The deltoid origin at the superior and lateral margins of the acromion is prominently tendinous, whereas the origin at the lateral third of the clavicle is composed by muscle attached directly to the periosteum.[8] The acromial origin is, therefore, a fibrocartilaginous enthesis, whereas the clavicular origin is a fibrous one.[9] The insertion of the deltoid on the humerus is also a fibrous enthesis. Interestingly, not all entheses are equally targeted in spondyloarthritis: fibrocartilaginous entheses are typically affected, whereas fibrous entheses are characteristically spared. One of the theories accounting for this differential effect is that inflammatory enthesopathy in spondyloarthritis may reflect immunity to fibrocartilage.[10]

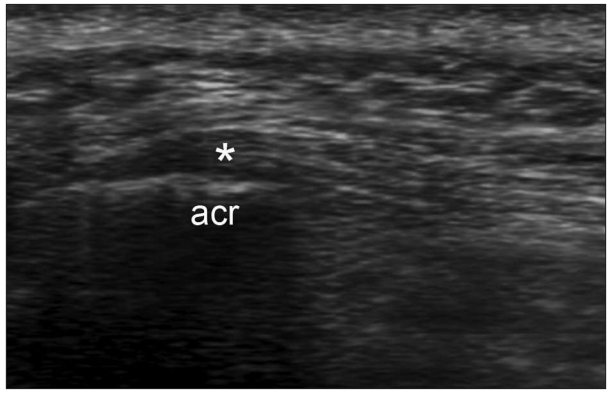
Spectrum of Sonographic Findings

On sonography, the normal enthesis shows a typical fibrillar pattern and appears hyperechoic when imaged at a perpendicular angle (Figure 1).[11] Enthesopathy is depicted as a thickened and hypoechoic enthesis (Figure 2A). Normal entheses are also avascular, and neovascularization indicates active disease (Figure 2B). Adequate equipment settings are essential to maximize low-flow detection, and the color box must be sized to the area of interest to reduce background noise and optimize system resources. A careful scanning technique is also necessary because excessive compression with the probe can attenuate or even eliminate the flow signal.[12] Bone erosion and enthesophytes may be observed in long-standing disease. It is important for the referring physician to specifically request assessment of deltoid entheses when ordering sonography for posterior shoulder pain because such an evaluation is usually not included in routine shoulder protocols.

Spectrum of MRI Findings

Sagittal images are the most helpful in detecting deltoid acromial enthesopathy. Analogous to vertebral corner inflammatory lesions, bone marrow edema secondary to deltoideal acromial enthesopathy may be defined into 2 categories. The first category (type A) is characterized by low signal intensity on T1-weighted and high signal intensity on T2-weighted fat-suppressed images, consistent with edematous hyperemic inflammatory tissue; in the second category (type B), the signal abnormality follows fat on all pulse sequences.[13] In active enthesopathy, MRI typically depicts type A bone marrow edema and perientheseal hyperemic inflammatory soft tissue changes (Figure 3). Chronic inactive disease lacks both bone marrow edema and adjacent inflammatory abnormalities and may present as thickened and hypointense entheses on all pulse sequences (Figure 4); bone erosions and enthesophytes may also be observed.

Figure 1. Long-axis 12–5-MHz sonogram obtained from a healthy volunteer shows the normal fibrillar pattern of the acromial origin of the deltoid muscle (asterisk); acr indicates acromion.



Discussion

Enthesopathy has traditionally been evaluated with debatable accuracy by clinical examination based on the presence of tenderness, swelling, or both at attachment sites.[14] The diagnosis may be challenging in obese individuals because deep-seated entheses are difficult to assess. The situation is further complicated by fluctuation of symptoms and a number of conditions that may cause palpable tenderness and simulate enthesopathy. Even so, there is a growing interest in early diagnosis, especially because effective treatment options are currently available for spondyloarthritis.

Conventional radiography and computed tomography show only the more chronic bony changes and are not suited to early diagnosis. In contrast, both sonography and MRI may depict early signs of enthesopathy.[15–20] There is currently no reference standard for detecting enthesopathy, but sonography seems to be the imaging modality of choice because it is fast, sensitive,[21–23] specific,[23–25] reliable,[25–27] easy to combine with the clinical assessment, and widely available. Technology has markedly improved since the first description of sonographic evaluation of lower limb enthesopathy by Lehtinen et al[28] 2 decades ago. High-resolution 10-MHz linear array transducers are now the standard of care in most imaging centers and provide axial

Figure 2. Deltoideal acromial enthesopathy. **A**, Long-axis 12–5-MHz sonogram shows thickened and hypoechoic enthesis (asterisk); acr indicates acromion. **B**, Corresponding Doppler sonogram shows neovascularization at the acromial origin of the deltoid muscle.

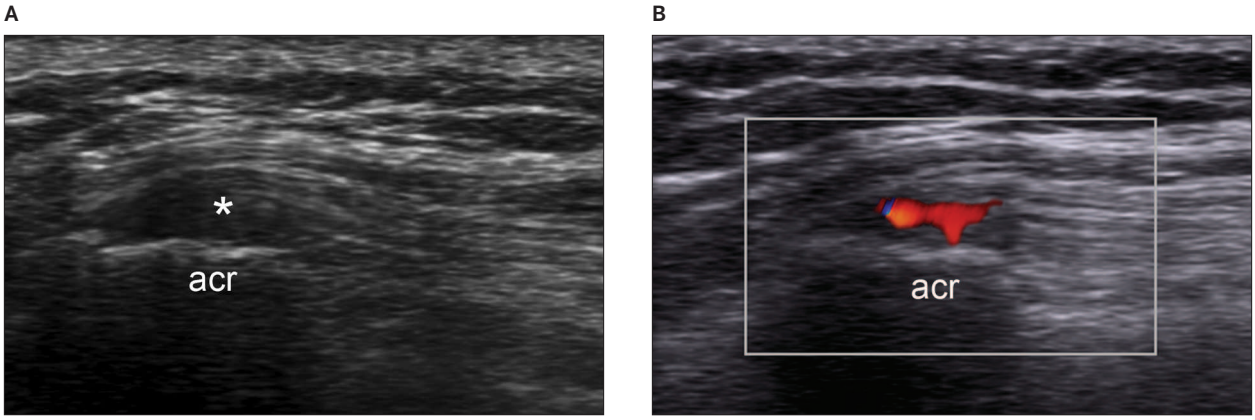


Figure 3. Deltoideal acromial enthesopathy. Sagittal short-tau inversion recovery MRI shows type A bone marrow edema (arrowhead) and a hyperintense signal abnormality in the perientheseal soft tissue (arrow), both secondary to hyperemic inflammatory changes.

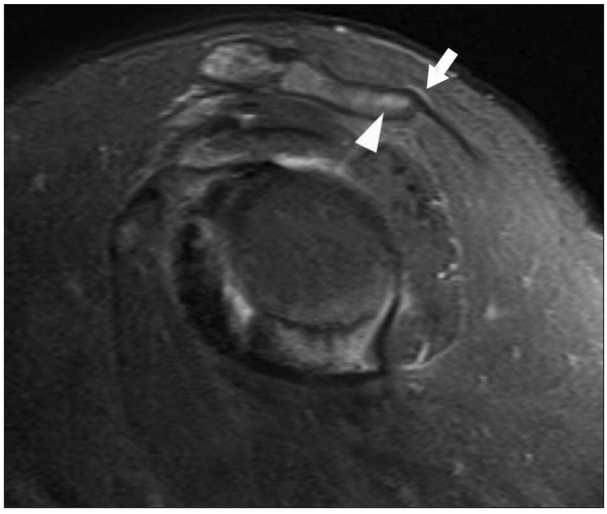
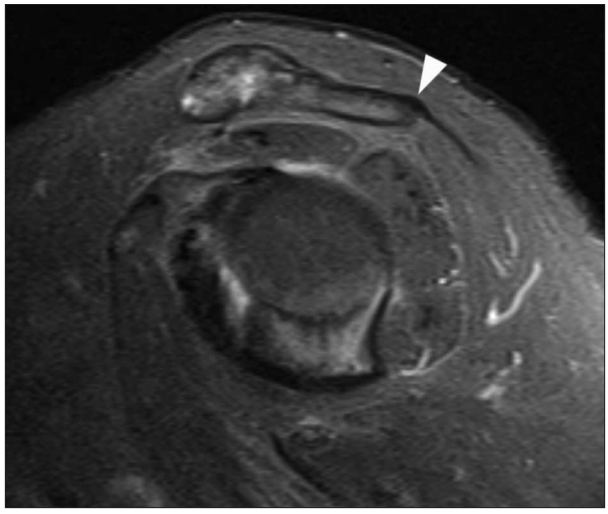


Figure 4. Deltoideal acromial enthesopathy. Sagittal short-tau inversion recovery MRI shows a thickened and hypointense enthesis (arrowhead). Note the absence of hyperemic inflammatory changes.



resolution of approximately 150 μm,[29] which is 3 times better than the 469 μm currently achievable with clinical 1.5-T MRI scanners.[30] Sonography is more sensitive than clinical examination, and subclinical enthesopathy is not unusual. Sonography is also less expensive and more sensitive than MRI for early detection of enthesopathy.[19] Also, compared to MRI, sonography is more comfortable and does not require sedation of young children. However, because of the inability of sonography to penetrate bone, only MRI can fully evaluate bone marrow edema.

Anecdotal experience suggests that grayscale sonographic findings should be viewed as permanent structural damage, which does not completely disappear over time. Adult entheses have a limited capacity to undergo regeneration and heal through a reparative process, which frequently results in suboptimal reconstruction and functional deficits. Despite limited evidence of healing, clinical and anatomic deterioration is not universal, and lesions may remain stable for years. The primary objective of the treatment is not to restore normal grayscale sonographic anatomy but to halt or slow the progression of the disease and offer symptomatic relief.

Grayscale sonographic findings may be useful for assessing long-term disease progression but are less suitable for assessing short-term responses to treatment, and there is growing interest in enthesis vascularization to fill this gap. However, since the first description on the utility of power Doppler sonography for detecting neovascularization of the enthesis in 2003,[23] there has been much confusion regarding the clinical relevance of this finding. The common misconception is that increased blood flow reflects an inflammatory disorder, when, in fact, it represents an inflammatory response that can be found in both inflammatory and degenerative disorders.[31–35] Therefore, Doppler interrogation is not helpful for differentiating deltoideal acromial enthesopathy caused by spondyloarthritis from that caused by mechanical stress. In chronic degenerative conditions, such as mechanical enthesopathy, increased blood flow reflects an active reparative process.[2] Despite the fact that Doppler sonography has not yet been systematically addressed for deltoideal acromial enthesopathy secondary to spondyloarthritis, it is reasonable to assume a pattern similar to synovitis: namely, a decrease in vascularization and a reduction in the resistive index following successful treatment.[36]

Magnetic resonance imaging has also been proven a useful modality for assessing enthesopathy, and it has been proposed that early inflammatory type A bone marrow edema may resolve completely if therapy is introduced before bone formation pathways become activated.[37] However, once bone marrow edema has evolved to the more advanced B type, introduction of therapy may alleviate inflammation but at the same time promote enthesophyte formation through downregulation of Dickkopf-1, a major inhibitor of bone formation by inhibiting signaling through Wingless proteins.[37,38]

In conclusion, both sonography and MRI represent substantial advancements for the diagnosis of deltoideal acromial enthesopathy. Adequate awareness of such enthesopathy as a potential manifestation of spondyloarthritis is critical for optimizing clinical and serologic investigations to prevent long-term morbidity.

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