Ultrasound imaging in psoriatic arthritis and ankylosing spondylitis

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ABSTRACT

Musculoskeletal ultrasound (US) is a reliable imaging technique which has a key role in the assessment of patients with psoriatic arthritis (PsA) and ankylosing spondylitis (AS). US can help in the diagnosis of the disorder, in the evaluation of the extent of the joint and enthesis involvement and in therapy monitoring because it can reflect both morphostructural changes and inflammatory activity.

Several studies have reported that US revealed pathological findings at joints and enthesis in a large number of PsA patients who do not complain of active pain and/or swelling at the time of the clinical examination and in psoriasis patients with no signs of musculoskeletal disease. The application of US in the evaluation of nail and skin involvement in patients affected by psoriasis, with or without arthritis, and the imaging of sacroiliac joints is an interesting approach. US has already become commonplace in both clinical and research fields, and improvements in US technology will offer further possibilities for future research.

Introduction

It is well known that musculoskeletal ultrasound (US) is a reliable imaging technique that plays a key role in the early detection and careful characterisation of the inflammatory process in arthritides.

The use of US in psoriatic arthritis (PsA) and in ankylosing spondylitis (AS), two disorders belonging to the group of spondyloarthritis (SpA), has became commonplace in both clinical and research fields.

US is being used in PsA and AS patients to image enthesis, joint and tendon involvement but also in patients who only have skin psoriasis to identify enthesis and joint pre-clinical changes (1, 2). US can help in the diagnosis of the disorder, in the evaluation of the extent of the joint and enthesis involvement and in therapy monitoring because it can reflect both morphostructural changes and inflammatory activity.

The following review provides an update of the data available on US imaging in PsA and AS.

Ultrasound of the enthesis

Definitions and localisation

Because of the great importance of the enthesitis involvement in SpA (3), which is considered the typical feature-of this group of disorders, the fact that the features of enthesopathy are similar regardless of the diagnosis and, finally, the fact that the patients involved in the studies on US assessment of the entheses are, most of the time, grouped together as "SpA group", instead of single PsA or AS groups, we will discuss this point at the beginning of the review, before entering into the specific diseases part of the paper.

Since 1994, when the first description was made by Lehtinen *et al*. (4), an increasing interest in using US technique in the evaluation of SpA enthesitis has been observed. However, US imaging might present some limits, mostly related with the poor number of vessels in the enthesis and with a risk of Doppler artifacts due to the proximity of the cortical bone.

In any case, the most important point to keep in mind is the different meaning of enthesopathy and enthesitis. The OMERACT Ultrasound group proposed an ultrasound definition of enthesopathy as "an abnormal hypoechoic region with loss of normal fibrillar architecture and/or thickened tendon or ligament at its bony attachment, seen in 2 perpendicular planes that may exhibit Doppler signal and/or bony changes including enthesophytes, erosions or irregularity". In this definition, signs of acute and chronic inflammation are

combined with findings of structural damage (5). The involvement of the enthesis in any pathologic process, whether metabolic, inflammatory, traumatic or degenerative, is referred to as "enthesopathy", while "enthesitis" is restricted to the presence of inflammation of tendons, ligaments and capsules insertions into the bone, and it appears to be a cardinal feature of SpA (6).

An increasing number of studies have applied US to the evaluation of entheses in SpA patients but no clear agreement exists on the definition of enthesitis, and on the choice and number of entheses to examine (7). In order to better clarify the definition of enthesitis, recently, the OMERACT published a new paper providing definition of normal entheses as well as the definition of the elementary lesions (8).

Inflammation may occur at any enthesis. Considering that entheses are subjected to repeated mechanical loading, it is reasonable that mechanical factors, together with physiological and anatomical characteristics of the enthesis, might influence the pattern of localisation of enthesitis. Indeed, the more clinically relevant sites of enthesitis are those localised in the lower limbs; in particular, heel enthesis is the most frequently involved (as plantar fasciitis or Achilles enthesitis) (6, 9).

Enthesopathy in non-arthritic patients

The presence of enthesopathy has been demonstrated in patients with psoriasis without any clinical musculoskeletal involvement. In fact, Gisondi *et al*. evaluated 30 patients with psoriasis and 30 controls by US examination of Achilles, quadriceps, patellar entheses and plantar aponeurosis, and reported that the mean Glasgow Enthesitis Scoring System score (GUESS), the thickness of all tendons and the number of enthesophytes in all sites examined were significantly higher in the psoriasis group. In both cases and in the controls, the GUESS score was directly correlated with age, Body Mass Index (BMI) and waist circumference, while it was not correlated with the duration and severity of psoriasis according to the Psoriasis Area Severity Index (PASI) and body surface area involvement (2). According to the authors, these findings could be related to a subclinical entheseal psoriatic inflammation. The heavy burden of findings related to enthesopathy in "pure" psoriasis patients was confirmed also by Gutierrez *et al*. who studied 45 patients with psoriasis and 45 healthy controls (10). Naredo *et al*. studied 162 patients with plaque psoriasis (without musculoskeletal diseases) and 60 controls, examining joints, tendons and enthesis. US synovitis and enthesopathy were significantly more frequent in psoriatic patients than in controls (1). These findings suggest that a careful follow-up of patients with psoriasis with entheseal abnormalities for early diagnosis of PsA is needed. This should be remembered also because Farouk *et al*. found a non-statistically significant difference between psoriasis and PsA patients when comparing US entheseal abnormalities of both calcaneal insertions of Achilles tendons (11).

Differential diagnosis in enthesopathy

During enthesitis, new vessels and inflammatory cells penetrate the cortical subentheseal bone from bone marrow to entheseal tissues, leading to: thinning of cortical bone, focal loss of bone (erosions) and direct contact between fibrocartilage and underlying bone spaces. The reparative process with reactive bone formation leads to ill-defined osteosclerosis and spur formation (12).

Discordant data are reported on the capacity of grey-scale US to differentiate mechanical or metabolic enthesopathy from inflammatory enthesopathy (12), and enthesitis could be present in athletes as a consequence of traumatic injuries even if, in this case, it is not associated with intrarticular inflammation (*i.e*. synovitis) (9). What is actually well accepted is that abnormal vascularisation, detected by power Doppler ultrasound (PDUS), at the insertion of tendons, ligaments, fascia and capsules into the bone is seen as a primary lesion that may underlie all SpA skeletal manifestations and is considered to be seen exlusively in SpA patients (13).

Enthesophytosis cannot be considered a specific sign of SpA-related enthesitis, as it is also reported with high prevalence in mechanical and osteoarthritis-related enthesopathy and in normal asymptomatic subjects. Multiple and irregular enthesophytes and calcific deposits are possibly more specific for SpA-related enthesitis, but the use of enthesophytosis alone as sign of arthritis-related enthesitis is an incorrect assumption (12).

Enthesitis scoring system

Several quantitative scoring systems have been developed to quantify US abnormalities of the entheses, but four of them are considered the most important. The first and still most commonly accepted US scoring system on enthesitis, is the GUESS (14). It assesses five entheseal sites in the lower limb (given the higher prevalence of entheseal involvement in those areas with respect to the rest of the body) only using grey-scale (GS) US.

The D'Agostino scoring system combined GS and Doppler; severity is weighted according to the severity of the Doppler signal and the presence of structural damage (12).

The Spanish Enthesitis Index (SEI), developed at the patient level (*i.e*. giving information about different enthesis sites and allowing the evaluation of global patient inflammatory activity or entheses structural damage) uses GS abnormalities only. This scoring system, however, does not differentiate between involvement of enthesis, body of tendon and bursa (15).

The Madrid Sonographic Enthesitis Index (MASEI), combines abnormalities detected by GS US and PDUS (also including the involvement of the bursa) and evaluates not only the lower limbs, but also an enthesis site in the upper extremity (the attachment of the triceps tendon to the olecranon). Finally, it scores bone erosions, power Doppler signal and also enthesophytes (16).

All of those different scoring systems combine inflammatory signs (in GS alone or with PD) and structural signs (erosions, enthesophytes, etc.), allowing a possibly good combination for diagnostic purposes, but it may not be sensitive enough for follow-up purposes. However, all of them are not comparable, in fact the GUESS and D'Agostino

scoring systems were developed for grading enthesis involvement (*i.e.* enthesitis level). The MASEI and SEI were developed as enthesitis indices at patient level. For this reason, these scoring systems can not be compared. Currently, there is still a need to reach a consensus on the best system to use (13).

Enthesopathy in SpA

US is better than clinical examination for the detection of enthesitis. This has been demonstrated by Balint *et al*. in 2002. Studying 35 patients with SpA (mainly AS), they showed that US was better than clinical examination in the detection of SpA entheseal involvement of the lower limbs and that most entheseal abnormalities are not detected at clinical examination (17). This was confirmed by Scarpa *et al*. (18), who studied 47 patients with early PsA. Clinical evaluation, bone scintigraphy, and US assessment were performed in all patients and US was able to visualise signs of enthesitis in a significantly higher number of patients. It was also able to detect all of the areas of increased radionuclide uptake on scintigraphy.

More recently, in a study of thirty-six AS patients by Spadaro *et al*., clinical and PDUS examination of 432 enthesis revealed at least one abnormal enthesis in 23 (63.9%) and 35 (97.2%) patients, respectively. Moreover, of 432 entheses examined in AS patients, 64 (14.8%) were considered abnormal by clinical examination and 192 (44.4%) by PDUS (19, 20).

There are multiple studies that added the bursa to the elementary entheseal lesions considered in the OMERACT enthesopathy definition (21, 22). In fact, according to the 'enthesis organ concept', the bursa should be considered part of the synovio-entheseal complex (23). This highlights the fact that stress concentration at an insertion site involves not only the enthesis itself, but neighbouring tissues as well. Collectively, the fibrocartilages, bursa, fat pad and the enthesis itself constitute the enthesis organ.

A higher prevalence of bursa abnormalities in SpA patients than in rheumatoid arthritis (RA) patients and controls (in 6.6% of cases associated with Doppler signal) was demonstrated by Falcao *et al*. in a US study of Achilles enthesis (21).

Frediani *et al*. (24) evaluated the knees of 40 PsA patients and 40 RA patients and reported quadricipital enthesitis in 45% of patients with PsA, while Delle Sedie *et al*. in a study of 83 PsA patients, showed a prevalence of knee enthesitis of 39.7% (25).

Very recently, US shoulder assessment of 38 AS patients and 38 healthy controls showed that enthesitis was significantly more frequent in AS patients than in controls (56.6% *vs*. 10.5%) and that involvement of rotator cuff tendons was significantly higher in patients with AS, (42.1% *vs*. 15.2%). In both groups, the most frequent involved entheses were the supraspinatus followed by sub-scapularis and infraspinatus (26).

Entheseal involvement in the feet of 44 patients with SpA, of whom 19 subjects had AS, was examined by US and the results were compared with radiological and clinical findings. US revealed pathological findings in 25 out of 44 (56.8%) patients, most of whom exhibited no clinical signs of foot involvement (27).

In the international literature, many studies have been published on enteseal US involvement in AS (9, 27-34). They all demonstrated that US is a valuable tool with a relevant role in the assessment of peripheral entheseal involvement in AS and allows the detection of enthesis abnormalities better than clinical evaluation.

Entheseal involvement: responsiveness to therapy

US monitoring of enthesitis showed significant sensitivity to change after specific AS treatment. In particular, its ability to show responsiveness appeared superior when a Doppler evaluation was included in the examination. Therefore, Doppler evaluation is an important feature to take into account to evaluate responsiveness to treatment and it should be included in enthesis examination also for this purpose. Aydin *et al*. evaluated 43 AS patients with active disease, requiring TNF-α antagonist therapy. Grey-scale and PDUS imaging and physical examination were performed to detect Achilles enthesitis and/or retrocalcaneal bursitis before and after 2 months after the initiation of therapy. US detected subclinical Achilles enthesitis in a subset of AS patients and a significant improvement can be demonstrated after 2 months of TNF-α antagonist therapy (35).

US can guide clinicians in positioning the needle in inflamed joints, tendon sheaths and enthesis, to locally inject steroids or other drugs.

Huang *et al*. reported that AS patients with Achilles tendon enthesitis, treated with US-guided local injection in the enthesis of betamethasone or etanercept experienced clinical improvement associated with a decrease in the blood flow signal (36).

Ultrasound in PsA

PsA is an inflammatory arthropathy associated with psoriasis, classified within the seronegative SpA, that can show a great variability in clinical features and severity. Distal interphalangeal joint (DIP) predominant arthritis, arthritis mutilans, symmetrical polyarthritis indistinguable from rheumatoid arthritis (RA), asymmetrical oligoarticular arthritis or predominant spondylitis can be identified.

Several studies have reported that US revealed pathological findings in joints and enthesis in a large number of PsA patients who do not complain of active pain and/or swelling at the time of the clinical examination and in psoriasis patients with no signs of musculoskeletal disease (1, 2, 10, 25, 37-41). In 2000, Galluzzi *et al*. studied ankle involvement in 31 patients with PsA using US and discovered pathological findings at both entheseal and tendon level in a high proportion of subjects, most of whom exhibited no ankle pain or swelling (40).

Peripheral arthritis

By grey-scale US, effusion and synovial proliferation in peripheral joints can easily be imaged. Power Doppler sonography (PDUS) provides useful information about the vascularity of synovial tissue and the degree of inflammatory activity. The US prevalence of knee, hip, shoulder, hand and foot in-

volvement in PsA patients has been the subjects of various studies (25, 37-39, 42, 43) and a good diagnostic sensitivity of this imaging method in the detection of synovitis in the different joints has been reported. Delle Sedie *et al*. investigated knee joints in 83 PsA patient and disclosed at least one US finding indicative of inflammation in 84.3% of joints, while clinically involvement was present in 74.7% of the evaluated joints (25). US bilateral examination of the hip in 65 PsA patients detected effusion, with or without synovial proliferation, in 21% of the subjects. Joint effusion was also imaged in 8 hips which were negative for pain and/or tenderness (37). One hundred and eighty feet were investigated in 101 PsA patients and US findings indicative of metatarsophalangeal joint inflammation were obtained in 77 (76.2%) patients, while only 34 (33.7%) patients were positive to the clinical examination (38). The prevalence of US pathologic abnormalities in the shoulders was also investigated in 97 PsA patients. The gleno-humeral joint was rarely involved; in fact joint effusion was found in only 4 shoulders and was associated to synovial hypertrophy in 3 cases with no PD signal (39). Two comparison studies between US and other imaging techniques (MRI, x-ray and scintigraphy) and US and clinical examination in PsA patients have been published (42, 43). Wiel *et al*. using US, contrast-enhanced MRI, x-ray and clinical assessment, examined each joint of the 2nd–5th finger of both hands and the 1st–5th metatarsophalangeal joints of feet of 15 patients with PsA, 5 with RA and 5 healthy controls (42). Weiner *et al*. evaluated the hands and feet of 13 patients with PsA by US, MRI, bone scintigraphy and x-ray (43). Even if both the studies enrolled a small number of patients, US appeared more sensitive than radiography and clinical examination in the assessment of inflammatory changes, particularly synovitis. A recent study compared clinical examination and US findings in 49 patients affected by early PsA and showed that subclinical synovitis, identified by US, is very common in early PsA and led to the majority of oligoarthritis patients being reclassified as polyarthritis (44).

It is important to remember that, until now, it had not been possible to distinguish whether the synovitis was due to RA or PsA because the features are the same. However, in a comparison between 18 RA and 20 PsA patients, all of them with a clinical involvement of metacarpo-phalandeal joints (MCP), Gutierrez *et al*., investigating the presence of joint cavity widening, synovial fluid and/or synovial hypertrophy, peritenon extensor tendon inflammation (PTI) and intra-articular or peri-tendinous PD signal, showed different frequencies of involvement between the two diseases, and an apparent absence of PTI pattern in the RA group (45).

Dactylitis and tendon and bone abnormalities

US examination in both finger and toe dactylitis can detect flexor tenosynovitis, arthritis of interphalangeal and metacarpo-phalangeal joints and marked adjacent soft tissue swelling. However, conflicting data exist regarding the frequency of soft-tissue involvement and synovitis identified in dactilitis (46-48). Kane *et al*., in 25 dactylitic fingers and toes, reported subcutaneous soft-tissue enlargement in all affected digits with flexor tenosynovitis in 96% of cases and joint synovitis in about half of the digits (46). On the contrary, Olivieri *et al*., in 12 dactylitic fingers, found fluid collections surrounding the tendons according to flexor tenosynovitis but no involvement of the peritendinous soft tissues or the synovial joints (47).

Fourniè *et al*. comparing PDUS findings in 25 fingers with RA and 25 fingers with PsA showed that, while erosive synovitis and tenosynovitis could be imaged in both forms of arthritides, extra-synovial abnormalities, including enthesitis, enthesopathy of deep flexor tendon insertion on the distal phalanx, juxtaarticular periosteal reaction, and subcutaneous soft tissue thickening of the finger pad or entire finger, were imaged only in the PsA patients (48).

US examination has demonstrated marked involvement of some tendon synovial sheaths in PsA patients (*i.e*. posterior tibialis, flexor digitorum and peroneal), even in those who were asymptomatic (40). In the previously cited study on the prevalence of US pathologic abnormalities in the shoulders of 97 PsA, the most common abnormal finding regarding tendons, was represented by tendinosis (particularly of the supraspinatus, which was also the most frequently involved anatomical structure when considering tendon tear). Clinical examination frequently failed to detect abnormalities in patients in whom US examination showed pathological findings (39).

As previously stated, a hypoechoic swelling of the soft tissue surrounding the extensor digitorum tendon, with or without peri-tendinous PD signal, interpreted as PTI pattern, was detected by US examination in the MCP joints in a high percentage of PsA but in none of the RA patients. The authors concluded that the PTI pattern was highly characteristic of PsA, suggesting a potential role of US in the differential diagnosis between RA and PsA at MCP joints level (45). The same pattern had already been described by De Filippis *et al*. (49) in psoriatic patients without musculoskeletal involvement.

US is an imaging technique that can detect bone erosion, enthesophytes and new bone formation and helps in the evaluation of arthritis outcome over time in PsA patients (43, 50).

Axial disease

The sacroiliac joints (SIJ) are often involved in PsA, but US can only visualise the superficial part of the joint and the surrounding soft tissue structures, and, in particular, US cannot visualise the cartilaginous portion of the SI joints. The role of US in the assessment of sacroiliac and spine involvement in axial SpA is minimal (51). However, it has been reported that it may be able to diagnose active sacroiliitis based on increased vascularisation of the joints (52). More details about SIJ involvement imaged by US will be dealt with when analysing the role of US in AS.

Nail disease

Nail disease is common in psoriasis and can be a clinical predictor of PsA. The nail is intimately linked to the enthesis extensor tendon as reported by Tan and co-workers, and DIP joint disease

in PsA is associated with diffuse inflammation that envelops the nail root and the adjacent bone (53, 54). Aydin *et al*. using US and clinical assessment (with modified nail psoriasis severity index), investigated the nail and adjacent tendons in 86 subjects with psoriatic nail disease. They concluded that the demonstration of extensor tendon enthesopathy in both psoriasis and psoriatic arthritis supports the importance of enthesopathy in nail disease pathogenesis whether or not clinical arthritis is present (55). This hypothesis is also supported by Ash *et al*., who performed sonographic evaluation of 804 entheses of upper and lower limbs of 46 patients with psoriasis (31 with nail disease) and 21 healthy controls. Enthesopathy scores were higher in patients with nail disease than in patients without. The authors concluded that psoriasis patients with nail disease have more frequently underlying systemic subclinical enthesopathy than those with normal nails (56).

US examination could also be useful in the assessment of the nail itself. The normal nail plate appears as a trilaminar structure, characterised by two hyperechoic sharp margins with an interposed thin anechoic line. In the early stages of psoriatic nail disease, a minimal loss of the sharpness of the hyperechoic definition of the ventral plate (which may appear focally curved and/or thickened) might be seen. As the disease progresses, the US assessment shows the loss of the intermediate anechoic layer, which may be focal or complete; finally, the thickening and fusion of both plates (with loss of the intermediate anechoic layer) can be found. Also the nail bed (distance between the ventral plate and the bone margin of the distal phalanx) can be involved with a thickening (>2.5 mm). Finally, PD mode can show an increased blood flow within the nail bed, in the presence of a psoriatic nail disease, with respect to healthy subjects) (57, 58).

Skin disease

In the last few years, US machines equipped with very high frequency probes (18 MHz or more), which are mandatory to clearly distinguish epidermidis, dermis and subcutaneous fat, has allowed the visualisation of detailed findings of psoriatic placque including the dermal blood flow. PDUS examination of psoriatic placque in 12 patients showed a significant correlation between PDUS findings and both PASI and histological degree of vascularisation before and after etanercept treatment (59). Similar data were demonstrated by De Agustin *et al*. in 24 patients with significant improvement for clinical variables, *i.e*. visual analogue scale (VAS) tender and swollen joint counts (TJC and SJC) as well as for erythrocyte sedimentation rate (ESR), C-reactive (CRP), synovitis and PD signal and some dermatologic outcomes such as PASI and plaque thickness (60).

Combining the knowledge on different structures involved in PsA, a preliminary PDUS composite score for the assessment of blood flow changes induced by anti-TNF-α therapy in PsA patients at five target areas (joint, tendon, enthesis, skin and nail), has recently been proposed (61).

Ultrasound in AS

AS is a type of axial SpA, characterised by sacroiliitis with definite evidence on plain radiographs (meeting the modified New York criteria for AS), enthesitis and possible asymmetric peripheral arthritis, predominantly of the lower limbs.

The distinguishing features of AS are chronic inflammatory back pain and progressive restriction in spinal movements owing to the formation of bony bridges across the axial joints. Oligoarthritis and enthesitis may result in bone erosions or impairment of the structure and function of tendons and ligaments. For decades the gold standard in AS imaging has been conventional radiography. The improvements in computed tomography (CT), MRI and US imaging systems, that have taken place over the past years, have enhanced the visualisation of joint and enthesis involvement and determined a dramatically increase in the amount of data obtainable for early diagnosis of axial spondyloarthritis, before irreversible damage has occurred.

US is a very useful imaging method to evaluate all the peripheral joints and entheses in AS, however, few studies have been reported on the use of US in the examination of SIJ and spine.

Peripheral arthritis

Peripheral synovitis in AS patients is a frequent but a non-specific finding and US technique images those aspects in the same way as in PsA or RA.

Data on US hip evaluation in a cohort of 56 AS patients were recently reported. Hip effusion and synovial hypertrophy (with no power Doppler signal) were imaged in 26.7% and 16% subjects respectively. Patients with detectable, US abnormalities had higher median visual analogue scale pain and C-reactive protein level. US findings had only a moderate concordance with symptoms suggestive of an inflammatory hip involvement (62).

Synovitis of gleno-humeral joint was imaged solely in 1 out of 38 AS patients evaluated mainly for entheseal involvement (26).

Axial joint ultrasound

The use of US in the assessment of the axial joints is not as widespread as it is for the assessment of other more peripheral sites. Owing to the anatomical features of SIJ, direct imaging of synovitis in such articular structure, is not easy with grey-scale US. However, in 2009, Spadaro *et al*., by US, showed joint effusion in the SIJ of 38.9% of SpA patients and in 1.7% of controls, and SIJ effusion assessed by US alone or plus at least one SIJ clinical test had a positive likelihood ratio (LR) (2.67 and 4.04, respectively) for the presence of inflammatory back pain higher than the LR of single clinical tests (63).

It has been reported that the evaluation of the vascularisation features of the SIJ by colour flow signals can be used to determine the existence of inflammation.

In 1999, Arslan *et al*. demonstrated that vascularisation around the posterior portions of the sacroiliac joints increased while the resistive index (RI) value (a measure of the vasodilatation, and therefore, a surrogate for inflammation) decreased in patients with active

sacroiliitis. They concluded that colour and duplex Doppler sonography can be used in the diagnosis of active sacroiliitis and the follow-up after treatment (64).

Ünlü *et al*. assessed with colour and duplex Doppler US the SIJ, lumbar vertebral (LV) and thoracal vertebral (TV) paraspinal areas in 39 AS patients and 14 healthy controls, and observed that there was an increased vascularisation in those patients with active disease. Moreover, SIJ and LV RI showed a significant increase after anti-TNF-α treatment suggestive of recovering after the therapy (65).

Further studies have demonstrated that colour Doppler US is a valuable tool in the diagnosis of active sacroiliitis and, in particular, in the evaluation of disease activity and in therapy monitoring (52, 66, 67). Recently, Jiang *et al*. showed that the blood flow signals in the SIJ (evaluated by PDUS) became weaker or disappeared and the RI values increased after infliximab treatment. These results suggest that PDUS of SIJ can be useful in the follow-up of patients with axial AS (68).

Moreover, microbubble contrast-enhanced colour Doppler US appeared to be a more sensitive technique with a higher negative predictive value, with respect to unenhanced colour Doppler US, when MRI was used as the gold standard for the detection of sacroiliitis (69).

US-guided injections in sacroiliitis

SIJ are considered a difficult site for intra-articular therapies, in particular when a chronic inflammatory disease has narrowed the joint space. However, in some AS patients, US-guided injection of the SIJ might be feasible and effective. This technique was described by Klauser *et al*. (70, 71). Even using a US-guided approach, positioning the needle correctly is still difficult to do, and besides, the efficacy of the corticosteroid injection does not seem to be related to the perfect maneuver (72). Migliore *et al*. have demonstrated that US-guided intra-articular injections of the SIJ with acetonide triamcinolone were related to benefits on articular symptoms lasting for at least 6 months (73).

Moreover, other data in the literature have shown that also intra-articular injections of etanercept into the SIJ might improve joint function and decrease the frequency of local enthesitis (74).

Sonoelastography and AS

Real-time sonoelastography (SE) is a new ultrasound-based imaging technique that, coupling together US and ultrasonic elastography, provides information on tissue elasticity and stiffness. Some studies have investigated its application in the assessment of Achilles tendon of AS patients (75, 76).

SE is an imaging technique that allows a non-invasive visualisation of the elastic properties of tissues under examination, providing a coloured map superimposed on the grey-scale US imaging, that measures tissue deformation as a response to an external force, assuming that the deformation is lower in rigid tissues, compared with the elastic, soft tissues. This method is based on comparing the radiofrequency of ultrasonic waves obtained before and after an easily made compression with a conventional transducer, using a free hand technique (77, 78). Using SE, the normal tendon structure is visualised as blue or green, while moderately or severely softened areas (considered pathological) are respectively depicted in yellow or red.

In two studies, SE showed that the distal area of the Achilles tendon was the most commonly affected area in AS patients when compared with healthy subjects (75, 76)

Moreover, it has been shown that pathological SE findings tended to correlate with achillodynia intensity, enthesopathy findings and tendinous enlargement, thus demonstrating a moderate to good correlation with B-mode findings. SE may be useful for the evaluation of tendon abnormalities in patients with AS, but further studies are needed to standardise this technique and to assess its usefulness in clinical practice.

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