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REVIEW ARTICLE

The role of ultrasound in rheumatic skin and nail lesions: a multi-specialist approach

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Abstract The skin and nails are commonly involved in rheumatic conditions, both by the primary disease and/or long-term immunosuppressive treatments. These superficial affections may also imply a worsening of the quality of life in patients and cosmetic sequels. The latest advances in ultrasound technology show that skin and nail abnormalities are now recognizable and therefore susceptible to follow-up non-invasively. Thus, an ultrasound examination of these superficial tissues may be an adjunct tool for evaluating the progression and/or severity of rheumatic diseases in their primary or secondary manifestations.

Keywords Nail ultrasound · Non-invasive imaging · Rheumatic ultrasound · Rheumatology ultrasound · Skin ultrasound

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Introduction

The skin and nails are targets frequently involved in rheumatic disorders [1–4], both as a broader expression of the primary disease and/or the result of long-term immunosuppressive treatments. Their involvement can imply several complications such as clinical worsening of rheumatic diseases, permanent cosmetic sequels, and progressive deterioration of the patient's quality of life [5, 6]. Currently, the quantification of the severity in rheumatic diseases is mostly determined clinically and sometimes applying complex and long-time demanding score systems [7, 8], which may also present a lack of consensus.

During the last decade, substantial evidence about the role of ultrasound (US) in the musculoskeletal involvement within several rheumatic entities had been assessed [9–11]. Moreover, reports in literature about the usage of ultrasound in the dermatological field had been continuously growing in the last decade [12, 13]. However, little is the number of studies focused to specifically demonstrate the capability of this imaging technique in the study of both skin and nail abnormalities in rheumatic conditions [14, 15].

The continuous technological advances in the field of US have permitted the development of systems provided with high variable frequency transducers (≥15 MHz) and very sensitive vascular tools (>11 MHz) by color Doppler (blood flow representation) or power Doppler (map for the low velocity blood flow). These characteristics allow an accurate and detailed assessment of both morphostructural and vascularity changes in the most superficial tissues such as the dermal layer or the nail bed [16–18].

The aim of this paper is to demonstrate the potential of ultrasound using the latest technology for the assessment of skin and nail involvement in rheumatic conditions.

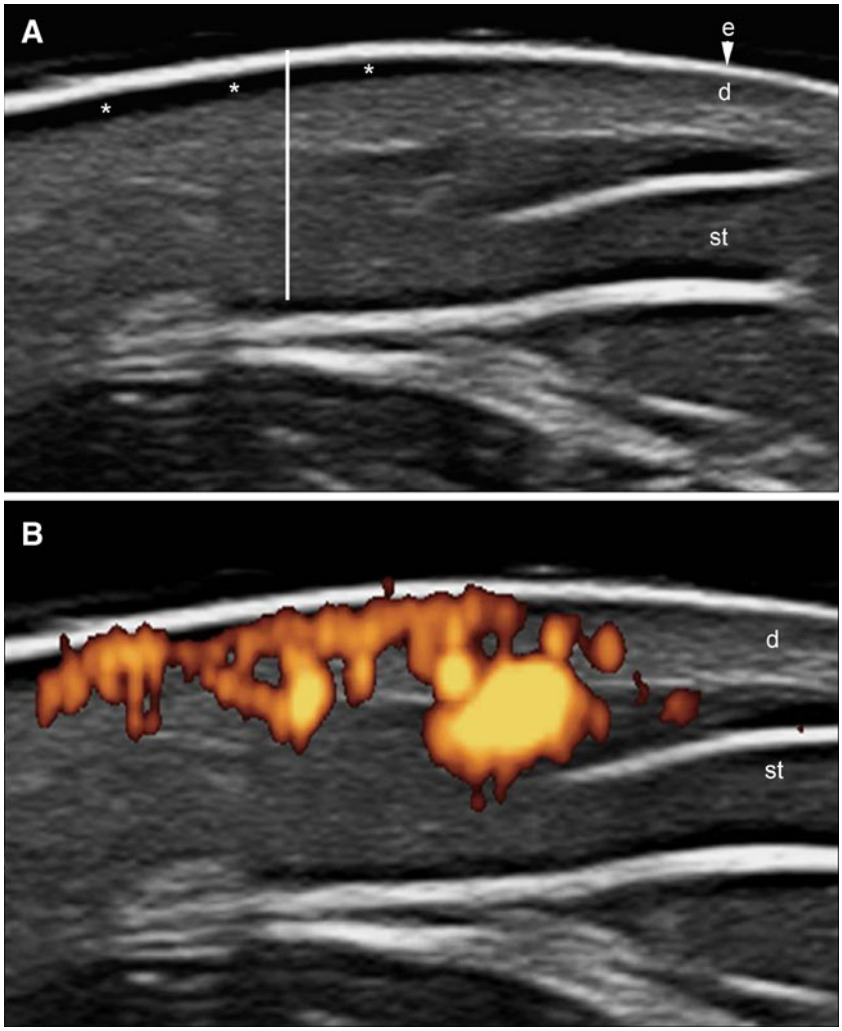

Fig. 1 (**A**, **B**) Psoriatic plaque. **A** Ultrasound (transverse axis) shows thickening of the epidermis and dermis and also increased echogenicity of the superficial subcutaneous tissue (*vertical white line*). A hypoechoic band is detected in the superficial dermis (*asterisks*). Abbreviations: *e* epidermis, *d* dermis, *st* subcutaneous tissue. **B** Power Doppler ultrasound (transverse axis) demonstrates increased blood flow (on *yellow color*) within the lesional skin

Methods and technical considerations

For an optimal examination of the skin and nails, high resolution color Doppler machines and linear probes working within the highest range of frequencies (≥15 MHz) are recommended [15, 18]. Moreover, these equipments usually come with compound imaging enhancers and panoramic field of view capabilities.

As a starting point, a visual inspection of the superficial lesion is performed by the ultrasound operator. This step that may seem trivial may allow to precisely locate the probe and to program the sequential lightening of the room in the case of multiple lesions. Then, a copious amount of gel is applied over the skin or nail surface for adjusting the focus, evenly distributing the probe pressure, and generating the necessary acoustic coupling. Thus, multiple sonographic sweeps are performed, at least using both longitudinal and transverse axes. Moreover, a side by side comparison of normal versus abnormal tissues should be desirable. The latter could be performed by using the contralateral region or the normal skin outside the borders of the lesional tissue.

Last but not least, the ultrasound operator should be trained in rheumatic and dermatologic diseases as well as work in close contact with the referring physicians. Thus, trained operators can have an integrated view of the lesions, the local sonographic normal/abnormal anatomy, and the ultrasound artifacts. Therefore, a more accurate interpretation and fast decisions that may imply to extend the examination to other corporal segments can be performed during the same test.

All these latest technology machines are now widely available worldwide, and the costs of the examinations usually range under the costs of other imaging techniques such as MRI/PET-CT without providing the secondary effects of radiation, intravenous contrast, and/or confinement for the patients.

Rheumatic diseases may present several cutaneous or nail abnormalities during their usually long-term course. Thus, the present review is mostly focused on those entities

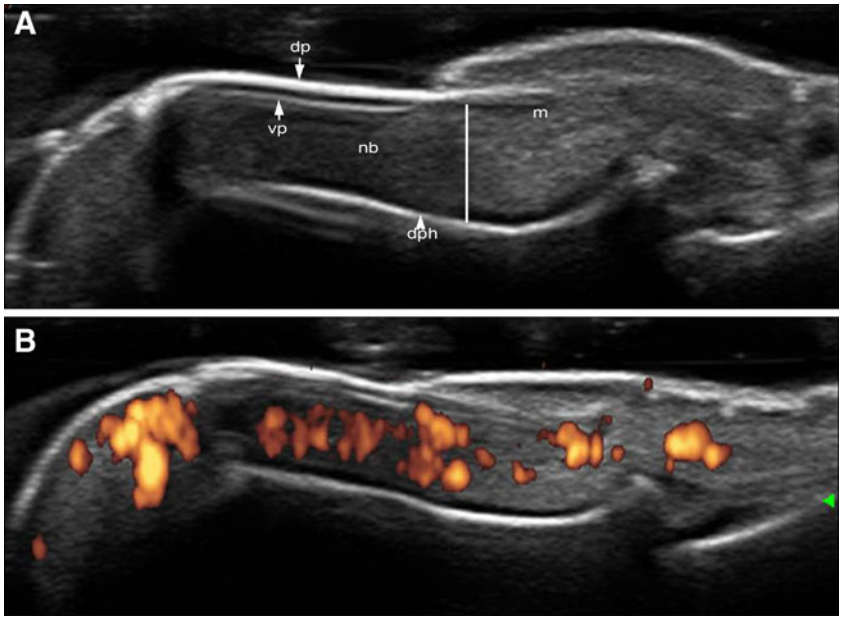

Fig. 2 Psoriatic onychopathy (**A**, **B**). **A** Ultrasound (longitudinal view) shows thickening of the nail bed (*white vertical line*). Loss of definition of the ventral plate is also observed. **B** Power Doppler ultrasound (longitudinal view) shows increased blood flow (on *yellow color*) within the nail bed. Abbreviations: *nb* nail bed, *vp* ventral plate, *dp* dorsal plate, *dph* distal phalanx bony margin

that may present a challenge for the diagnosis and/or monitoring, the ones that are generally difficult or non-susceptible to test with multiple biopsies, those conditions that may present clinically unsuspected characteristics that could influence treatment, and/or on the ones that demand strong improvement of the cosmetic prognosis All cases presented were selected from 12,046 skin and nail ultrasound examinations, derived by dermatologists from January 2001 to May 2010. The present review was granted an exemption of informed consent by the institutional

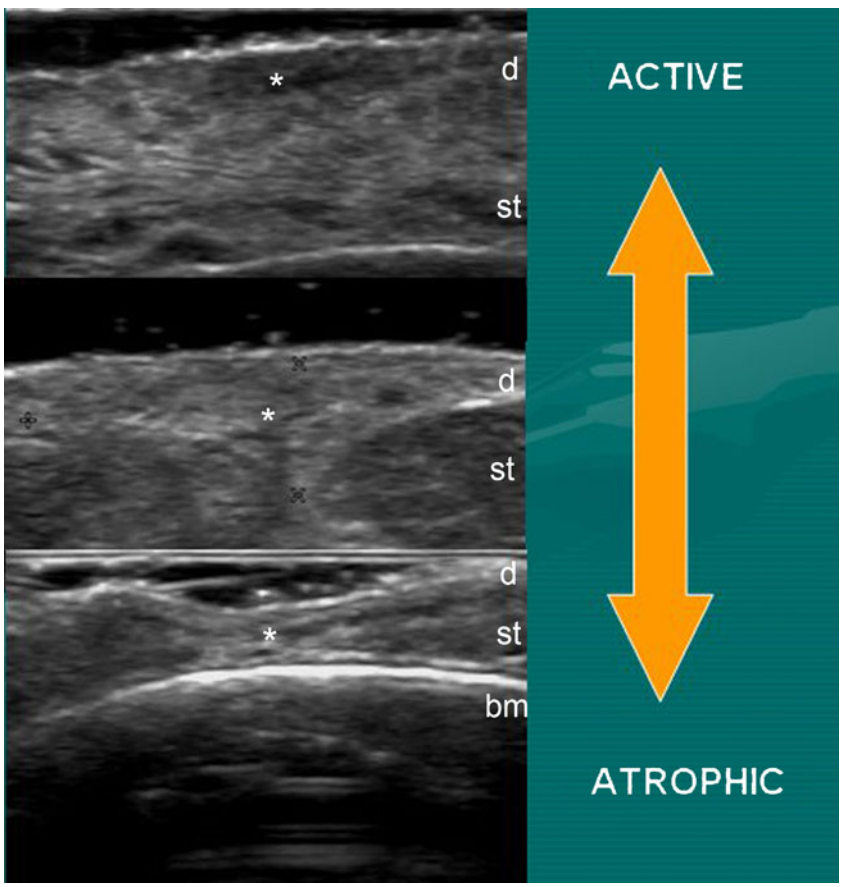

Fig. 3 Activity phases of morphea on gray scale ultrasound going from active/inflammatory (*top*) to atrophic (*bottom*). Abbreviations: *d* dermis, *st* subcutaneous tissue, *bm* bony margin of the skull

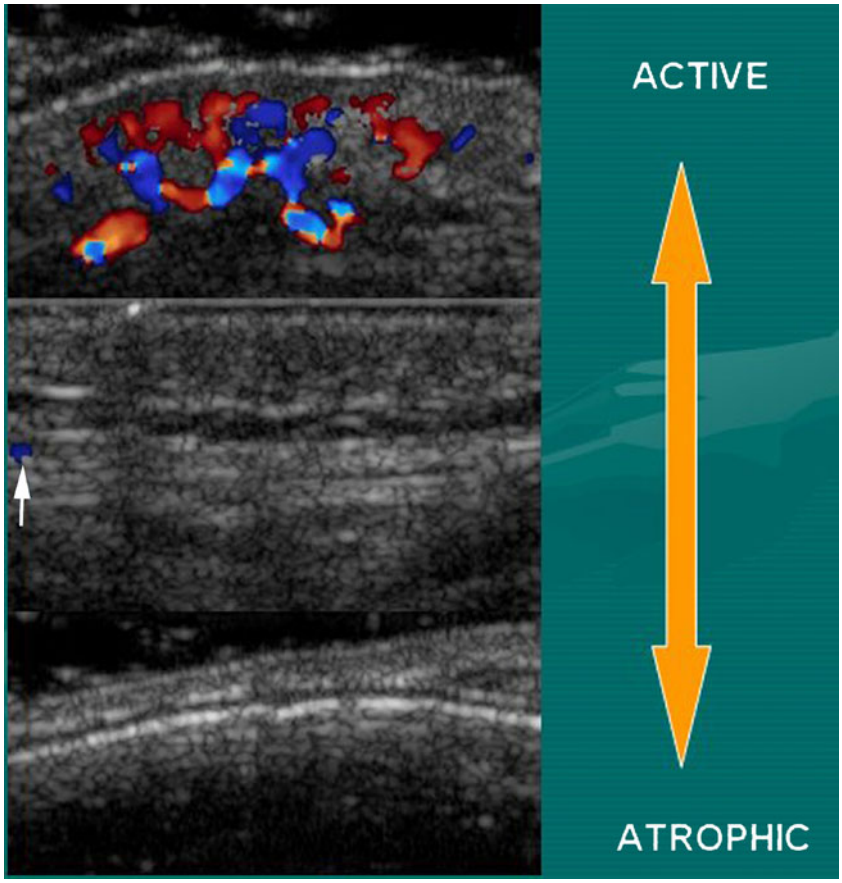

Fig. 4 Activity phases of morphea on color Doppler ultrasound going from active/inflammatory (increased blood flow on colors, *top*) to atrophic (absence of hypervascularity, *bottom*)

review board and followed the Helsinki principles of medical research. Therefore, cases were selected from a database in a national referral center for skin ultrasound examinations (Clinica Servet, Santiago, Chile). This database contained 6,102 benign non-vascular tumors, 1,816 inflammatory and periarticular lesions, 1,603 benign vascular tumors, 1,483 exogenous skin components, 826 nail lesions, and 216 malignant tumors. All patients presented were histologically confirmed and evaluated by a team of experts that included dermatologists, rheumatologists, and radiologists.

Sonographic findings in common inflammatory conditions

Psoriasis

Both psoriatic plaque and onychopathy can be studied by ultrasound. The main gray scale US findings of the psoriatic plaque include thickening of both the epidermis and dermis and presence of an hypoechoic band in the upper dermis of the lesional site (Fig. 1a). According to the level of severity present in the inflammatory phase, variable degrees of increased blood flow within the dermis can be detected by color or power Doppler (Fig. 1b) [19].

In psoriatic onychopathy, the ultrasonographic changes (going from early to late phases) are represented by thickening of the nail bed (distance from the ventral plate to the bony margin of the distal phalanx), loss of definition of the ventral plate, hyperechoic focal involvement of the ventral plate, and thickening of both dorsal and ventral plates that may also include wavy-shaped or convex nail plates. Also, increased blood flow can be detected within the nail bed on active phases of onychopathy (Fig. 2) [20, 21].

Scleroderma, lupus, and dermatomyositis

Ultrasound can detect a wide range of anatomic abnormalities within the skin layers in patients with connective tissue disorders and also can support the assessment of the level of activity of the diseases [22]. Thus, ultrasonographic findings can vary in their representation according to the activity level of the disease, varying from active (inflammatory) to atrophic phases [23–28] (Figs. 3, 4, and 5).

The inflammatory phases are characterized by thickening and decrease of the echogenicity of the dermis, usually associated with an increase of both the echogenicity of the subcutaneous tissue and local blood flow, the latter being

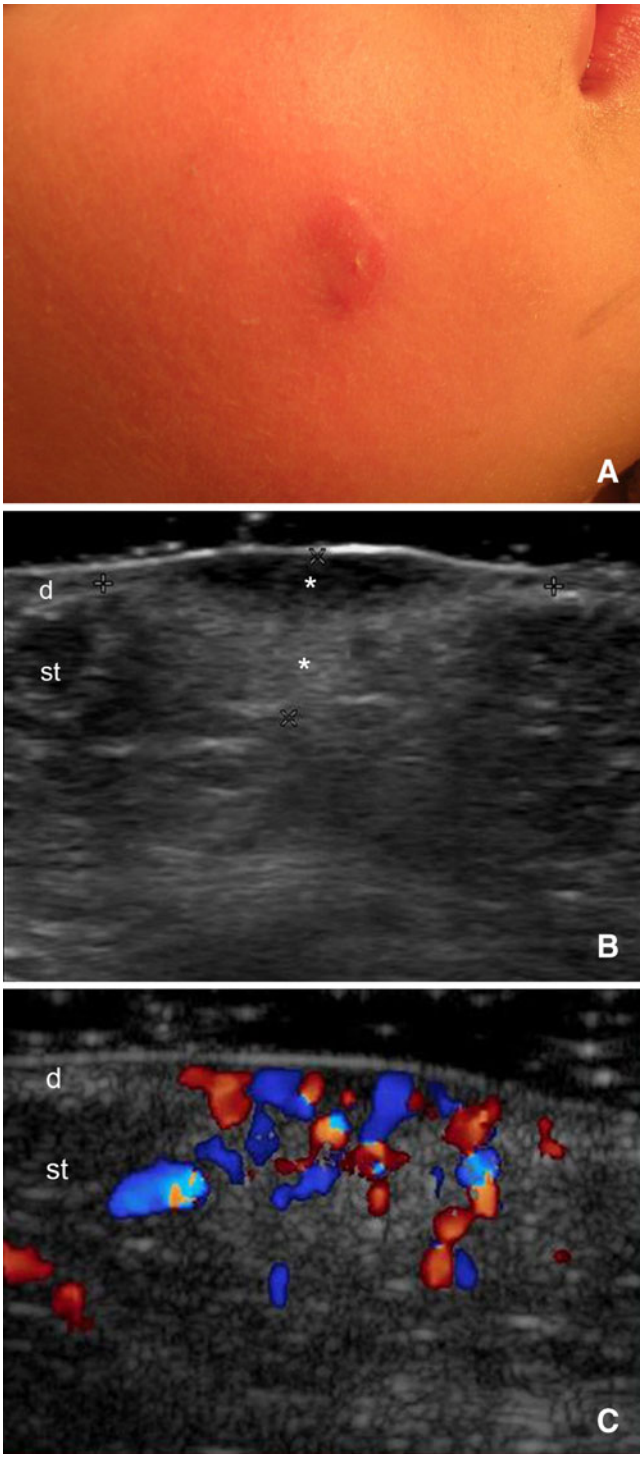

Fig. 5 (**A**-**C**) Active/acute cutaneous lupus. **A** Clinical erythematous lesion in the right cheek. **B** Ultrasound (transverse view) in the lesional area (*asterisks*) shows decreased echogenicity and thickening of the dermal layer. Also, increased echogenicity of the subcutaneous tissue is detected. All these changes represent the inflammatory process present in the active inflammatory phase. **C** Color Doppler ultrasound (transverse view) in the same lesion shows increased blood flow within the lesional tissue also implying an inflammatory active phase of the disease. Abbreviations: *d* dermis, *st* subcutaneous tissue

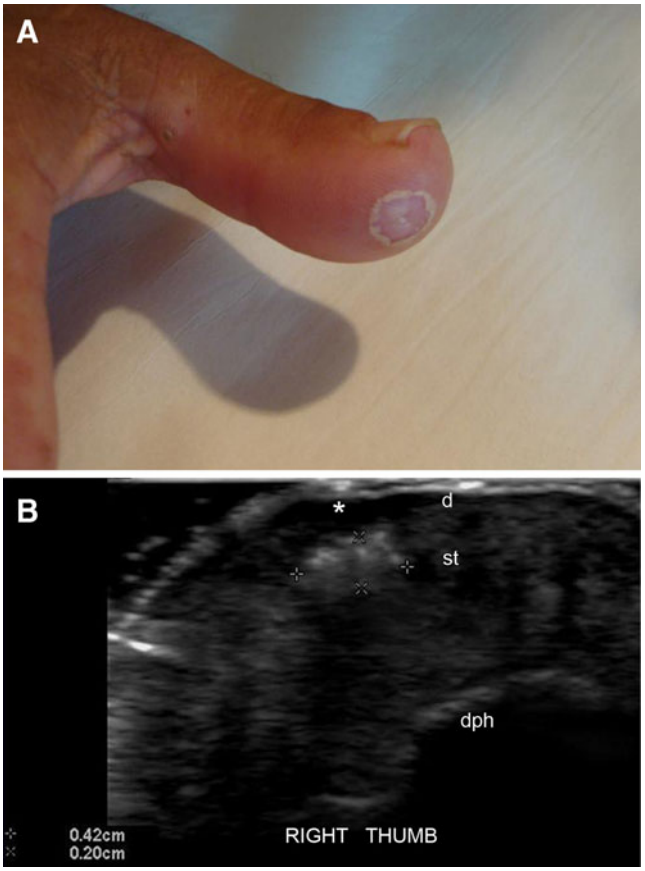

Fig. 6 (**A**, **B**) Cutaneous calcinosis in scleroderma. **A** Skin lesion on the right thumb. **B** Ultrasound (transverse view) shows a 4.2 x 2.0-mm hyperechoic nodule in the subcutaneous tissue that corresponds with the calcium deposit. Decreased echogenicity of the lesional dermis (*asterisk*) is also detected. Abbreviations: *d* dermis, *st* subcutaneous tissue, *dph* distal phalanx

easily detected by color Doppler or power Doppler. In contrast, at the atrophic phase, the predominant sonographic findings are the decreased thickness of both the dermis and subcutaneous tissue and the lack of blood flow abnormalities [29].

Additional anatomical changes can be detected in systemic sclerosis and dermatomyositis, such as calcium deposits ("calcinosis"), which are seen on ultrasound as hyperechoic spots within the subcutaneous tissue. Also, these calcium deposits can be associated with posterior acoustic shadowing [30] (Fig. 6). Furthermore, information about the involvement of vessels such as the digital arteries can be performed. These vessels can present thrombotic and vasculitis phenomena, which may complicate the treatment and/or prognosis of the rheumatic diseases [31] (Fig. 7).

Also, ultrasonographic abnormalities can be found within the nail bed, mainly represented by a decrease of both the echogenicity and the blood flow, secondary to microvascular changes. Some of these ungual changes had been recently confirmed by capillaroscopy [32], and when

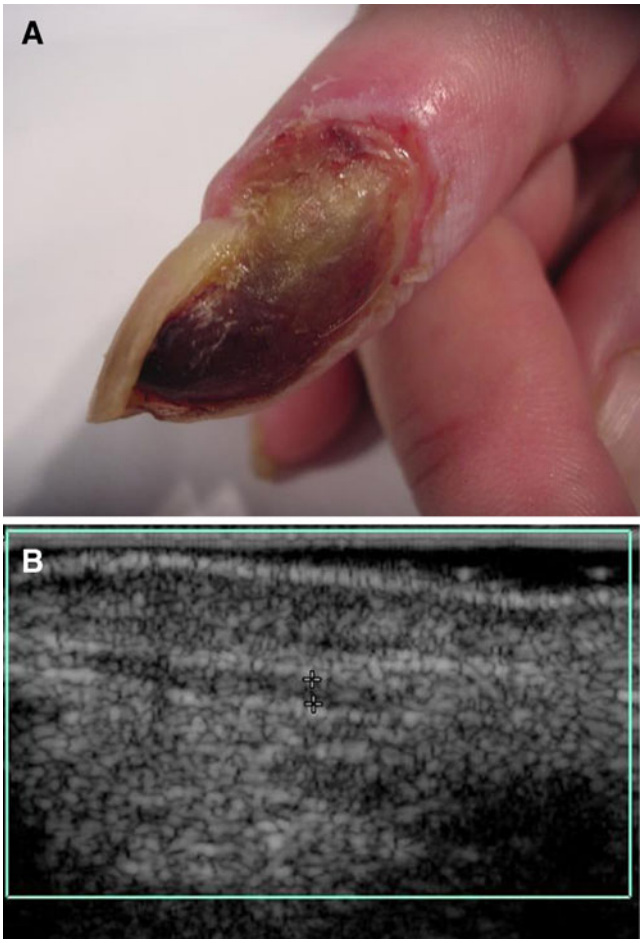

Fig. 7 (**A**, **B**) Dorsal digital artery thrombosis in systemic lupus. **A** Clinical lesion. **B** Color Doppler ultrasound (longitudinal view) of the right index finger shows hypoechoic thrombotic material filling the lumen of the digital artery (between markers) without detectable blood flow

affecting the ungueal matrix, a nail dystrophy can be generated.

Hidradenitis suppurativa

Hidradenitis suppurativa (HS) is a chronic inflammatory disease of the skin characterized by recurring painful abscesses, nodules, sinus tracts, and scarring usually localized in the groin and axillae [33]. HS can be associated with inflammatory bowel diseases. Moreover, the comorbidity between Crohn's disease, ulcerative colitis, and HS had been reported in up to 17% of the patients with Crohn's disease and 14% of the patients with ulcerative colitis [34].

The main ultrasonographic findings in this condition are represented by anechoic fluid collections, hypoechoic fistulous tracts, anechoic dermal abscesses, decreased echogenicity of the dermis by edema, and enlargement of the regional hair follicles. All these sonographic signs may help assess the extension and severity of the disease [33–36] (Fig. 8).

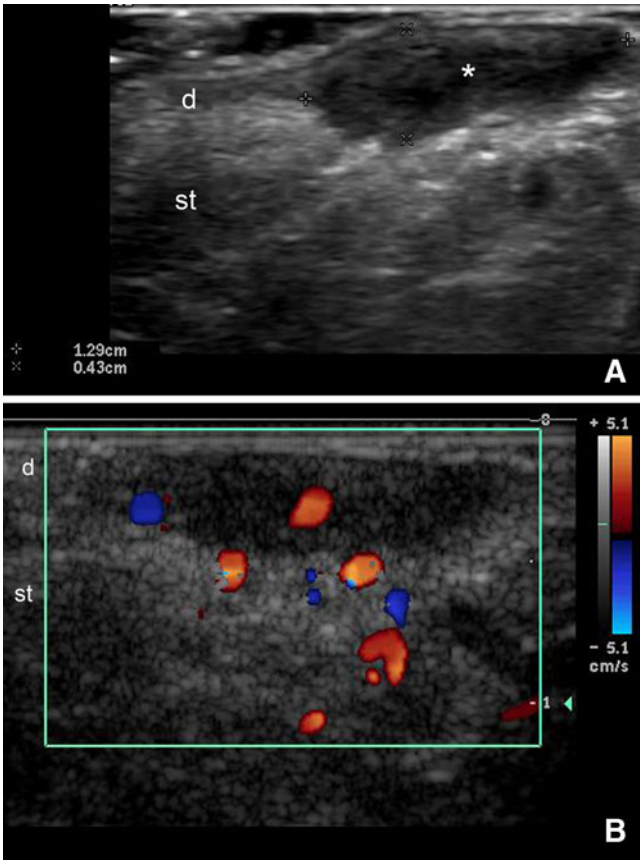

Fig. 8 (**A**, **B**) Hidradenitis suppurativa. **A** Ultrasound (transverse axis) shows an hypoechoic dermal fluid collection (*asterisk*, between markers). **B** Color Doppler ultrasound (transverse axis) demonstrates increased blood flow surrounding the collection. Abbreviations: *d* dermis, *st* subcutaneous tissue

Infectious diseases

Under inmunosuppression, the spread of infectious agents is favored. Among the common infectious entities that affect the skin are:

(a) Cellulitis

A spreading infection that primary occurs in the subcutaneous tissue and secondarily may sometimes affect the dermis. Cellulitis generates increased echogenicity areas, sometimes with anechoic free fluid or abscesses between the fat lobules of the subcutaneous tissue. Thus, the ultrasound examination allows ruling out organized collections and also guides their drainage sonographically. Moreover, the inflammation of deeper structures such as bursae or joints can be detected [37]. The development of clinically unsuspected fluid collections or abscesses may complicate treatments. Thus, these conditions could be more frequently and early detected when imaging studies are available. Moreover, a faster appearance of these entities also could be related to the degree of immunosuppression present in the rheumatic patient.

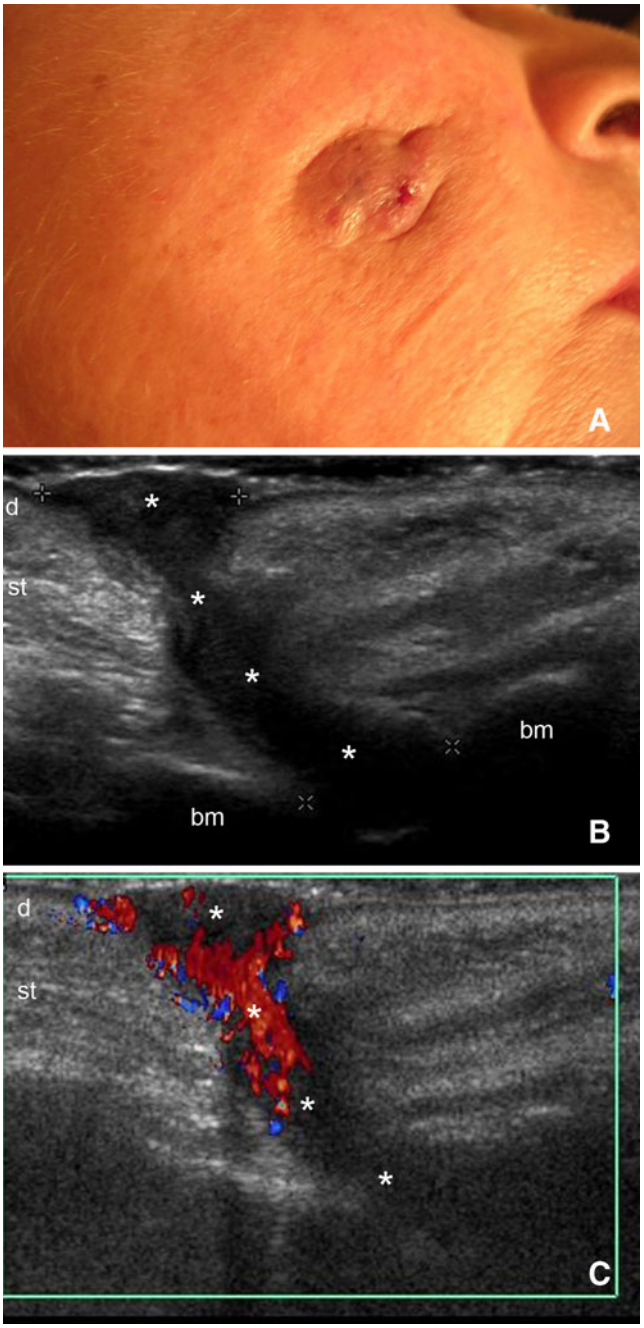

Fig. 9 (**A**, **B**) Odontogenic fistula. **A** Clinical lesion in the right cheek. **B** Ultrasound (transverse view) shows a fistulous tract (*asterisks*) connecting the skin to the bony margin of the upper maxilla. **C.** Color Doppler ultrasound (transverse view) demonstrates increased blood flow within the fistulous tract. Abbreviations: *d* dermis, *st* subcutaneous tissue, *bm* bony margin

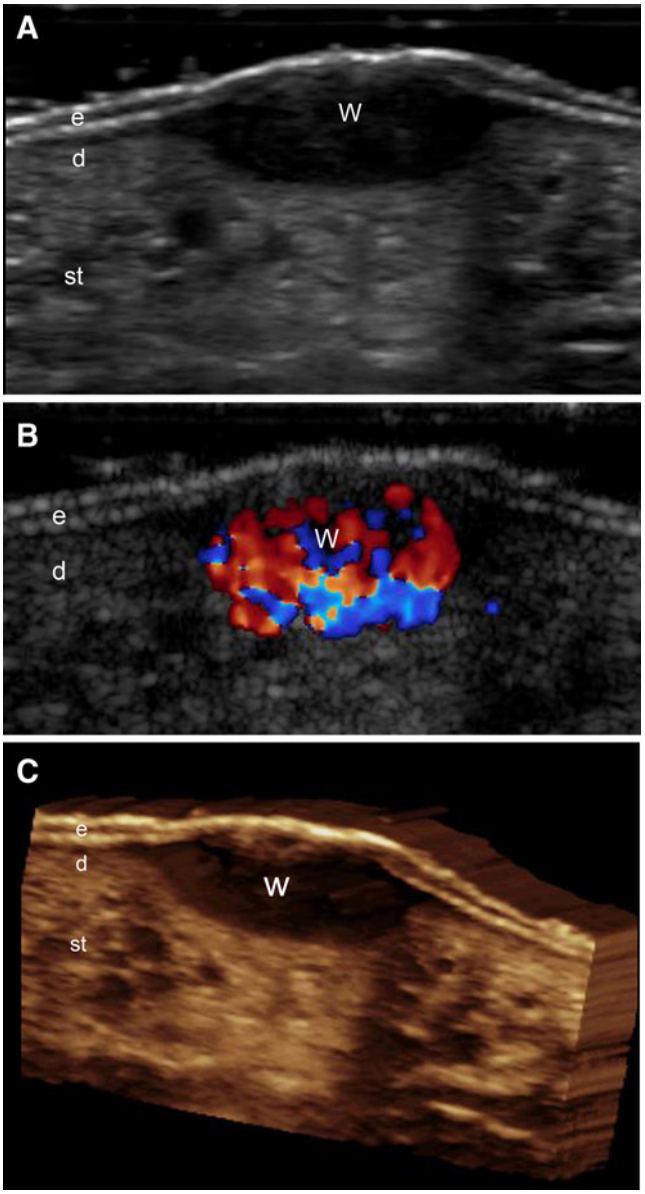

Fig. 10 (**A-C**) Plantar wart. **A** Ultrasound (transverse axis) shows a fusiform hypoechoic lesion that involves the epidermis and dermis. **B** Color Doppler ultrasound (transverse axis) demonstrates increased blood flow within the dermis and sublesional subcutaneous tissue. **C** Ultrasound 3D image of the plantar wart (5-seconds sweep through the lesional skin). Abbreviations: *W* wart, *e* epidermis, *d* dermis, *st* subcutaneous tissue

(b) Fistulae

Communicating fistulous tracts of variable sizes and through the different anatomical layers can be developed. Moreover, these fistulae may connect the bone to the skin such as the odontogenic fistula in the face, commonly generated by poor dental conditions, not infrequent in inmunosupressed patients (Fig. 9). These fistulous tracts may clinically appear as a single erythematous cutaneous lesion, therefore mimicking a dermatological origin and also can be associated to ostemyelitis [38].

(c) Viral infections

Warts are caused by the human papilloma virus, a common infectious condition that may easily affect immune-

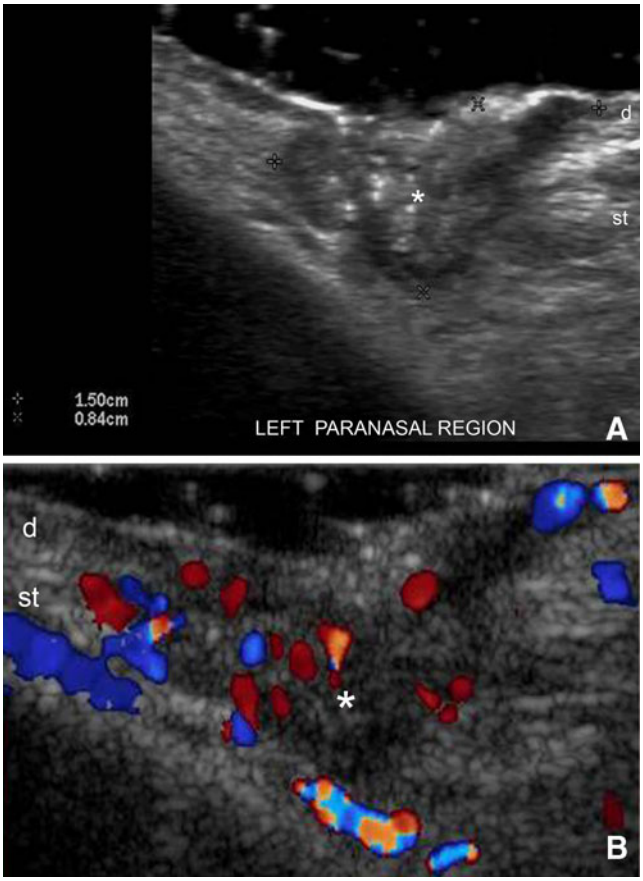

Fig. 11 (**A**, **B**) Basal cell carcinoma. **A** Ultrasound (transverse view) shows an hypoechoic tumoral lesion (*asterisk*) with irregular and lobulated borders affecting the dermis and subcutaneous tissue. Hyperechoic dots (*white*) are visible within the tumoral tissue. **B** Color Doppler ultrasound (transverse axis) shows increased blood flow within the tumor (*asterisk*). Abbreviations: *d* dermis, *st* subcutaneous tissue

compromised patients. Plantar warts can be clinically challenging in their diagnosis because of the usual intense pain within the site of infection that could be clinically misdiagnosed as a foreign body or Morton's neuroma. Their sonographic appearance has been described by ultrasound as a fusiform hypoechoic structure that involves the epidermis and dermis [39, 40] (Fig. 10). Secondary anatomical changes can be also detected such as increased dermal arterial blood flow and the underlying plantar bursitis in the lesional site. Also, they can involve other regions such as the nail bed or the glabrous skin of the hands [41].

Skin cancer

Non-melanoma skin cancer is more frequent in patients under immunodepression conditions [42]; among these entities, basal cell carcinoma (BCC) and squamous carcinoma are the most common tumoral conditions [43]. Particularly, BCC is the most frequent tumor among human beings and commonly affect the skin exposed to sun areas such as the face, which can leave important cosmetic sequels. Moreover, these facial locations commonly include areas where the skin is thin such as the nose, lips, eyes, and ears and where involvement of cartilage, orbicular muscles, or bony margins may be found and therefore challenge surgical procedures [44]. Ultrasound can support the detection of the primary lesion as well as the secondary involvement of deeper layers with very good histologic correlation [45]. Thus, it provides access to the unknown axis—depth. Furthermore, detection of subclinical lesions of BCC had also been described [45]. Squamous carcinoma is usually more aggressive upon presentation, and the detection of both primary and secondary involvement can support surgical planning. Besides, recurrent tumors can be also better characterized in their extension.

As regards the usage of ultrasound in the diagnosis of melanoma and its locoregional and in-transit metastasis, this support had been deeply investigated in literature showing very good correlations with histologic results [46]. Moreover, the Breslow index had been well correlated with melanoma histologic thickness, and perhaps, the usual high presence of blood flow detected by color Doppler within the melanoma may explain the extensive angiogenic dissemination of these tumors [47].

On ultrasound, malignant skin tumors appear as hypoechoic lesions that may present irregular borders and increased lesional blood flow [18, 45–47] (Fig. 11). In BCC, hyperechoic spots within the lesions had also been described [48]. Melanomas usually show a fusiform appearance and can be associated to oval or round-shaped hypoechoic in-transit subcutaneous metastasis, besides the involvement of locoregional adenopathies [49, 50].

The primary and/or secondary involvement of the skin and nails in rheumatic diseases can be both an objective and non-invasive index of activity and severity. Furthermore, awareness and assessment of the cutaneous and/or ungual involvement secondary to long-term immunosuppressive treatments may also improve the management for these patients.

Conclusion

Ultrasound is an adjunct tool that can support management of skin and nail lesions under common rheumatologic conditions. This non-invasive technique may help the clinician assess the extension, activity, and severity of the diseases and their complications.

Disclosures None.

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