Chapter 8

Ultrasonography as a New, Non-Invasive Imagistic Technique Used for the Diagnosis and Monitoring of Psoriasis

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/67812

Abstract

Psoriasis is a chronic inflammatory autoimmune disease that involves the skin, nails, joints and other organs, being a systemic disease. Regardless of the clinical form, sonography can be effectively used to complete the clinical diagnosis.

Aim: The identification of non-invasive sonographic markers for the assessment of the severity of the disease and the efficacy of various therapies. Our study involved two research directions: (a) clinical and imagistic assessment of the skin and nail psoriasis lesions and (b) the imagistic evaluation of the therapeutic efficacy in psoriasis plaques and nail psoriasis by acquirement of sonographic images prior and after various therapies.

Methods: In our prospective study, we used a multimodal evaluation of the disease, based on a non-invasive approach: clinical exam, dermoscopy, conventional and high frequency sonography, Doppler, power Doppler and elastography.

Conclusions: Ultrasonography is an important tool for the non-invasive assessment of psoriatic lesions. It offers specific markers related to morphology, elasticity and blood supply of the lesions, improving the diagnosis and monitoring of the skin and nail lesions.

Keywords: psoriasis, ultrasound, skin, nails, therapy

1. Introduction

Sonography is a routine method used in clinical medicine in fields such as internal medicine, gastroenterology and gynaecology. In the past 2–3 decades, sonography has extended its utility to the field of clinical dermatology. This non-invasive method offers in '*real time*' morphological details about the skin structure and its specific conditions. It is important to mention that histology still remains the gold standard for the assessment of the skin structure and diagnosis of its associated pathology. Despite this, researchers are permanently looking for new non-invasive methods for the skin assessment, which can offer similar, identical or new markers to the histological ones, in order to improve the clinical and differential diagnosis, as well as to optimize the evaluation of the efficacy of various therapies. There is a wide range of ultrasound devices with frequencies ranging from 5 to 100 MHz. In the range of 5–10 MHz, real-time B-mode sonography is successfully applied as a non-invasive diagnostic tool in internal medicine. High-frequency ultrasound (HFU) systems using frequencies ranging from 20 to 100 MHz can be used for the study of the integumentary system and for research purposes [1–3]. High-frequency sonography devices can vary from a resolution of 72 μm and a penetration depth of 35 mm up to a resolution of 15 μm and a penetration depth of 0.8–1.5 mm [4].

These examination techniques can provide the clinician with important information about the axial and lateral extension of tumoural and inflammatory processes of the skin and the subcutaneous fatty tissue and are therefore of special interest in the diagnosis and monitoring of skin conditions under various therapies [5, 6].

1.1. Sonography: general considerations

Sonography has proven to be a useful non-invasive imaging method for the study of the skin [1]. The recent development of high-frequency ultrasound (HFU) transducers has led to a vast range of applications in dermatology, such as the evaluation of inflammatory diseases (psoriasis, scleroderma), tumours and skin ageing and so on [7]. Several studies have proven similarities between ultrasound (US) and histological sections [8]. The inclusion of ultrasound among the procedures used for the dermatological diagnosis is an attempt to replace the invasive procedures such as biopsies, with non-invasive ones as much as possible. The motivation for the extensive use of HFU derives from its ability to reveal the skin components in detail, up to 1.5 cm in depth, to assess the axial and lateral extension of various lesions, the inflammatory processes, as well as the efficacy of different local therapies [9].

The main ultrasonographic techniques used in dermatology in present times are conventional ultrasound (CUS) and high-frequency ultrasound (HFU) [10, 11]. The integumentary system can be explored both with conventional imagistic equipments and specialized dermatological devices.

The *conventional ultrasound* (CUS) skin examination can be performed with 7.5–13 MHz transducers offering an axial and lateral resolution of 0.2 mm and an ultrasonic depth of up to 5–7 cm. The B-mode is the recommended method for profound structures, but it can also identify skin and nail structures under specific conditions. The *Doppler* or *power Doppler* examination is important for the identification of blood vessels, an important feature for the discrimination

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between inflammatory or tumoural lesions. The *Doppler technique* can identify the presence of vascular signal, describes the distribution and characterizes the microcirculation (speed of the blood, pulsatile index, resistivity index). *Power Doppler* has a higher sensitivity than colour Doppler allowing the detection of smaller velocities. The method is particularly useful for the examination of superficial structures [12]. *Spectral Doppler* techniques allow the differentiation between venous and arterial flow and the measurements of specific parameters '*in real time*', such as velocity (V), pulsatile index (IP) or resistive index (IR). Combining greyscale ultrasound with Doppler ultrasound allows the assessment of skin and skin lesions including morphology, size, shape, margins, macrocirculation, microcirculation and elasticity [13].

High-frequency ultrasound (HFU) with more than 13 MHz transducers can characterize the integumentary system with greater precision [14]. According to literature data and our own experience, HFU has multiple applications both in the clinical and research field:

- Identification of the histological skin layers (epidermis, dermis, hypodermis).
- Histology of the nails and identification of its components (nail plate, nail bed).
- Assessment of the interphalangeal joint structures involved in inflammatory diseases.
- Identification, qualitative and quantitative monitoring of the cutaneous alterations induced by the senescence process.
- Monitoring of various chronic inflammatory skin conditions and the efficacy of different local therapies [15–17].

Optimising the sonographic diagnosis requires modern techniques and devices, which is why ultrasonography is constantly evolving in a number of directions. For example, HFU with 100 MHz transducers, currently used only for research purposes, has an axial resolution of 11 μm, a lateral resolution of 30 μm and allows visualisation up to a depth of 2 mm [9].

Elastography is a technique, which can assess the elasticity of soft tissues during application of mechanical compression. Because tumours are 5–28 times stiffer than normal surrounding tissue, qualitative elastography or strain ratio elasticity are techniques that may improve the diagnostic accuracy or monitoring of treatment efficacy [18, 19].

Sonoelastography (SE) may depict the stiffness of the tissues. Compared with manual palpation, SE is considered as a semi-quantifiable method using a visual scale score to evaluate the focal lesion [20].

The *strain-ratio* technique compares the strain of a region of interest in a focal lesion with the strain of the surrounding tissue. The strain ratio elastography measures the axial displacement of tissue caused by mechanical stress in real time. The elastogram may be displayed as a colour overlay on the B-mode picture [21].

The newest *shear wave elasticity* (SWE) or *transient elastography* is similar to strain elastography, but instead of using the transducer pressure to compare the stiffness in an ultrasound image measuring changes in strain, a higher intensity pulse is transmitted to produce shear waves, which extend laterally from the insonated structure [22]. This stiffness is believed to start from the early stages of cancer development. Visualization of stiffness data could enable early

stage differentiation of benign and malignant tissue. In addition, the elasticity of the tissue varies significantly under the influence of inflammation or congestion. Therefore, elastography is a reliable method for assessing the level of inflammation and congestion in various skin disorders and monitoring of the therapeutic efficacy; that is why ultrasonography may also be considered as a virtual knife, a stethoscope and a palpation device in the hand of a dermatologist.

Because in dermatology, most of the diagnoses are made by visual inspection and palpation of the skin, the sonographic assessment of the patients diagnosed with *psoriasis* represents a new approach of the disease, offering new, specific and non-invasive additional information [23, 24].

2. Sonographic anatomy of the skin and nails

2.1. The healthy skin

The skin is the most superficial organ of the body. It represents an area of relating to the exterior world. Along with its appendages (hair follicles, nails), the cutaneous organ represents a great morphological and functional complex structure, displaying particular and unique ultrasonographic features.

Skin disorders have a highly characteristic distribution pattern, which reflects regional differences related to structure, topography, blood supply and distribution of appendages. From histological point of view, the skin consists of three well-defined structures named epidermis, dermis and hypodermis, which can be separated into sonographic equivalents. **Figure 1** shows sonographic images taken with transducers of different MHz.

The epidermis is a stratified squamous keratinized epithelium which appears as a *continuous hyperechoic* line with homogeneous thickness, or as a bilaminar hyperechoic parallel line in the thicker palmar and plantar areas [25].

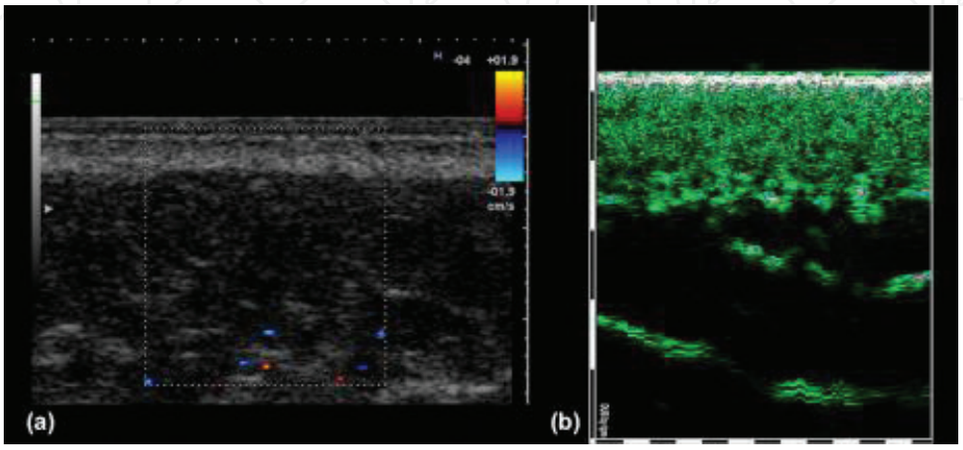

Figure 1. Sonographic diagram of the skin. (a) Skin sonography taken with an 18-MHz transducer and (b) skin sonography taken with a 22-MHz transducer (skin-scan).

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The dermis is represented by a dense connective tissue, situated between the epidermis and hypodermis. With a variable thickness of 0.6–2 μm in the palms and soles, the dermis is the structure, which induces the thickness of the epidermis. Dermis is a connective tissue rich in collagen and elastic fibres, which are responsible for the echogenicity of the structure. It appears as an *echogenic band* subdivided into two regions: the papillary superficial dermis located beneath the epidermis appears less echogenic due to a decreased amount of collagen fibres and the reticular dermis, more echogenic due to the higher amount of collagen fibrils assembled in mature collagen fibres [25, 26].

The hypodermis is the subcutaneous cellular tissue consisting of adipocytes organized in lobules and separated by connective tissue septa. In ultrasound, it appears as a *hypoechoic* structure separated by *hyperechoic* fibrous septa.

The blood vessels are represented by thin (<1 mm) and easily compressible venules and arterioles situated in the hypodermis or in the deep dermis. These small vessels appear as thin anechoic tubular structures in conventional ultrasonography. In the normal healthy thin skin, the superficial vessels are identified by power Doppler as small colour dots [27].

2.2. The healthy nail unit

The nails, located on the distal phalanx of each finger, are composed of plates of heavily compacted, highly keratinized cells termed nail plate (NP), lying on the dermis, termed nail bed (NB). The nails develop from cells of the *nail matrix*, situated beneath the proximal nail fold. The stratum corneum of the proximal nail fold forms the eponychium or cuticle, which extends from the proximal end up onto the nail for about 1 mm. The distal end of the nail plate is not attached to the nail bed which becomes continuous with the skin of the finger. Near this junction there is an accumulation of keratinised cells, named hyponychium [28]. All these components display characteristic sonographic images are illustrated in **Figure 2**.

The nail plate (*NP*) appears as two hyperechoic parallel lines, displaying in between a thin virtual hypoechoic line (dark grey) called interplate space. *The nail bed* (*NB*) and the matrix are hypoechoic, usually turning slightly hyperechoic in the proximal region beneath the nail

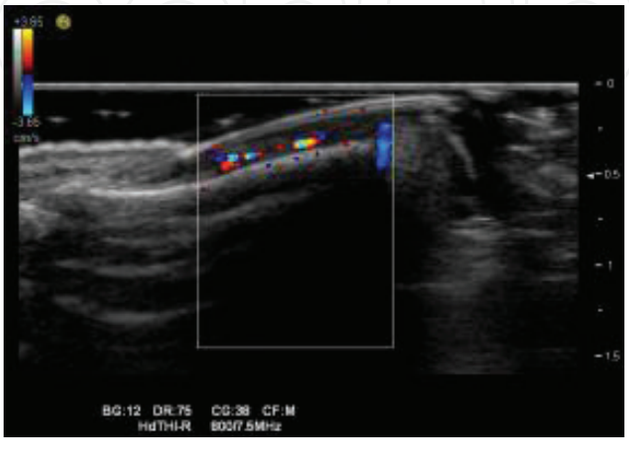

Figure 2. Ultrasonographic image of the healthy nail. Nail sonogram (18 MHz), showing the superficial hyperechogenic NP and the underlying hypoechogenic NB containing blood vessels.

matrix. *The nail folds* present the same ultrasonographic skin features with less adipose lobules in the subcutaneous tissue. *The bone margin* appears as a distinct hyperechoic line and corresponds to the dorsal bony margin of the distal phalanx. Doppler ultrasound or power Doppler detects the presence of *low-velocity* blood flow in the nail bed [13, 29].

According to Essayed et al., in nail psoriasis, the distal loss of the nail interplate space is more frequent, when compared to onychomycosis where the proximal loss of the interplate space is more frequent. In addition, they found a NB thickness greater than 1.85 mm at thumb level, which could be used to discriminate patients with psoriatic nails from onychomycosis with an accuracy, sensitivity and specificity of 73, 64 and 72%, respectively. According to the same group, the presence of three lines at the level of the nail plate could be an important ultrasonographic sign which may help in differentiating between psoriatic nail and onychomycosis [30].

3. Psoriasis

Psoriasis presents with a large spectrum of clinical features and evolution. According to literature data, about 1/3 of the patients have moderate to severe disease (PASI index >10) involving more than 10% of the body surface [31]. With a prevalence of 1–3%, the condition can occur in all age groups; however, it primarily arises in adulthood, with no gender predilection [32]. Psoriasis can also affect the nails, entheses and joints, leading to the development of a destructive inflammatory arthropathy seen in 25–34% of patients with psoriasis, named psoriasis arthritis (PsA) [33]. The pathogenesis of psoriasis is multifactorial and still not fully understood. Several lifestyle factors have also been associated with morbidity in psoriasis.

3.1. Classification and morphology of psoriasis

Psoriasis can be classified by morphology and by the pathogenetic mechanism. The commonest form of disease is *plaque psoriasis*, affecting about 80% of the patients [34]. It is characterized by thick, erythematous plaques with silvery, shiny deposits of scales. In this case, the erythematous scaly plaques tend to remain stationary or to progressively enlarge, affecting especially scalp, knees, elbows or lower back [35]. The clinical aspect of the psoriasis skin plaque is illustrated in **Figure 3**.

Inverse psoriasis usually affects the skin folds, especially the regions under the armpits, the abdominal skin fold, the breast area or the gluteal cleft; in this situation, the plaques are thinner and there is no or minimal scaling.

Guttate psoriasis usually emerges acutely following a bacterial or viral infection of the upper ways. It usually presents with small round scaly plaques scattered across the entire skin surface; it either resolves with infection or progresses to the development of psoriasis vulgaris [37].

Pustular psoriasis is characterized by a disseminated outburst of sterile pustules, accompanied sometimes by recurrent episodes of fever. It constitutes a less frequent clinical pattern. If the entire integument is affected, the condition is called 'generalized (von Zumbusch) type'. *Acrodermatitis continua of Hallopeau* is a rare, localized form of palmoplantar pustular psoriasis, often unresponsive to treatment. It usually emerges with pustules on erythematous,

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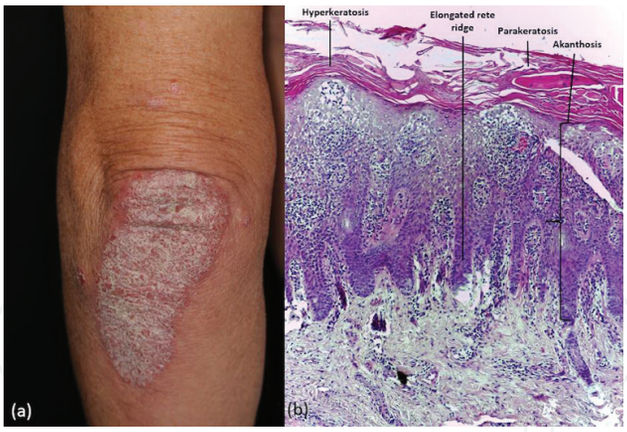

Figure 3. Clinical and histological features of psoriasis plaques. (a) Clinical aspect of a well-demarcated erythematous psoriatic plaque covered with 'silvery' scales (University Clinic Ulm, Clinic for Dermatology and Allergic diseases); (b) schematic structure of psoriasis-affected skin with thickened stratum corneum due to a differentiation disturbance of keratinocytes, elongated rete ridges due to the hyperproliferation of the stratum spinosum, parakeratosis (no loss of nuclei of keratinocytes in the stratum corneum) and acanthosis (thickening of the epidermis) [36].

scaly patches of the distal phalanges of fingers and toes. The frequent involvement of the nail bed and matrix leads to severe nail dystrophy [38].

Erythrodermic psoriasis is the generalized form of the disease, where the entire integument is highly erythematous and covered by superficial scales. Patients usually also develop fatigue, myalgia, fever and chills.

Nail psoriasis emerges in about 61% of cases of cutaneous psoriasis. In less than 5% of cases, the involvement of the nails may appear without cutaneous plaques. The classical manifestations of the nail apparatus include pitting, trachyonychia, leukonychia, Beau 's lines and transverse grooves. The nail bed and hyponychium can present with onycholysis, oil drops, subungual hyperkeratosis and at the distal nail bed splinter haemorrhages may occur [34]. The clinical aspect of nail psoriasis is illustrated in **Figure 4**.

Psoriatic arthritis is an inflammatory disease in which the cutaneous psoriasis plaques coexist with arthritis usually in the absence of rheumatoid factor [39]. The estimated prevalence of psoriatic arthritis among patients with psoriasis is 4–42% (typically) and 80% of patients with psoriatic arthritis present nail psoriasis.

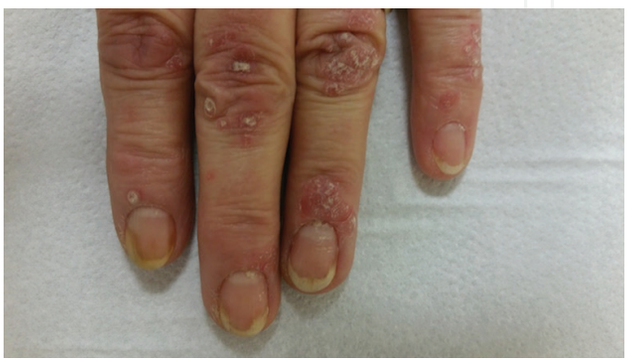

Figure 4. Clinical aspect of nail psoriasis. Pitting, onycholysis, discoloration, periungual lesions.

3.2. Sonography of the psoriasis plaque

Sonography of the psoriasis plaque reveals different features accordingly to the inflammatory process in psoriasis (**Figures 5** and **6**):

- Thickening of the epidermis (hyperechogenic band) and dermis (echogenic or hypoechogenic band) as one of the most common features.
- Hypoechoic band in the upper dermis, particularly detectable in the most active stages of the disease; the hypoechoic band corresponds to the thicker stratum corneum of the epidermis of the psoriasis plaque and is associated with the local inflammatory reaction.
- Increased dermal blood flow (vasodilatation) within the lesion (colour Doppler, power Doppler) due to the local inflammatory process.
- Reduction of epidermal and dermal thickness and the thinning/disappearance of the hypoechoic band at the superficial dermis level as indicators of therapeutic efficacy.
- Slightly increased tissue stiffness (elastography) compared to the surrounding healthy skin (induced by the inflammatory reaction) and a decrease of the lesion stiffness after topical or oral therapies; the tissue stiffness increases in inflammatory processes; it is not specific to psoriasis, can be however of great value for the assessment of the anti-inflammatory therapy in psoriasis [21].

The clinical and sonographic features of active and chronic stationary psoriasis lesions are illustrated in **Figure 5**.

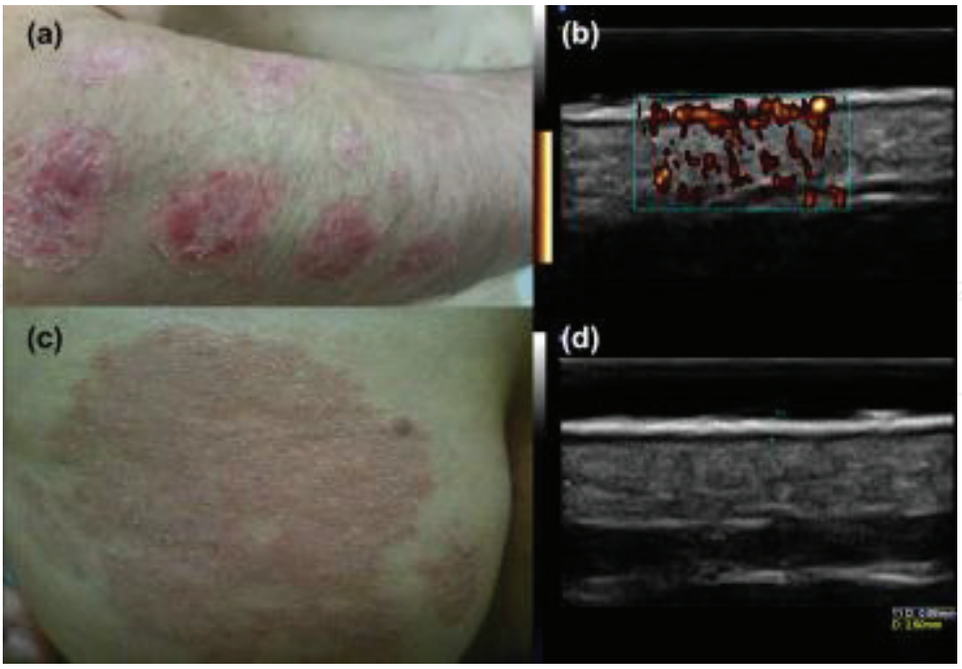

Figure 5. Clinical and sonographic images of active inflammatory and chronic stationary psoriasis plaques. (a) Active inflammatory, infiltrated red plaques covered by silvery scales; (b) thick hyperechoic epidermis, thin hypoechoic band in the upper dermis, thick echogenic and hypervascularised dermis; (c) pale red and less infiltrated stationary psoriasis plaque; (d) thickening of the epidermis and dermis with a thin hypoechoic subepidermal band and no blood vessels identified by Doppler.

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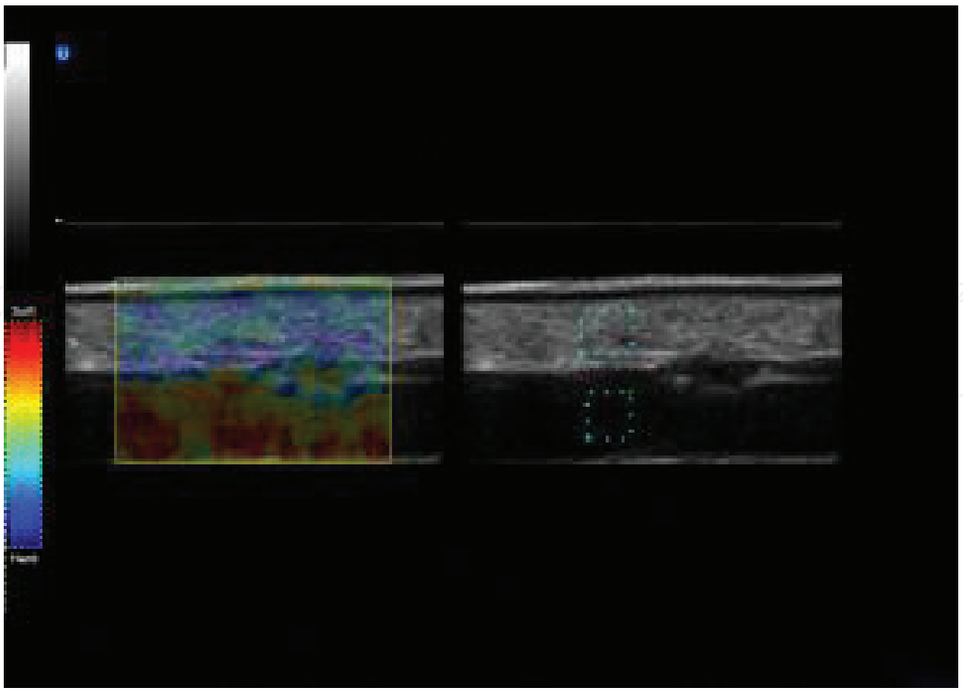

Figure 6. Sonoelastographic appearance of a psoriasis plaque. Slightly blue appearance of the skin lesion, codifying the increase in the stiffness due to the local inflammatory process, compared to the healthy surrounding skin.

The local changes of the tissue elasticity corresponding to a psoriasis plaque are revealed in **Figure 6**.

Related to the therapeutic approach in psoriasis patients, our group used high-frequency ultrasound to investigate the skin reaction after topical therapy with *low potency steroids* (cortisone) and natural extracts of *cranberry* and *black elderberry*, showing that ultrasound can evaluate with great accuracy the changes in psoriasis plaques induced by various topical therapies [16, 17]. We assessed in a comparative manner the anti-inflammatory effect of the natural extracts of cranberry and black elderberry and of cortisone with control lesions only treated with emollients. We could demonstrate by using high-frequency ultrasound a significant improvement of the psoriasis lesions following local therapy with the above-mentioned products. Our results showed a significant decrease of the dermal echogenicity as well as a decrease of the dermal thickness at the level of the treated plaques, due to the decrease of the local inflammatory infiltrate.

3.3. Sonography of nail psoriasis

Psoriatic onychopathy can be the single manifestation of psoriasis or precede the psoriatic plaques in the skin. About 80% of patients with psoriatic arthritis present nail psoriasis [40]. Ultrasound can identify nail changes in psoriasis; however, the finding varies according to the phase of activity of the disease, going from the early inflammatory phase to the late fibrous phase [30]. The most common sonographic features revealed by sonography in nail psoriasis are as follows:

- increased thickness and decreased echogenicity of the NB (**Figure 7**);
- focal hyperechoic spots in the ventral plates;

- loss of definition of the dorsal and ventral nail plate;
- wavy plates and thickening of the dorsal and ventral plates;
- increased blood flow in the proximal NB with low flow arterial vessels especially during the active phases of disease;
- decreased blood flow in the late phase especially in the middle and distal NB;
- preserved distal interplate space of the NP (loss of interplate space proximally in onychomycotic nails);
- thickening of the nail bed (NB thickness > 2 mm as a cut-off value to differentiate between psoriatic nails and healthy nails) [30].

3.4. Sonography of the distal nail joints in psoriasis

In patients with psoriasis arthritis (PsA), the immunological process at joint level is very similar to that in the skin [39]. The process occurs in the deep layer of the synovial membrane whose cells begin to proliferate. The histology of PsA reveals a more intense hyperaemia when compared to rheumatoid arthritis (RA). Inflammatory lesions of tendon and ligament entheses are common in PsA [39]. Five clinical manifestations of PsA were described by Gladman et al. considering that the clinical manifestations are quite distinctive and different from rheumatoid arthritis (RA) [41].

PsA spinal lesions and sacroiliac joint lesions are asymmetric. Involvement of the smaller joints of the hands and feet, especially of the distal interphalangeal joints, seems to be a characteristic feature. According to the same authors, the lesions are accompanied by proliferative lesions of bone tissue located at erosion margins, a very characteristic sonographic sign [42].

The sonographic features of PsA were described by using different equipments: greyscale ultrasound, colour Doppler; power Doppler (power Doppler technique visualizes slow flow in soft tissue, but unlike colour Doppler it does not provide the direction and velocity of blood

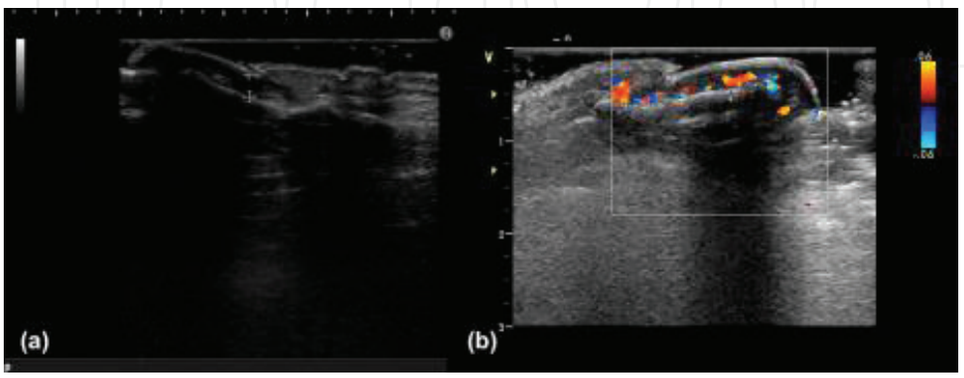

Figure 7. Sonography in nail psoriasis. (a) Nail psoriasis and psoriatic arthropathy with thickening of the NB, irregular wavy nail plates, hyperechoic spots in the nail plate, prominent synovium, anechoic fluid (greyscale). (b) Nail psoriasis with irregular nail plate (NP) and intense Doppler signal in the NB.

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flow); contrast agents show the microcirculation in real time, providing a dynamic assessment of lesion vascularity [43].

The most common sonographic features of PsA are as follows:

- prominent synovium, as a form of an intra-articular mass with echogenicity comparable to soft tissues and non-compressible;
- anechoic fluid;
- periarticular erosions commonly in the interphalangeal joints, appearing as tiny discontinuities of regular bone margins;
- tendinopathy as hypo or heterogeneous echogenicity at the insertion sites of the tendinous even in subclinical stages;
- increased blood flow in the synovium on colour Doppler imaging in active phases [44].

Various sonographic techniques can therefore be effectively used in order to compare different sonographic parameters as an evaluation marker of therapeutic effectiveness. Power Doppler is important for allowing the slow flow detection allowing the visualisation of increased vascularity within inflamed tissue. The method has been used for the semi-quantitative assessment of inflammatory processes (synovial hyperemia) [45].

By means of Doppler, the number of coloured pixels before and after therapy can be evaluated as an indicator of therapy efficacy. The evaluation of treatment effectiveness by spectral Doppler is based on assessing different parameters of which the peripheral flow resistance quantified as resistive index (RI) is more important.

According to literature data, normal peripheral blood flow in the osteoskeletal system is characterised by high values of the IR and the diastolic phase of blood flow is not observed (RI = 1) [39]. The blood flow resistance within inflamed synovium decreases. By contrast, a normalisation of the RI values appears following therapy [24]. The flow in normal synovial membrane, tendons and entheses remain undetectable [39].

4. Study

4.1. Objective

The aim of our study is to identify non-invasive sonographic markers for the assessment of chronic stationary psoriasis plaques and nail psoriasis and for the evaluation of the therapeutic efficacy of various local treatments. We have focused on this issue taking into consideration the research done in the field of imagistic skin assessment as well as our own experience. Thus, during the past 2–3 years, our work involved two research directions:

- A clinical and imagistic assessment of patients suffering from chronic stationary plaque psoriasis and nail psoriasis.
- An imagistic evaluation of the therapeutic efficacy by acquirement of sonographic images before and after different topical therapies.

4.2. Methods

In our prospective controlled study, we used a multimodal evaluation of the disease, based on a non-invasive approach: clinical examination, dermoscopy, conventional and high-frequency ultrasound, colour Doppler, spectral Doppler, power Doppler and elastography.

The study included a total of 74 patients, 46 females and 28 males, aged between 19 and 63 years, with a duration of disease of 6–39 months before admission to the study. The diagnosis of plaque psoriasis with or without nail involvement was made by an experienced dermatologist based on clinical findings. Another group of 30 healthy subjects, 13 females and 17 males, aged 18–59 years, were included as the control group. Patients suffering from autoimmune diseases, diabetes, onychomycosis smokers were excluded from the study, since these conditions might have an influence on the peripheral circulation especially at nail bed level.

All subjects, patients and healthy control participants underwent a sonographic examination, performed by an experienced sonographer, using transducers ranging from 13 to 20 or 40 MHz, in order to better identify structural details.

Sonographic images were taken from the psoriatic skin lesion, healthy surrounding skin, healthy and psoriatic nails. In the healthy control group, the sonographic images of the nails were taken from the same fingers: the thumb and index. On the psoriasis plaque, the centre and the margin of the lesion together with the surrounding normal skin were examined before and after therapy. In the psoriasis group, sonograms were taken from nails with clinical signs of psoriasis as well as apparently healthy nails.

In all our examinations, the ultrasound probe was perpendicularly placed over the region of interest, covered with a large amount of gel in order to provide the best acoustic interface. Each area was examined in greyscale mode in order to identify the morphological and structural parameters, with Doppler techniques and elastography. Part of our work concerning the role of ultrasound in the assessment of the therapeutic efficacy in plaque psoriasis patients was already published [16, 17, 21]. Therefore, in this study, we focused on the examination of the nail apparatus. The parameters of interest were the morphology of the nail unit, the thickness of the nail plate and nail bed, the blood flow distribution, the measurement of the resistive index (IR) and pulsatility index (IP). Data description and data analysis were performed using Microsoft Excel and PSPP 0.10.2. The hypothesis testing was performed by means of *t*-tests for independent samples, with Bonferroni correction for multiple comparisons. Informed consent was obtained from each patient included in our study. The study protocol was approved by the Ethical Committee of the institution.

4.3. Results and discussion

The sonograms of the skin showed differences between healthy skin and the psoriasis plaque. The sonography of the psoriasis plaques revealed: a thicker epidermis, a thicker dermis, with detectable blood vessels only in the active lesions as well as a focal hypoechoic band in the upper dermis compared to the healthy skin. Active lesions are the erythematous infiltrated psoriasis patches appeared for less than 6 months, covered with thinner scales, allowing a better penetration of the ultrasound.

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No blood vessels were identified in the healthy skin. Similar aspects were described by other authors [24]. According to literature data, our work revealed that the thickness of the epidermis and dermis, the presence and the intensity of the Doppler signal and the presence of the hypoechoic subepidermal band are imagistic markers, which characterize the psoriasis plaque and allow an effective monitoring of the therapeutic efficacy. The ultrasonographic evaluation in psoriasis completes the clinical diagnosis, being sometimes essential for the differential diagnosis of various dermatoses (eczema, scleroderma, erythematous lupus, etc.).

The sonograms of psoriatic nails revealed an increased thickness of the NP and NB in psoriasis onychopathy, compared to healthy control nails, but with no statistical significance. The same observations were communicated by Essayed et al. [29]. According to literature data, the thickness of the nail bed could be a morphologic marker for a subclinical nail involvement and a good parameter for the evaluation of the therapeutic efficacy [46].

The blood supply of the nail bed as well as blood velocity (V), pulsatility index (PI) and resistive index (RI) were investigated by colour Doppler, spectral and power. We found an interesting distribution of the blood vessel parameters in the NB according to the local inflammatory process. We measured all data mentioned above and established the mean values for each of them in every group of interest.

In the control group, all parameters mentioned were taken from the same fingers (thumb and index). We noticed that the thickness of the nail plate has an average of 0.55 mm, being slightly higher in men (statistically not significant). The average thickness of the nail bed was slightly higher in left-handed persons. This can be explained by the fact that left-handed people, using mainly their left hand for daily activities, can develop a local hypervascularity state at the level of the nail bed, leading to a structural reorganization and consequent thickening of the nail matrix.

Concerning the distribution of the blood vessels at nail bed level, we identified following aspects:

- In *healthy nails*, we identified few thin blood vessels especially in the middle part and distal extremity of the NB; power Doppler revealed tiny vascular spots in the whole NB.
- In *psoriasis patients without clinical nail involvement*, we identified larger colour spots corresponding to dilatation of blood vessels according to the local inflammation status.
- In 21 *psoriasis patients with nail involvement having clinical changes* and an evolution longer than 19 months, the blood supply was reduced and present especially at the proximal NB region.

The variation of the mean values of the sonographic parameters is presented in **Table 1**.

Concerning the IP parameter, we found a discrete increase in psoriasis patients without nail involvement (due to a minimal local inflammatory process) and almost double values in patients with nail involvement. The highest values were observed in patients having changes in the associated distal interphalangeal joints. The data is displayed in **Figure 8**.

The IP index is known to display increased values in the periphery due to the presence of the pre-capillary sphincters, as it is the first parameter to undergo a change at the beginning of

	Average values in control group		Psoriasis patients without nail changes		Psoriasis patients with nail changes	
Vm average	4.49	[1.3–8.49]	5.28	[1.3–10.23]	5.99	[0.9–13.48]
IP average	1.34	[0.52–2.79]	1.31	[0.39–2.04]	2.36	[1.44–3.98]
IR average	0.66	[0.41–1.12]	0.64	[0.28–0.79]	0.98	[0.83–1.75]

Table 1. Average values of blood velocity, IP and IR in the control group, patients with psoriatic nail changes and without nail changes.

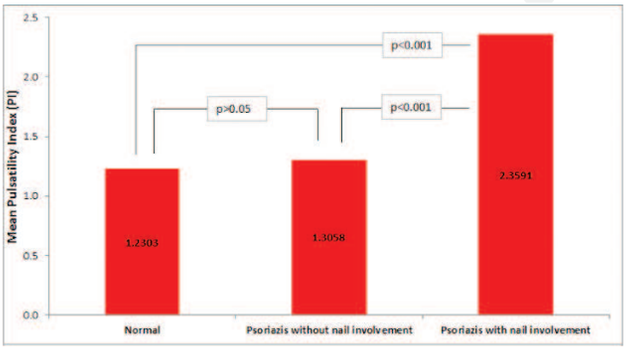

Figure 8. The evolution of IP parameter during the clinical stages of the psoriasis. The pulsatile index (IP) measured at the nail level increases slightly in patients with skin plaque psoriasis and reach high values in patients with clinical nails involvement.

the local inflammatory process. Therefore, a slight increase of the IP is noticed at the level of the nail bed, due to the existence of a subclinical inflammatory process. In chronic situations where fibrosis settles in, IP continues to increase reaching almost double values. IP values above 2 can be seen in patients displaying the involvement of the distal interphalangeal joints (synovitis, articular erosions). Therefore, the IP index can be considered a predictor marker for the progression of the disease towards nail psoriasis and involvement of the distal interphalangeal joint.

Concerning the IR parameter, the value slowly decreases from 0.66 to 0.64 in patients without nail involvement and increases in patients with clinical nails changes to 0.98 (**Figure 9**).

IR, IP and the blood velocity are imagistic markers, which can quantify the microcirculation at the level of the nail bed. In psoriasis patients with no nail involvement, a subclinical inflammatory status can be identified at the level of the nail bed, quantified by an increase of the IP value and a decrease of the IR. Clinical nail changes in psoriasis represent the morphological expression of an intense inflammatory process (IP > 1.3), which induces a local fibrosis of the tissue with a slow increase of the IR (IR > 0.64). According to Ovistgaard et al., inflammatory processes also involving the inflammation of the joint synovia display a decreased IR, which tends to normalize after therapy [47].

Further clinical, imagistic and histological studies are required to better characterize the accuracy and relevance of the studied parameters as potential signs of disease progression, risk of complications' development and efficacy of various therapies in psoriasis.

http://dx.doi.org/10.5772/67812

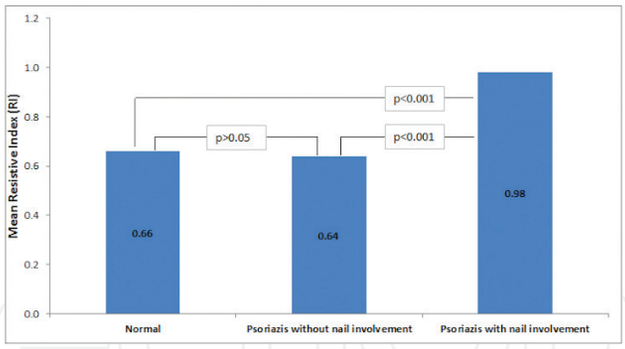

Figure 9. The evolution of the IR parameter according to the clinical stages and local inflammation process of disease.

To our knowledge, this is the first imagistic study quantifying the microcirculation at nail bed level in psoriasis, by measuring the values of the vascular parameters (IP, IR). We consider IP and IR as two imagistic parameters which can be objectively used for the diagnosis as well as for the long-term evaluation of various therapies.

5. Conclusions

Ultrasonography is an important non-invasive tool, which completes the clinical diagnosis in skin pathology. It offers new and specific 'real time' markers, which allow the assessment of the extension, evolution, risks and long-term therapeutic efficacy in inflammatory skin disorders such as psoriasis. Ultrasound has become an invaluable tool for dermatologists for daily clinical practice, offering at the same time multiple new research perspectives.

Acknowledgements

We are indebted to Prof. Sorin Dudea for providing us with the ultrasonographic images

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