RASIŃSKA, Aneta, RZYCZNIOK, Piotr, RZYCZNIOK, Anna, WERONIKA RASIŃSKA, JACHIMCZAK, Justyna, GRYDŹ, Filip, FILIPOW, Joanna, REBIZAK, Anna, BALA, Paulina, ROSTKOWSKA, Aneta, KUPISIAK, Sebastian, PASIERB, Natalia, MATUSIK, Justyna and KOPCZYŃSKI, Mateusz. High-Frequency Ultrasonography As An Innovative Diagnostic Method in Dermatology. Quality in Sport. 2025;43:61400. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.43.61400
https://apcz.umk.pl/QS/article/view/61400

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 24.05.2025. Revised: 05.07.2025. Accepted: 05.07.2025. Published: 12.07.2025.

High-Frequency Ultrasonography As An Innovative Diagnostic Method in Dermatology

Aneta Rasińska[1], MD
Municipal Hospital No. 4 in Gliwice Ltd. Zygmunta Starego 20, 44-100, Poland
ORCID 0009-0007-2872-8000
ane.rasińska@gmail.com

Piotr Rzyczniok[2], MD
Private Healthcare Institution ProCordi Ltd., 44-335 Jastrzębie Zdrój, ul. Wyspiańskiego 8, Poland
ORCID 0009-0004-5899-2345
piorzy@gmail.com

Anna Rzyczniok[3]
Medical University of Silesia in Katowice, 40-055 Katowice, ul. Poniatowskiego 15, Poland
ORCID 0009-0007-6069-2650
anna.rzycz@gmail.com

Weronika Rasińska[4], B. Eng.
Silesian University of Technology, 44-100 Gliwice, ul. Akademicka 2a, Poland
ORCID 0009-0004-2404-2958
weronika.rasinska@gmail.com

Justyna Jachimczak[5], MD
Our Lady of Perpetual Help Hospital in Wołomin, 05-200 Wołomin, ul. Gdyńska 1/3, Poland
ORCID 0009-0005-7614-9500
justyna.jachimczak@op.pl

Filip Grydź[6], MD
Our Lady of Perpetual Help Hospital in Wołomin, 05-200 Wołomin, ul. Gdyńska 1/3, Poland
ORCID 0009-0001-6341-7810
filip.grydz7@gmail.com

Joanna Filipow[7], MD
Warsaw Southern Hospital, 02-781 Warszawa, ul. Rtm. Witolda Pileckiego 99, Poland
ORCID 0009-0002-3491-9667
joannafilipow99@gmail.com

Anna Rebizak[8]
Academy of Silesia in Katowice, 40-555 Katowice, ul. Rolna 43, Poland
ORCID 0009-0000-6439-2726
aniarebizak@gmail.com

Paulina Bala[9], MD
Our Lady of Perpetual Help Hospital in Wołomin, 05-200 Wołomin, ul. Gdyńska 1/3, Poland
ORCID 0009-0007-0604-8549
p.bala@op.pl

Aneta Rostkowska[10], MD
Independent Public Clinical Hospital named after Prof. W. Orłowski, 00-416 Warszawa, ul. Czerniakowska 231, Poland
ORCID 0009-0007-1142-2507
aarostkowska@gmail.com

Sebastian Kupisiak[11], MD
Czerniakowski Hospital Ltd., 00-739 Warszawa, ul. Stępińska 19/25, Poland
ORCID 0009-0007-9631-2314
sebastiankupisiak@gmail.com

Natalia Pasierb[12], MD
Military Medical Institute in Warsaw, Warszawa 04-141, ul. Szaserów 128, Poland
ORCID 0009-0002-9701-1162
nnpasierb@gmail.com
Justyna Matusik[13]
Academy of Silesia in Katowice, 40-555 Katowice, ul. Rolna 43
ORCID 0009-0009-7907-9690
matusik.justyna1@gmail.com

Mateusz Kopczyński[14], MD
Municipal Hospital Complex in Częstochowa, Częstochowa 42-200, ul. Mirowska 15
ORCID 0009-0009-6592-3061
kopczynskimat@gmail.com

Abstract:

Ultrasonography is now a standard, non-invasive imaging technique used in many areas of medical diagnostics. Currently it is also an important tool in the diagnosis of skin diseases. Ultrasound examination of the skin is possible thanks to classic ultrasound scanners equipped with probes with a frequency of up to 20MHz, as well as high-frequency ultrasound scanners with mechanical probes with a frequency of up to 100MHz. In clinical practice, High Frequency Ultrasonography (HFU) is used more and more often because it has proved to be a valuable diagnostic tool for assessing the condition of skin tissue. The physical conditions of HFU make it possible to estimate the parameters of the skin structure, such as thickness and echogenicity (a feature related to the center) of its layers in relation to the surrounding tissues. Therefore, HFU allows to obtain information concerning the condition of the examined area of the skin., the rate of lession development and the effectiveness of implemented theraphy. HFU is applied in the imaging of focal skin lesions, including melanoma and basal-cell carcinoma. It can also be used to monitor the treatment of inflammatory skin diseases and diseases associated with its thickening. Aesthetic medicine and cosmetology are areas in which the use of HFU is more and more popular. The aim of this chapter is to familiarize the reader interested in dermatology and in particular diagnostics in this field, the possibilities associated with the use of HFU.
Purpose – To introduce high-frequency ultrasonography (HFU, ≥ 20 MHz) as an innovative, non-invasive imaging modality in dermatology, outlining its physical principles and demonstrating how it

enhances diagnosis, staging and therapeutic monitoring of cutaneous diseases such as melanoma, basal-cell carcinoma, inflammatory dermatoses and photo-ageing.
Material and Methods – Narrative literature review combined with technical exposition of HFU devices (20–100 MHz mechanical and broadband linear probes). The authors summarise depth–resolution trade-offs, standard scanning protocols and representative clinical images to illustrate HFU performance across anatomical sites and skin conditions.
Findings – HFU resolves skin strata down to 10 µm, quantifies tumour thickness (Breslow depth) pre-operatively, delineates BCC margins, detects subepidermal low-echogenic band as a marker of photoageing or atopic dermatitis severity, and guides real-time assessment of fillers, vascular flow, oedema and fibrosis. Frequencies of 20–30 MHz visualise full dermis, 50 MHz epidermis/upper dermis, while lower (7–12 MHz) probes image deeper lesions and lymph nodes.
Value – HFU offers radiation-free, bedside, repeatable skin imaging that improves diagnostic accuracy, surgical planning and outcome monitoring; its adoption is expanding from research centres into routine dermatology, aesthetic medicine and cosmetology. Standardised protocols and operator training are needed to fully integrate HFU into personalised patient care.

Keywords: dermatology, high frequency ultrasonography, melanoma, basal-cell carcinoma

INTRODUCTION

Ultrasound was first introduced into dermatology in 1979, when Alexander and Miller used a mechanical ultrasound transducer operating at a frequency of 15 MHz to measure skin thickness [1]. Their published scientific article laid the foundation for the development of specialized skin imaging scanners. In recent years, there has been significant progress in diagnostic methods used in dermatology. Novel and advanced high-resolution imaging techniques have emerged, such as reflectance confocal microscopy and optical coherence tomography [2, 3]. Although the clinical application of these technologies in dermatology is highly promising, skin ultrasonography is gaining increasing popularity. Technological advancements have made it possible to enhance the frequency of ultrasound waves generated by the transducer, resulting in images with significantly higher resolution. As a result, high-frequency ultrasonography (HFU) has become a promising tool that is now being successfully incorporated into the daily practice of dermatologists. A major advantage of this diagnostic method is its reliability and safety for patients, due to the absence of ionizing radiation [4]. Moreover, it is a user-friendly, quick, relatively inexpensive, and widely accessible technique [5]. Additional benefits of HFU include real-time imaging capabilities and a general lack of contraindications for its use.

Basic Principles of Ultrasonography

The term HFU (High-Frequency Ultrasound) has been introduced and reserved for frequencies equal to or greater than 20 MHz, which are specifically intended for skin imaging. These frequencies allow for the differentiation of structures smaller than 100 µm along the beam axis (axial resolution) and 200 µm along the scanning axis (lateral resolution) [4, 6–8]. Probes operating at 20 MHz represent an established method in dermatology for visualizing the entire skin structure (including the papillary and reticular dermis, and the upper parts of the subcutaneous tissue—depending on anatomical location). In contrast, higher frequencies—up to 100 MHz—provide even more detailed imaging of the epidermis and upper dermis, offering axial resolution around 10 µm and lateral resolution of approximately 84 µm. However, such high-resolution imaging remains primarily in the experimental phase. Visualizing lesions located in the deeper layers of subcutaneous tissue and evaluating regional lymph nodes requires greater penetration of the ultrasound waves into these structures, which is made possible by using frequencies ranging from 5 to 12 MHz [4]. The composition of the tissue determines the appearance of the ultrasound image because it directly influences the characteristics of the reflected sound waves. Waves that strike the boundary between two media with different acoustic properties may be reflected [4–8]. Once reflected, they return to the transducer as echoes of a specific energy. Waves that are not immediately reflected become attenuated or are reflected at the next interface encountered between two media. The ultrasound image is essentially a reflection of the acoustic impedance differences between various tissues. Acoustic impedance depends on the density and elasticity of a given medium. The greater the difference in acoustic impedance between two media, the stronger the wave reflection. The most pronounced impedance differences exist between bones or calcifications and soft tissues. In ultrasound images, bright areas are referred to as hyperechoic, while dark areas are described as anechoic [4, 6–8].

Frequencies of Applied Ultrasound

Ultrasound imaging of the skin requires the use of transducers operating at higher frequencies than those used in conventional ultrasonography (up to 20 MHz). Higher frequencies enhance image resolution, enabling the visualization of finer skin structures. However, this comes at the expense of reduced penetration depth of the ultrasound beam. Transducers operating at frequencies of 50 MHz, 20 MHz, and 10 MHz penetrate tissues to depths of approximately 3–4 mm, 10 mm, and 35 mm, respectively (Table 1) [7, 9, 11]. The selection of the appropriate frequency depends on the diagnostic goal. For imaging the dermis and subcutaneous tissue, a 20–30 MHz transducer is most suitable. The epidermis is best visualized using a transducer in the 75–100 MHz range. Transducers operating at frequencies >20 MHz are classified as high-frequency ultrasound (HFUS) devices. Transducers in the 30–70 MHz range are considered ultra-high frequency (UHF) transducers and are capable of evaluating minute structures such as sebaceous, apocrine, and eccrine glands [10]. Currently available devices on the market include standard ultrasound scanners with broadband linear transducers operating between 10 MHz and over 20 MHz, as well as specialized scanners equipped with mechanical transducers of fixed frequencies >20 MHz. For comprehensive ultrasound imaging of the skin, the most optimal approach would involve the combined use of both types of scanners mentioned above [11].

Frequency [MHz]	Penetraion Depth [mm]	Visualized Structures
7,5	>40,0	Deep structures, lymph nodes
10,0	35,0	Epidermis, dermis, subcutaneous tissue
20,0	10,0	Epidermis, dermis, part of the subcutaneous tissue
50,0	3,0-4,0	Epidermis, dermis
75,0	3,0	Epidermis, part of the dermis
100,0	1,5	Epidermis only

Table 1. The table presents the varying depth of ultrasound penetration depending on the applied frequency [7, 9, 11].

Ultrasonographic Image of Healthy Skin

In the ultrasonographic image of healthy skin in vivo, three distinct layers can be identified (Figure 1) [4–8, 12–15].

Epidermis – (thickness = 0.06–0.6 mm): This layer appears as a thin, highly hyperechoic band, often referred to as the entry or initial echo. The epidermis consists of two main cell types: keratinocytes and melanocytes, located in the outermost layer [12, 15].

The concept of the entry echo remains a subject of discussion. It is debated whether the initial echo corresponds solely to the stratum corneum or to the full thickness of the epidermis. Some authors argue that the term "epidermal echo" would be more accurate [8, 14]. The entry echo is most likely caused by differences in acoustic impedance between the skin and the ultrasound gel applied during examination [15]. It reflects the outermost part of the epidermis, particularly the interface between the water-based gel and the stratum corneum. Below this, a second echogenic band may correspond to the boundary between the stratum corneum and the Malpighian layer [16]. This double entry echo is more frequently observed in skin with a thick stratum corneum, such as the palms and soles [13]. Studies have not confirmed a direct correlation between the thickness of the entry echo and the measured thickness of the stratum corneum or the entire epidermis [8]. Using a 20 MHz probe, it is not possible to distinguish all layers of the epidermis—only the stratum corneum and the dermo-epidermal junction can typically be visualized [5, 8].

Dermis – (thickness = 1–4 mm): This layer appears heterogeneous, rich in scattered echoes of varying intensity. Hypoechoic reflections originate from the extracellular matrix, whereas hyperechoic signals are generated by collagen fibers. Within this layer, it is possible to visualize vessels, glands, and hair follicles, which appear as hypoechoic structures. In some cases, deeper layers of the epidermis may also be visible within the dermis [11, 12, 15]. Dermal thickness varies with anatomical location and gender. Male skin is generally thicker than female skin. The thickest dermis is typically found on the torso, neck, and submental area. The thicker the dermis, the more difficult it becomes to visualize subcutaneous structures [15, 17]. With age, dermal echogenicity also changes. It is most hypoechoic in newborns. A progressive increase in echogenicity is observed over the following months and continues into adulthood [15–18]. Dermal echogenicity is influenced by the content of collagen fibers and water. An accumulation of collagen fibers increases echogenicity, while an increase in water content, damage to elastic fibers, or the presence of inflammatory or neoplastic cells decreases the overall echogenicity [12].

Subcutaneous Tissue – (thickness = 5–22 mm): This layer appears hypoechoic (ranging from anechoic to low echogenicity), within which more echogenic structures can be visualized. Fine, linear, hyperechoic reflections radiating in various directions originate from connective tissue fibers separating fat lobules. Depending on the selected frequency, either the entire subcutaneous layer or only part of it can be imaged. Moreover, the latest generation of ultrasound devices allows visualization of both arterial and venous vessels. When examining certain anatomical areas - such as the nose or forehead - underlying bone structures may also be visualized [7, 11, 12, 15, 16].

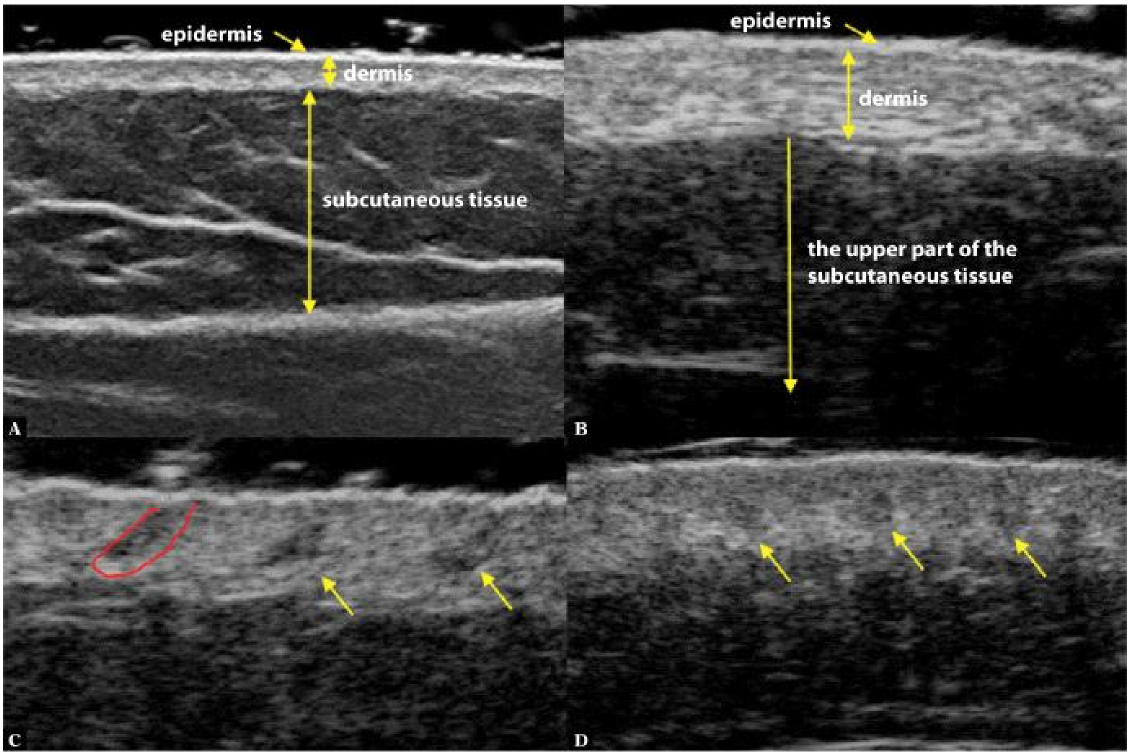

Figure 1. *The figure presents the ultrasonographic image of healthy skin:*
A. Conventional ultrasonography using a linear probe (5–18 MHz).
B. High-frequency ultrasonography (48 MHz probe).
C. HFU, 48 MHz probe – hair follicles indicated.
D. HFU, 48 MHz probe – sweat glands indicated within the forehead skin [11].

Subepidermal low-echogenic band (SLEB) /Subepidermal non-echogenic band (SENEB)

In the ultrasound image of skin that has been heavily exposed to sunlight, the presence of a subepidermal low-echogenic band (SLEB) or a subepidermal non-echogenic band (SENEB) can be observed (Figure 2) [18, 19]. The occurrence of SLEB is most likely associated with solar elastosis, alterations in collagen structure, and water accumulation [18]. The thickness of the SLEB increases with age, and its presence has been demonstrated in more than 50% of adults over the age of 40 [20]. Since the presence and thickness of SLEB correlate with skin exposure to solar radiation, it is considered a marker of photoaging. As a result, SLEB has been used to monitor the effectiveness of anti-aging treatments [16–18].

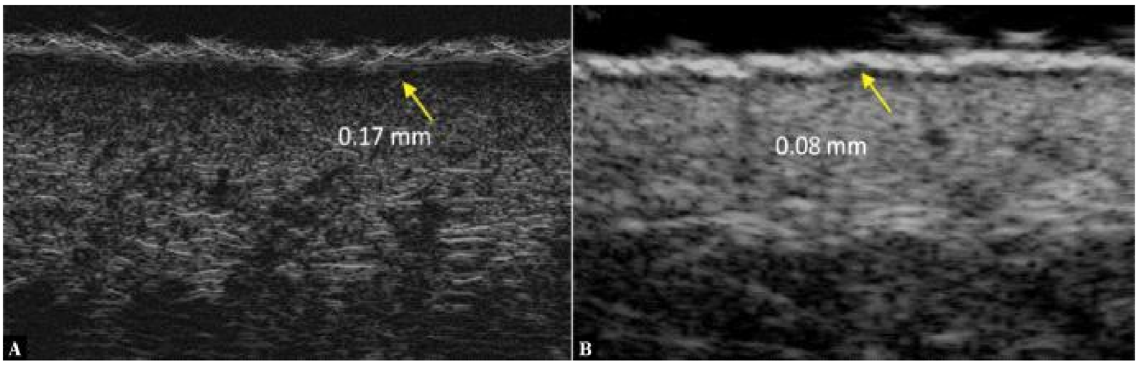

Figure 2. The arrows in the figure indicate the SLEB in the ultrasound image of healthy skin. A. Forehead skin, 50 MHz probe. B. Hand skin, 48 MHz probe [11].

Ultrasound Image Analysis

The ultrasonographic image of the skin is assessed both qualitatively and quantitatively. Qualitative analysis is performed by the examiner based on visual comparison of images. To evaluate the severity of a skin lesion, it is necessary to compare the image of the affected skin with that of healthy skin at a corresponding anatomical location (e.g., if the affected skin is on the right forearm, the image is compared with that of healthy skin on the left forearm). To monitor therapy progress or disease progression, images of the same site are compared over time (e.g., comparing the scarred skin before treatment, during therapy, and after its completion). The most commonly used parameter for qualitative assessment is echogenicity. Recently, scanners equipped with mechanical transducers have been introduced, which allow for pixel count measurements within a specific grayscale range in the area under evaluation. This enables a quantitative determination of echogenicity [11].

Assesed Parameters

The following parameters are subjected to quantitative analysis:

1. **Thickness -** this is the primary parameter evaluated; the thicknesses of all skin layers (epidermis, dermis, subcutaneous tissue) as well as SLEB/SENEB are taken into account [11, 21].
2. **Surface area and depth** of lesions or selected skin tissue structures [11].
3. **Blood flow in small vessels -** the presence of slow and minimal blood flow in the fine skin vessels [11].
4. **Tissue stiffness and its susceptibility to deformation -** measured using sonoelastography [11, 22].

CURRENT APPLICATIONS OF HFU IN DERMATOLOGY

Existing studies show that High-Frequency Ultrasound (HFU) can be particularly useful in imaging focal lesions—benign lesions, skin cancers (including melanoma and basal cell carcinoma (BCC))—as well as in monitoring dermatological treatments for inflammatory skin diseases and disorders associated with skin thickening [4, 7, 12, 13]. Moreover, HFU has found numerous applications in aesthetic medicine and cosmetology.

Melanoma

Melanoma is a malignant, potentially fatal tumor. Incidence rates of melanoma continue to rise [23]. Among newly diagnosed cases in Europe, the highest mortality rates are observed in Central and Eastern European countries [24]. Currently, the qualification for surgical removal of a suspected melanoma lesion is mainly based on dermatoscopic examination. The surgically excised specimen is then subjected to histopathological evaluation [25]. The most important parameter assessed by pathologists is tumor thickness, measured in millimeters and refined using the Breslow scale [26]. Other key parameters evaluated include the mitotic rate (mitotic index), satellitosis, distant metastases, presence of ulceration, and number of involved lymph nodes [26, 27, 28, 29]. The results guide decisions about potential additional excision margins, sentinel lymph node biopsy, or systemic treatment implementation [30, 31].

It is undisputed that accurate determination of tumor depth and excision margin size is essential for effective treatment. HFU, as a non-invasive method, proves highly valuable in the preoperative assessment of skin melanoma. Tumor thickness measured by HFU correlates well with histopathological results [32–36]. Precise knowledge of melanoma invasion borders undoubtedly contributes to an increase in radical surgical procedures. It should be noted that tumor thickness measured by ultrasound is generally greater than that measured by histopathology [16]. This discrepancy arises from the presence of inflammatory infiltrate around the tumor (ultrasound resolution may be insufficient to distinguish inflammatory from malignant infiltration) or pigmented skin lesions located beneath the melanoma [32, 37]. Tissue shrinkage during histopathological specimen preparation (biopsy material contraction) also significantly affects thickness measurements.
In ultrasound images, melanoma typically appears as homogeneous echo-enhancing areas [8, 14–16]. The shape of these areas depends on the melanoma subtype. Nodular echo-enhancing areas may be spherical, whereas superficially spreading melanoma presents echo-enhancing areas as a thin layer parallel to the entrance echo (Figure 3) [12]. Such an image lacks specific features diagnostic for melanoma, making it impossible to distinguish melanoma from melanocytic lesions. Melanocytic nevi appear as echo-free (anechoic) structures, similar to melanoma [4, 5, 16].

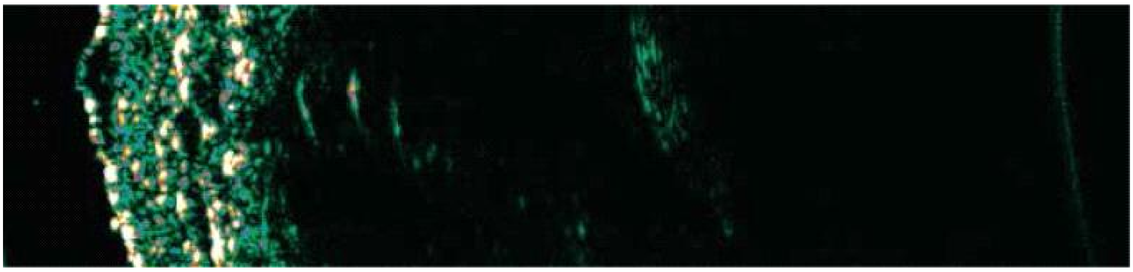

Figure 3. The figure shows an ultrasound image of superficial melanoma on the right forearm of a 64-year-old woman [12].

Analysis of ultrasound images obtained using HFU showed that melanoma can be distinguished from seborrheic keratosis with 100% sensitivity and 79% specificity. However, the differentiation between melanoma and melanocytic nevi is very poor, with a specificity of only 30%. Ultrasound images of melanomas typically show small shadows and most often a thin entrance echo. In contrast, seborrheic keratosis is characterized by distinct attenuating properties (acoustic shadow) and an increased exit echo caused by hyperkeratosis [38].

Skin neoplasms - Basal Cell Carcinoma (BCC)

Basal cell carcinoma (BCC) is the most common skin cancer in humans. The incidence of BCC continues to rise worldwide. The main etiological factor in BCC development is exposure to UV light, especially UVB. BCC mainly occurs on sun-damaged skin and rarely develops on mucous membranes, palms, or soles. It is usually a slow-growing tumor that rarely metastasizes. Although BCC rarely leads to death, it can be highly destructive and deform local tissues if treatment is inappropriate or delayed. Clinically, BCC typically appears as flesh-colored or pink, pearly papules with ulceration or telangiectatic vessels [39]. The ultrasonographic image of BCC shows hypoechoic oval or round structures surrounded by hyperechoic areas (Figure 4) [16, 13]. Additionally, increased entrance echo can be visualized in BCC, which may show interruptions in the presence of erosions or ulcers [14-16, 40]. In some BCC subtypes, scattered hyperechoic structures described as “cotton flower” can be seen within the hypoechoic oval tumors [12]. This phenomenon is most likely caused by keratinized cells, calcifications, nests of apoptotic cells, and necrosis [7, 8, 16]. When defining tumor margins, approximately 30-70% of BCCs have a clearly defined basal border, and only 50% have a sharp lateral margin [12]. Sebaceous gland hypertrophy may further complicate sonogram interpretation, resulting in a blurred image (a "blurred tumor") [13].

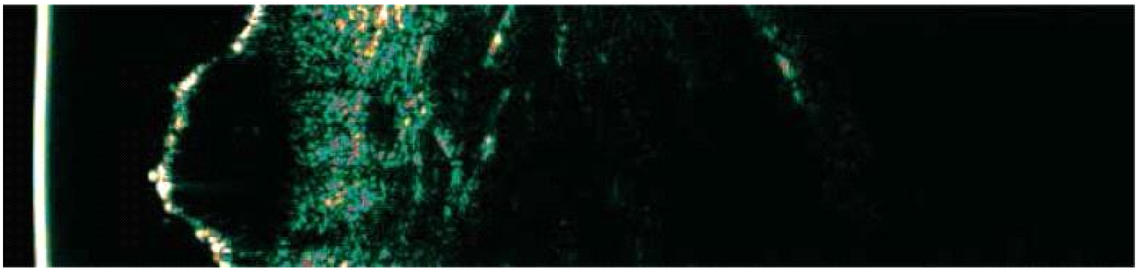

Figure 4. *The figure shows the ultrasonographic image of BCC, location – neck [12].*

Diseases Characterized by Skin Thickening

An important application of HFU is monitoring the treatment of diseases characterized by collagen deposition in the skin. An increased number of collagen fibers results in thickening of the skin and increased echogenicity. Ultrasonographic examination of the skin in systemic sclerosis has demonstrated skin thickening [41]. In diseases with skin thickening, the phase of the disease significantly influences the ultrasonographic appearance. Thus, increased echogenicity and thickness are observed during the sclerosis phase, while the atrophic phase is characterized by skin thinning and echogenicity similar to surrounding tissues.

Inflammatory Skin Diseases

The ultrasonographic image of inflammatory skin diseases—such as atopic dermatitis (AD), eczema, and psoriasis—is characterized by a subepidermal low-echogenic band (SLEB) of variable thickness and reduced echogenicity of the dermal layers [7, 8, 42, 43]. Reduced echogenicity results from infiltration of inflammatory cells and skin edema. The presence of water causing edema increases the spacing between collagen fibers, leading to decreased density of the skin tissue. The location of hypoechoic areas depends on the cause. Hypoechoic areas mainly in the upper dermis are typical for eczema and are also seen in chronic venous insufficiency. In contrast, hypoechoic areas localized primarily in the reticular dermis (usually its lower part) are caused by congestive heart failure [44].
The ultrasonographically measured thickness of the SLEB can serve as a justified parameter to monitor the course of AD because it correlates with the severity of skin lesions during the disease [45, 46]. Comparison of sonograms from AD patients with histopathological examinations shows statistically significant correlations between the thickness of the hypoechoic band and parameters such as epidermal hyperplasia, degree of epidermal hyperkeratosis, parakeratosis, and intensity of inflammatory infiltrates [12, 45]. Furthermore, in some AD patients, a thin SLEB can be detected in the apparently healthy skin surrounding the inflamed area, which likely reflects subclinical inflammation [45]. The sonogram of psoriatic scales resembles that of lesions seen in AD. Additionally, psoriasis exhibits a thickened entrance echo and blurred, perpendicular shadows to the entrance echo, probably caused by air bubbles trapped between the scales [40]. The total skin thickness within psoriatic plaques increases and decreases during treatment, which can be visualized using HFU [47].

Aesthetic Medicine and Cosmetology

In aesthetic medicine and cosmetology, ultrasonographic examination of the skin is useful at every stage of the procedure: from planning and monitoring treatment to evaluating therapy outcomes and potential complications [12, 13]. The most important applications are listed below.

- Assessment of skin condition and the degree of photoaging, followed by monitoring treatment effectiveness. In evaluating photoaging, measuring the thickness of the SLEB (subepidermal low-echogenic band) holds the greatest diagnostic value [10, 48].
- Identification and evaluation of the location and extent of tissue fillers and botulinum toxin. Tissue fillers are very well visualized in ultrasound images. The most common filler—hyaluronic acid—is seen as a round, anechoic space [12, 49, 51].
- Assessment of complications following aesthetic procedures [10, 12]. HFU allows monitoring of early complications such as edema of the dermis and subcutaneous tissue, lymphatic swelling, abscesses, and hematomas. It also enables control over late complications, including fat necrosis, granulomas, and fistulas [52].
- Evaluation of subcutaneous tissue, including cellulite, and monitoring of anti-cellulite therapy [12, 53]. Ultrasound can clearly visualize cellulite, which appears as characteristic rough projections of subcutaneous tissue into the dermis [12].
- Performing procedures under HFU guidance, such as hyaluronidase injections and visualization of the reduction in size of hyaluronic acid deposits [49].

CONCLUSION

Ultrasonographic examination using high-frequency ultrasound (HFU) is an extremely valuable yet significantly underappreciated diagnostic and monitoring tool in the field of dermatology. Despite its proven utility and growing evidence supporting its applications, HFU remains primarily confined to scientific and research institutions, where it is most often utilized for advanced studies and clinical trials. This limited use is likely due to several factors, including the high cost of equipment, the need for specialized training, and the lack of standardized protocols for skin ultrasonography. Nevertheless, the landscape is gradually changing, and high-frequency ultrasound devices are beginning to find their way into routine clinical practice within dermatology offices. This trend is promising, as HFU offers numerous advantages over other diagnostic methods: it is non-invasive, provides real-time imaging, allows for quantitative assessment of skin layers and lesions, and can be repeated as often as necessary without patient risk. Early adoption in everyday clinical settings could significantly improve diagnostic accuracy, treatment planning, and monitoring of various skin conditions. The integration of HFU into daily practice is even more advanced in the fields of aesthetic medicine and cosmetology. These disciplines, driven by rapid innovation and high patient demand for effective and minimally invasive treatments, tend to embrace new technologies quickly. Aesthetic practitioners often utilize HFU to assess skin condition, plan interventions such as filler injections or laser treatments, monitor therapeutic outcomes, and detect potential complications early on. The dynamic nature of these fields, combined with a strong emphasis on precision and safety, has made HFU an increasingly indispensable tool. For HFU to become widely adopted across dermatology and related fields, there is an urgent need to develop clear, standardized, and comprehensive guidelines specifically tailored for skin ultrasonography. These guidelines should cover aspects such as scanning protocols, parameters to be measured, image interpretation criteria, and reporting standards. Establishing uniform procedures would help ensure consistency, reliability, and reproducibility of results across different centers and operators. In addition to standardized protocols, the implementation of dedicated training programs for HFU operators is critical. Ultrasonography of the skin requires a specialized skill set that includes understanding skin anatomy, disease-specific ultrasonographic patterns, and technical proficiency in handling high-frequency transducers. Proper training would enhance operator competence, reduce diagnostic errors, and increase clinician confidence in utilizing HFU effectively. Moreover, popularizing HFU through conferences, workshops, and educational materials targeted at dermatologists, cosmetologists, and other skin care specialists will play a vital role in raising awareness of the technique's benefits and applications. Increasing familiarity with HFU could lead to its more routine incorporation into clinical workflows, ultimately benefiting patient care. From a technological standpoint, high-frequency ultrasound scanners equipped with mechanical transducers also require further refinement and standardization. Different devices and transducer models may produce variable results, particularly when assessing echogenicity—a key parameter in skin evaluation. Harmonizing device calibration and image acquisition settings will facilitate comparison of results between clinics and improve the overall quality of ultrasonographic assessments. Additionally, the future development of ultrasound software should prioritize automation and intelligent analysis features. Automated measurement tools, image enhancement algorithms, and AI-assisted interpretation can significantly reduce operator-dependent variability and measurement errors, leading to more objective and accurate evaluations. The various promising applications of high-frequency ultrasound presented in this paper—from diagnosing skin tumors and inflammatory conditions to monitoring therapeutic outcomes in aesthetic treatments—underscore its potential to transform dermatologic practice. By encouraging physicians, cosmetologists, and other skin specialists to embrace HFU, this technology can become an integral part of everyday patient management, improving diagnostic precision, guiding targeted therapies, and ultimately enhancing patient outcomes.

Disclosure

Authors do not report any disclosures.

Authors' contributions

Conceptualization: Aneta Rasińska, Aneta Rostkowska, Paulina Bala, Filip Grydź;

Methodology: Piotr Rzyczniok, Justyna Matusik, Anna Rebizak;

Software: n/a; check: Piotr Rzyczniok, Natalia Pasierb;

Formal analysis: Aneta Rasińska, Anna Rebizak, Aneta Rostkowska;

Investigation: Aneta Rasińska, Joanna Filipow, Justyna Matusik, Weronika Rasińska, Anna Rzyczniok;

Resources: Natalia Pasierb, Filip Grydź, Anna Rebizak, Mateusz Kopczyński;

Data curation: Aneta Rostkowska, Paulina Bala, Joanna Filipow;

Writing -rough preparation: Natalia Pasierb, Sebastian Kupisiak, Anna Rzyczniok;

Writing -review and editing: Justyna Jachimczak, Justyna Matusik, Weronika Rasińska;

Visualization, A. Rasińska, Filip Grydź, Sebastian Kupisiak, Weronika Rasińska, Mateusz Kopczyński;

Supervision: Paulina Bala, Justyna Jachimczak, Joanna Filipow;

Project administration: Piotr Rzyczniok, Aneta Rasińska, Natalia Pasierb;

Receiving funding: n/a.

All authors have read and agreed with the published version of the manuscript.

Funding statement

This research received no external funding.

Institutional Review

Board Statement Not applicable.

Informed Consent Statement

Not applicable.

Data availability statement

Not applicable.

Acknowledgments

The authors declare that there are no acknowledgments for this study.

Conflict of Interest Statement

The authors declare no conflict of interest.

REFERENCES

[1] Alexander H, Miller DL. Determining skin thickness with pulsed ultra sound. J Invest Dermatol. 1979;72(1):17-19. doi:10.1111/1523-1747.ep12530104

[2] Rajadhyaksha M, González S, Zavislan JM, Anderson RR, Webb RH. In vivo confocal scanning laser microscopy of human skin II: advances in instrumentation and comparison with histology. J Invest Dermatol. 1999;113(3):293-303. doi:10.1046/j.1523-1747.1999.00690.x

[3] Hinz T, Ehler LK, Hornung T, et al. Preoperative characterization of basal cell carcinoma comparing tumour thickness measurement by optical coherence tomography, 20-MHz ultrasound and histopathology. Acta Derm Venereol. 2012;92(2):132-137. doi:10.2340/00015555-1231

[4] Schmid-Wendtner MH, Dill-Müller D. Ultrasound technology in dermatology. Semin Cutan Med Surg. 2008;27(1):44-51. doi:10.1016/j.sder.2008.01.003

[5] Schneider SL, Kohli I, Hamzavi IH, Council ML, Rossi AM, Ozog DM. Emerging imaging technologies in dermatology: Part I: Basic principles. J Am Acad Dermatol. 2019;80(4):1114-1120. doi:10.1016/j.jaad.2018.11.042

[6] Dill-Müller D, Maschke J. Ultrasonography in dermatology. J Dtsch Dermatol Ges. 2007;5(8):689-707. doi:10.1111/j.1610-0387.2007.06453.x

[7] Jasaitiene D, Valiukeviciene S, Linkeviciute G, Raisutis R, Jasiuniene E, Kazys R. Principles of high-frequency ultrasonography for investigation of skin pathology. J Eur Acad Dermatol Venereol. 2011;25(4):375-382. doi:10.1111/j.1468-3083.2010.03837.x
[8] Jemec GB, Gniadecka M, Ulrich J. Ultrasound in dermatology. Part I. High frequency ultrasound. Eur J Dermatol. 2000;10(6):492-497.
[9] Kleinerman R, Whang TB, Bard RL, Marmur ES. Ultrasound in dermatology: principles and applications. J Am Acad Dermatol. 2012;67(3):478-487. doi:10.1016/j.jaad.2011.12.016
[10] Alfageme F, Wortsman X, Catalano O, et al. European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) Position Statement on Dermatologic Ultrasound. Stellungnahme der European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) zu Dermatologischem Ultraschall. Ultraschall Med. 2021;42(1):39-47. doi:10.1055/a-1161-8872
[11] Mlosek RK, Migda B, Migda M. wysoka częstotliwość ultradźwięków w 21 st wieku. J Ultrason . 2021; 20 (83): e233-e241. doi: 10.15557 / JoU.2020.0042
[12] Polańska A, Dańczak-Pazdrowska A, Jałowska M, Żaba R, Adamski Z. Current applications of high-frequency ultrasonography in dermatology. Postepy Dermatol Alergol. 2017;34(6):535-542. doi:10.5114/ada.2017.72457
[13] Wortsman X. Ultrasound in d12ermatology: why, how, and when?. Semin Ultrasound CT MR. 2013;34(3):177-195. doi:10.1053/j.sult.2012.10.001
[14] Hoffmann K, Dirschka T, Schwarze H, et al. 20 MHz sonography, colorimetry and image analysis in the evaluation of psoriasis vulgaris. J Dermatol Sci. 1995;9(2):103-110. doi:10.1016/0923-1811(94)00358-l
[15] Cammarota T, Pinto F, Magliaro A, Sarno A. Current uses of diagnostic high-frequency US in dermatology. Eur J Radiol. 1998;27 Suppl 2:S215-S223. doi:10.1016/s0720-048x(98)00065-5
[16] Seidenari S. High-frequency sonography combined with image analysis: a noninvasive objective method for skin evaluation and description. Clin Dermatol. 1995;13(4):349-359. doi:10.1016/0738-081x(95)00074-p
[17] Olsen LO, Takiwaki H, Serup J. High-frequency ultrasound characterization of normal skin. Skin thickness and echographic density of 22 anatomical sites. Skin Res Technol. 1995;1(2):74-80. doi:10.1111/j.1600-0846.1995.tb00021.x
[18] Waller JM, Maibach HI. Age and skin structure and function, a quantitative approach (I): blood flow, pH, thickness, and ultrasound echogenicity. Skin Res Technol. 2005;11(4):221-235. doi:10.1111/j.0909-725X.2005.00151.x
[19] de Rigal J, Escoffier C, Querleux B, Faivre B, Agache P, Lévêque JL. Assessment of aging of the human skin by in vivo ultrasonic imaging. J Invest Dermatol. 1989;93(5):621-625. doi:10.1111/1523-1747.ep12319741
[20] Sandby-Møller J, Thieden E, Philipsen PA, Schmidt G, Wulf HC. Dermal echogenicity: a biological indicator of individual cumulative UVR exposure?. Arch Dermatol Res. 2004;295(11):498-504. doi:10.1007/s00403-004-0454-7
[21] Lacarrubba F, Tedeschi A, Nardone B, Micali G. Mesotherapy for skin rejuvenation: assessment of the subepidermal low-echogenic band by ultrasound evaluation with cross-sectional B-mode scanning. Dermatol Ther. 2008;21 Suppl 3:S1-S5. doi:10.1111/j.1529-8019.2008.00234.x

[22] Alfageme Roldán F. Elastography in Dermatology. Elastografía en dermatología. Actas Dermosifiliogr. 2016;107(8):652-660. doi:10.1016/j.ad.2016.05.004
[23] Rastrelli M, Tropea S, Rossi CR, Alaibac M. Melanoma: epidemiology, risk factors, pathogenesis, diagnosis and classification. In Vivo. 2014;28(6):1005-1011.
[24] Forsea AM, Del Marmol V, de Vries E, Bailey EE, Geller AC. Melanoma incidence and mortality in Europe: new estimates, persistent disparities. Br J Dermatol. 2012;167(5):1124-1130. doi:10.1111/j.1365-2133.2012.11125.x
[25] Piłat P, Borzęcki A, Jazienicki M, Krasowska D. Skin melanoma imaging using ultrasonography: a literature review. Postepy Dermatol Alergol. 2018;35(3):238-242. doi:10.5114/ada.2018.76211
[26] Crincoli E, Moliterni E, Catania F, Didona D, Calvieri S, Paolino G. Correlation of serum tryptase levels with total number of nevi, Breslow thickness, ulceration, and mitotic index in melanoma patients: evaluation of a promising prognostic marker. Melanoma Res. 2019;29(6):621-625. doi:10.1097/CMR.0000000000000561
[27] Balch CM, Gershenwald JE, Soong SJ, et al. Final version of 2009 AJCC melanoma staging and classification. J Clin Oncol. 2009;27(36):6199-6206. doi:10.1200/JCO.2009.23.4799
[28] Fong ZV, Tanabe KK. Comparison of melanoma guidelines in the U.S.A., Canada, Europe, Australia and New Zealand: a critical appraisal and comprehensive review. Br J Dermatol. 2014;170(1):20-30. doi:10.1111/bjd.12687
[29] Nagore E, Oliver V, Botella-Estrada R, Moreno-Picot S, Insa A, Fortea JM. Prognostic factors in localized invasive cutaneous melanoma: high value of mitotic rate, vascular invasion and microscopic satellitosis. Melanoma Res. 2005;15(3):169-177. doi:10.1097/00008390-200506000-00005
[30] Sondak VK, Gibney GT. Indications and options for systemic therapy in melanoma. Surg Clin North Am. 2014;94(5):1049-viii. doi:10.1016/j.suc.2014.07.007
[31] Morton DL, Cochran AJ, Thompson JF. The rationale for sentinel-node biopsy in primary melanoma. Nat Clin Pract Oncol. 2008;5(9):510-511. doi:10.1038/ncponc1205
[32] Pellacani G, Seidenari S. Preoperative melanoma thickness determination by 20-MHz sonography and digital videomicroscopy in combination. Arch Dermatol. 2003;139(3):293-298. doi:10.1001/archderm.139.3.293
[33] Tacke J, Haagen G, Hornstein OP, et al. Clinical relevance of sonometry-derived tumour thickness in malignant melanoma--a statistical analysis. Br J Dermatol. 1995;132(2):209-214. doi:10.1111/j.1365-2133.1995.tb05015.x
[34] Lassau N, Koscielny S, Avril MF, et al. Prognostic value of angiogenesis evaluated with high-frequency and color Doppler sonography for preoperative assessment of melanomas. AJR Am J Roentgenol. 2002;178(6):1547-1551. doi:10.2214/ajr.178.6.1781547
[35] Serrone L, Solivetti FM, Thorel MF, Eibenschutz L, Donati P, Catricalà C. High frequency ultrasound in the preoperative staging of primary melanoma: a statistical analysis. Melanoma Res. 2002;12(3):287-290. doi:10.1097/00008390-200206000-00013
[36] Guitera P, Li LX, Crotty K, et al. Melanoma histological Breslow thickness predicted by 75-MHz ultrasonography. Br J Dermatol. 2008;159(2):364-369. doi:10.1111/j.1365-2133.2008.08681.x

[37] Hayashi K, Koga H, Uhara H, Saida T. High-frequency 30-MHz sonography in preoperative assessment of tumor thickness of primary melanoma: usefulness in determination of surgical margin and indication for sentinel lymph node biopsy. Int J Clin Oncol. 2009;14(5):426-430. doi:10.1007/s10147-009-0894-3

[38] Harland CC, Kale SG, Jackson P, Mortimer PS, Bamber JC. Differentiation of common benign pigmented skin lesions from melanoma by high-resolution ultrasound. Br J Dermatol. 2000;143(2):281-289. doi:10.1046/j.1365-2133.2000.03652.x

[39] McDaniel B, Badri T, Steele RB. Basal Cell Carcinoma. In: StatPearls. Treasure Island (FL): StatPearls Publishing; November 20, 2020.

[40] Fornage BD, McGavran MH, Duvic M, Waldron CA. Imaging of the skin with 20-MHz US. Radiology. 1993;189(1):69-76. doi:10.1148/radiology.189.1.8372222

[41] Tedstone JL, Richards SM, Garman RD, Ruzek MC. Ultrasound imaging accurately detects skin thickening in a mouse scleroderma model. Ultrasound Med Biol. 2008;34(8):1239-1247. doi:10.1016/j.ultrasmedbio.2008.01.013

[42] Dańczak-Pazdrowska A, Polańska A, Silny W, et al. Seemingly healthy skin in atopic dermatitis: observations with the use of high-frequency ultrasonography, preliminary study. Skin Res Technol. 2012;18(2):162-167. doi:10.1111/j.1600-0846.2011.00548.x

[43] Rallan D, Harland CC. Ultrasound in dermatology--basic principles and applications. Clin Exp Dermatol. 2003;28(6):632-638. doi:10.1046/j.1365-2230.2003.01405.x

[44] Gniadecka M. Dermal oedema in lipodermatosclerosis: distribution, effects of posture and compressive theraphy evaluated by high-frequency ultrasonography. Acta Derm Venereol. 1995;75(2):120-124. doi:10.2340/0001555575120124

[45] Polańska A, Dańczak-Pazdrowska A, Silny W, et al. Comparison between high-frequency ultrasonography (Dermascan C, version 3) and histopathology in atopic dermatitis. Skin Res Technol. 2013;19(4):432-437. doi:10.1111/srt.12064

[46] Osmola-Mańkowska A, Polańska A, Silny W, Żaba R, Adamski Z, Dańczak-Pazdrowska A. Topical tacrolimus vs medium-dose ultraviolet A1 phototherapy in the treatment of atopic dermatitis - a preliminary study in relation to parameters of the epidermal barrier function and high-frequency ultrasonography. Eur Rev Med Pharmacol Sci. 2014;18(24):3927-3934.

[47] Gupta AK, Turnbull DH, Harasiewicz KA, et al. The use of high-frequency ultrasound as a method of assessing the severity of a plaque of psoriasis. Arch Dermatol. 1996;132(6):658-662.

[48] Gniadecka M, Gniadecki R, Serup J, Søndergaard J. Ultrasound structure and digital image analysis of the subepidermal low echogenic band in aged human skin: diurnal changes and interindividual variability. J Invest Dermatol. 1994;102(3):362-365. doi:10.1111/1523-1747.ep12371796

[49] Wortsman X, Wortsman J, Orlandi C, Cardenas G, Sazunic I, Jemec GB. Ultrasound detection and identification of cosmetic fillers in the skin. J Eur Acad Dermatol Venereol. 2012;26(3):292-301. doi:10.1111/j.1468-3083.2011.04047.x

[50] Quezada-Gaon N, Wortsman X, Peñaloza O, Carrasco JE. Comparison of clinical marking and ultrasound-guided injection of Botulinum type A toxin into the masseter muscles for treating bruxism and its cosmetic effects. J Cosmet Dermatol. 2016;15(3):238-244. doi:10.1111/jocd.12208

[51] Schelke LW, Van Den Elzen HJ, Erkamp PP, Neumann HA. Use of ultrasound to provide overall information on facial fillers and surrounding tissue. Dermatol Surg. 2010;36 Suppl 3:1843-1851. doi:10.1111/j.1524-4725.2010.01740.x
[52] Mlosek RK, Skrzypek E, Skrzypek DM, Malinowska S. High-frequency ultrasound-based differentiation between nodular dermal filler deposits and foreign body granulomas. Skin Res Technol. 2018;24(3):417-422. doi:10.1111/srt.12444
[53] Sylwia M, Krzysztof MR. Efficacy of intradermal mesotherapy in cellulite reduction - Conventional and high-frequency ultrasound monitoring results. J Cosmet Laser Ther. 2017;19(6):320-324. doi:10.1080/14764172.2017.1334927