Ultrasonography in dermatologic surgery: revealing the unseen for improved surgical planning

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Summary

Ultrasonography (US) is a modern, in vivo imaging method, which is increasingly being used in dermatology as a complementary tool to clinical examination and dermoscopy. At higher frequencies (15 MHz and above), US is an established method for assessing benign and malignant skin lesions, locoregional staging, monitoring the therapeutic efficacy in various inflammatory skin conditions, and patient follow-up. One field, which may increasingly benefit from performant imaging techniques such as US is dermatologic surgery. Preoperative imaging of cutaneous tumors, inflammatory skin conditions (hidradenitis suppurativa, abscesses, etc.), or nail pathology provide dermatologic surgeons with relevant information for an optimal surgical planning, identifying potential complex aspects which might require interdisciplinary approaches, herein sparing unnecessary surgical interventions and increasing patients’ compliance. In this review, we discuss the increasing significance of US in the field of dermatologic surgery, as well as the spectrum of cutaneous pathology where sonography can aid in the preoperative setting to provide a more precise, individualized surgical planning for better counseling to our patients and improved surgical results.

Introduction

Ultrasonography is a promising, innovative, non-invasive, in vivo diagnostic technique that finds new and increasingly more applications in many clinical fields, such as dermatology, rheumatology, musculoskeletal and dental medicine. While frequencies of 7.5 MHz have a penetration depth of > 40 mm, allowing the visualization of deeper structures and lymph nodes at a low resolution, frequencies above 10 MHz enable a better spatial resolution imaging (16–158 μm) of superficial structures such as the integument, superficial blood vessels, and other small parts, however, in detriment...
of the penetration depth [1, 2]. Table 1 provides an overview of the sonographic penetration depth according to the used frequency [3].

Surely, histology remains the gold standard for diagnosing most dermatological conditions, however modern US imaging devices with higher frequency transducers, nowadays also enable an accurate visualization and multimodal characterization of the skin layers, their appendages and associated pathologies [4, 5].

According to the Guidelines for performing dermatologic ultrasound, published by the DERMUS group, the optimal frequencies for assessing dermatological conditions range from 15 to 22 MHz, and the main applications include benign and malignant skin tumors, vascular anomalies, cosmetic field, nail disorders, and inflammatory diseases [6, 7].

The greyscale examination, color, spectral Doppler, and contrast-enhanced ultrasonography for the *in vivo* assessment of the macro and microvascularization and elastography for tissue stiffness evaluation provide experienced clinicians significant information regarding morphology, structure, stiffness, and blood supply of investigated lesions which correlate to histological findings [8]. The accuracy of ultrasound analysis can be significantly enhanced by the additional use of Color Doppler, which can distinguish between vascular and non-vascular lesions and recognize the benign/malignant nature of skin neoplasms by characterizing the vascularization type [9–11].

Compared to other, more invasive or expensive diagnostic techniques (e.g., PET-CT, MRI), sonography was shown to be a reliable, real-time, complementary technique, which, used along with the physical examination, can provide objective parameters for the multimodal assessment, diagnosis, management, and follow-up of various dermatologic diseases [12, 13].

Other non-invasive imaging methods for the assessment of the integument also find increasing clinical applications in dermatology [14]. For instance, confocal microscopy (resolution 1 μm, penetration depth approximately 500 μm) enables the *in vivo* identification of surgical tumor margins pre- or intraoperatively, however only in superficial cases, as it has a significantly more limited depth of penetration than ultrasound, not always allowing the identification of invasive tumor parts. It does produce images with a subcellular resolution, which ultrasound does not provide, it can however not characterize the vascularization degree or stiffness degree of investigated lesions [14]. Optical coherence tomography (resolution 2–10 μm, penetration depth ca. 2 μm) generates similar images to ultrasound as well as a high image speed, is however limited by the depth of penetration and resolution for cancer cell morphology characterization as well as the lack of Doppler and elastography [15]. At last, optoacoustic imaging (resolution 1–10 μm, penetration depth ca 1 mm) is newly also finding clinical applications in the characterization of the integument, providing high-resolution in vivo interrogations of the skin at scalable depths (visualization of epidermis, partial dermis, capillaries) which might also provide significant data in the assessment of superficial skin cancers [16].

### Ultrasonography in dermatologic surgery

In the field of skin cancer surgery, US at frequencies above 15 MHz was shown to provide significant and objective information regarding tumor depth, lateral extension, and vascularity degree, showing a good degree of correlation to histological parameters, enabling clinicians to preoperatively better demarcate tumor involvement, thus reducing the size of surgical defects and choosing the most appropriate therapeutic approach [4, 17]. Dermatologic surgeons are also often confronted with challenging large tumors, where preoperative ultrasound permits an accurate visualization of potential neurovascular, muscular, cartilaginous, or bone

| Frequency (MHz) | Depth of penetration (mm) | Visualized structures |
|----------------|---------------------------|-----------------------|
| 7.5 MHz        | > 40                      | Lymph nodes, deep structures |
| 10 MHz         | 35                        | Epidermis, dermis, subcutis |
| 20 MHz (high frequency ultrasound) | 10 | Epidermis, dermis, part of subcutaneous tissue |
| 50 MHz         | 3–4                       | Epidermis and dermis |
| 75 MHz         | 3                         | Epidermis and part of dermis |
| 100 MHz        | 1.5                       | Epidermis only |

Table 1 Visualized structures according to used sonographic frequency (MHz) and penetration depth (mm) [3].
involvement; this knowledge may reconsider the therapeutic approach from surgery to other, less mutilating options [18].

Further, US may reveal clinically occult lesions (e.g., satellite lesions) during the preoperative assessment, allowing a better staging of skin cancer patients while sparing unnecessary surgical interventions [19, 20].

In hidradenitis suppurativa, preoperative ultrasound significantly improves resection margin delimitation by identifying subclinical lesions, leading to lower postoperative recurrence rates [21].

As for the nail unit, malignant tumors and benign lesions (e.g. cysts, glomus tumors and onychomatricoma, among others) can be diagnosed by clinical inspection and typical sonographic features with a specificity and sensitivity of nearly 100 %, avoiding more complex diagnostic techniques and optimizing the surgical approach [22–24].

The preoperative conventional sonographic assessment of the lymph node basin in high-risk skin cancer types (at frequencies of 7.5–10 MHz) enables the detection of subclinical lymphonodal involvement, cancelling the need for sentinel node biopsy. In addition, after lymph node surgery, US can be reliably employed to immediately differentiate between pathological lymph nodes and postoperative seromas, hematomas, or inflammatory conditions such as abscesses, reducing costs and complications associated with other diagnostic methods [13].

We discuss the increasing significance of US at conventional and higher frequencies in dermatologic surgery, which complement the clinical examination and histological assessment, allowing the clinician a more precise surgical planning, locoregional staging, and an accurate postoperative follow-up and better counseling of our patients.

**US in the pre- and postoperative assessment of malignant tumors, locoregional staging**

The early identification of the locoregional spread of skin cancer is essential for guiding the therapeutic management and improve morbidity and survival [11]. Along with clinical inspection and dermoscopy, US (15 MHz and above)

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**Figure 1A** Basal cell carcinoma on a lipoma. (a) Clinical aspect showing a sharply demarcated, erythematous nodule with central ulceration and telangiectasia on top of a skin-colored, nodular mass (a). Greyscale and color Doppler show a well-defined, oval-shaped hypoechoic lesion of the epidermis and dermis with low intrallesional vascularity (b). Below the lesion, a sharply demarcated, roundish hypoechoic structure with no vascularization within; according to the patient, both lesions had arisen simultaneously, so before excision, US was able to confirm the benign nature of the nodular mass situated below the tumor (c). 1B: Recurrent basal cell carcinoma on the right nasal wall. Clinical aspect showing the presence of a solid, infiltrating, erythematous plaque with multiple telangiectasias on a surgical scar on the lateral aspect of the nose (d). Pre-operative Grey-scale and Color Doppler show a well-defined, vascularized, roundish hypoechoic lesion of the epidermis and dermis infiltrating the nasal bone as marked by “**” (e). Skull CT demonstrating the infiltration of the tumor into the nasal bone, as marked by “>” (f).
provides accurate diagnostic information regarding tumoral dimensions, invasion extent, and relationship to surrounding anatomic structures [25]. Furthermore, performing regular sonographic assessments of the surgical scar and loco-regional lymph nodes (7.5–10 MHz) in the postoperative follow-up of patients with high-risk neoplasms facilitates the early detection of relapses, enabling early intervention and reducing morbidity [19, 26, 27].

Basal cell carcinoma (BCC) is the most frequent cutaneous malignant tumor with a slow growth tendency and exceptional metastatic potential, which can however cause significant local destruction by invasion into neighboring structures if not adequately recognized and treated [28, 29]. On ultrasound, BCCs appear as usually well-defined, hypoechoic lesions that sometimes present hyperechoic spots within (local calcifications), while color Doppler shows low-flow arterial and venous vessels within or at the bottom of the lesions [11, 30] (Figure 1A, a, b).

At frequencies above 15 MHz, US can facilitate the measurement of BCC tumor depth, which displays a good correlation degree with the histological tumor thickness (Breslow index), as we could recently show [31]. In a study of 83 BCCs, Barcaui et al. showed that US had a sensitivity of 96 %, specificity of 84 %, and accuracy of 91 % in preoperatively determining tumor depth [32]. The preoperative assessment of tumor depth in BCCs can decide between a surgical or conservative approach.

Furthermore, the involvement of adjacent structures such as (nasal) cartilage in the BCC of the nose can be ruled out by preoperative sonography [33]. In imagistically confirmed invasion into deeper structures (cartilage, muscle, and/or bone), the surgical approach can be complemented or even replaced by radiation or systemic oncologic treatments [11, 19] (Figure 1B, d, e, f).

By providing accurate data related to the lateral tumor extension, US helps surgeons reduce the extent of surgical defects and consequent reconstructive surgery, improving the esthetical outcome. Hence, by non-invasively determining the tumor depth and extension, we can refine our surgical procedures and increase the use of non-surgical methods, sparing patients from unnecessary surgery, potential esthetic impairments, and reducing the risk of local relapse by accurate margin determination [33].

Worth mentioning are however cases of certain histological types of BCC or squamous cell carcinomas, especially in photoexposed areas, where the sonographic assessment of the lateral tumor extension might in some cases be more challenging due to the presence of solar elastosis in the upper dermis, which also appears as an hypoechoic band/area and might lead to an overestimation of tumor extension [34, 35]. In such cases, the operator skills in distinguishing between tumor lateral extension and solar elastosis, as well as other imaging methods such as optical coherence tomography or confocal microscopy might support in more clearly determining tumor margins [36].

Squamous cell carcinoma (SCC), a cutaneous neoplasm with a known tendency to local infiltration but low lymphogenic and distant metastatic potential, usually presents in US as an inhomogeneous hypoechoic structure with prominent central and peripheral vascular flow (Figure 2A, a, b).

In hyperkeratotic lesions, the sonographic characterization might be limited by the presence of keratin; hence, removing the external hyperkeratotic component might facilitate more accurate imaging of SCC [1, 9, 37, 38].

Pre-operatively, sonographic imaging of the primary tumor and locoregional lymph nodes is essential, especially in patients with large, poorly differentiated tumors where loco-regional spreading (satellite lesions, lymph node metastasis) can be identified with high accuracy, determining the therapeutic approach [11]. Importantly, US can identify high-risk SCCs by preoperatively assessing a depth of invasion higher than 6 mm, a predictive factor for the metastatic potential of SCC [39]. Also, ultrasound of the surgical scar and locoregional lymph nodes is essential in the postoperative follow-up of patients with high-risk tumors, enabling early identification of a progressive disease or local recurrence (Figure 2A, c; B, d, e).

Merkel cell carcinoma (MCC), a rare, aggressive, cutaneous neuroendocrine tumor of the elderly, presents lymphnodal involvement in about 30 % of patients [40]. Although there is no distinct ultrasound pattern or prognostic features for MCC, hypoechoic, ill-defined masses localized in the deep dermis and/or subcutis with prominent vascularization throughout the entire lesion are suggestive for this type of neuroendocrine tumor [41]. The locoregional lymph nodes and the in-transit area should be assessed prior to sentinel node biopsy as the identification of satellite/in-transit lesions or clinically occult lymph node metastases can spare unnecessary surgery in patients, thereby confirming stage III disease.

For malignant melanoma (MM), studies have shown that US can preoperatively evaluate tumor thickness in vivo, the sonographic tumor thickness correlating with the histologic Breslow index [42–46]. We previously found a high correlation level (> 98 %) between sonographic and histopathologic depth measurements. Interestingly, we found that 20 MHz high-frequency ultrasound (HFUS) may slightly underestimate the thickness of nodular melanoma while overestimating the depth of superficial spreading melanoma, possibly due to the abundance of the surrounding inflammatory infiltrate or the presence of nevus components underneath the melanoma [31, 47, 48].

In a review of 22 different studies, Jasaitiene et al. found a high correlation between the histologic and the sonographic depth index in melanoma, with the 20 MHz frequency
providing the most accurate correlation [1]. The preoperative assessment of melanoma thickness is essential for establishing the correct safety margins and the indication for sentinel node biopsy, avoiding unnecessary surgery, accelerating diagnosis and therapy [1, 43, 49].

Regarding satellite and in-transit metastasis, these can be identified by US either preoperatively while assessing the primary tumor site and the locoregional lymphatic basin or during postoperative follow-up, confirming stage III disease [19, 50, 51].

Skin metastases usually present as solitary/multiple, cutaneous or subcutaneous, hypoechoic, nodular/oval lesions, mostly with flow signal, located in the area between the primary tumor and the lymph nodal basin [19] (Figure 3A, a, b).

In case of early identification of satellite lesions by US in patients with MM, excision of the primary tumor area with clear margins suffices, canceling the need for wide excision with 1–2 cm safety margins and sentinel node biopsy. Having confirmed stage III disease, these patients will be appropriately staged to rule out distant metastases and will not undergo unnecessary surgery but rather adjuvant radio- and systemic therapy.

The sonographic, preoperative lymphonodal assessment in patients with SCC, MCC, and MM has proven very accurate in identifying lymph node metastasis, reducing the need for invasive sentinel node biopsy while permitting a sonographic-guided fine needle aspiration cytology for confirmation of nodal disease [43]. Typical metastatic lymph nodes present in ultrasound as rather round, ballooned shaped lesions with a Solbiati index < 2, a partial or total loss of the hilum or its marginal displacement, while color Doppler shows a variable degree of vascularization [19] (Figure 3B, c, d).

In a study on 1288 melanoma patients assessing the in-transit area and regional nodal basins by clinical examination and sonography, Blum et al. showed that the sensitivity for the ultrasound examination was 89.2 % in comparison to 71.4 % for clinical examination with an identically high specificity of 97 %, showing a clear superiority of ultrasound in detecting occult metastases [52].
US in the diagnostic and preoperative evaluation of solid and cystic non-inflammator benign skin lesions

US can identify in vivo the nature of (sub)cutaneous lesions (solid, cystic, fluid, etc.) and their relationship to the surrounding structures. The most common nontumoral benign lesions in the dermatosurgical field are lipomas, cysts, inflammatory lesions (abscesses), seromas, and hematomas (described separately), which need to be differentiated from other potentially malignant lesions [53].

Table 2 illustrates the characteristic sonographic features of the most commonly encountered cysts and lipomas, as well as the surgery-relevant information provided by US.

US assessment and differentiation of fluid collections (seroma, hematoma)

Sonography has proven very helpful compared to other imaging methods in differentiating between postoperative seromas (lymphocele) or hematomas and solid, potentially metastatic lesions.

Seromas, which can develop after sentinel node biopsy or extensive excisions, present on US as anechoic lesions due to their serous content, being usually compressible with the ultrasound probe at initial, but not at later stages, as fibrous tissue replaces the fluid collection [63]. Thus, using US to differentiate between suspect solid lesions and fluid collections in the postoperative follow-up, progressive disease can be easily ruled out in patients with new, localized swelling at the level of lymphatic basins of the sentinel node. Doppler sonography can aid in differentiating metastatic lymph nodes from fluid collections, as these will display no vascularization. Postoperative seromas can be easily treated by sonographic-guided drainage and aspiration with a needle and a syringe. Ultrasound allows in such cases an in vivo observation of fluid removal and consequent lesion shrinkage [64] (Figure 5).

Similarly, hematomas have a different appearance on ultrasound depending on their evolutionary phase: usually,
they appear as well-defined anechoic collections which develop towards hypo- and sometimes hyperechoic lesions in time; furthermore, new hematomas can present a hypervascularization in the periphery, while older hematomas are hypovascular [63]. The sonographic distinction between hematoma and abscesses might sometimes be challenging, as both lesions can present as hyperechoic fluid collections; in such cases, the skills and experience of the sonographer and the clinical history can aid in elucidating the diagnosis.

**US in the preoperative assessment of inflammatory skin conditions (hidradenitis suppurativa, abscesses)**

**Abscesses**, localized collections of pus, mainly caused by bacterial infections, usually present on ultrasound as round, heterogeneous fluid collections with multiple centrally located echoes, while Color Doppler shows an increased vasculization in the periphery of the lesion (significant feature differentiating an abscess from a hematoma) [53]. Often, perilesional soft tissue edema presenting as cobblestoning surrounding the abscess can be observed. Furthermore, abscess cavities will present a posterior acoustic enhancement as the ultrasound beam is less attenuated in the liquid content of the abscess, leading to the appearance of a hyperechoic shadow on the posterior abscess wall [65].

When applying pressure over the abscess cavity using the sonographic probe, a local “ultrasonic fluctuance” may be observed, as the abscess contents tend to move inside the cavity, an aspect which can help in differentiating an abscess from a pathologic lymph node, for instance. The therapy of choice for such lesions is incision and drainage, which can be performed employing sonographic guidance, increasing the accuracy of the procedure by localizing and avoiding vessels, nerve bundles, or other anatomic structures [63, 65] (Figure 6A, a, b).
Figure 4A Epidermal cyst. Clinical aspect showing an asymptomatic, skin-colored nodule on the back (a). Greyscale and color Doppler show a well-defined, oval, hypoechoic structure located in the dermis and subcutaneous tissue with a centrally displayed hypoechoic communicating punctum, no signs of vascularization within the lesion and posterior acoustic enhancement (b). 4B: Trichilemmal cyst. Clinical picture showing a single nodule with localized alopecia (c). Greyscale displays a well-defined oval-shaped nodule with an anechoic structure and multiple echoes, corresponding to debris; Color Doppler shows no vascularization of the cyst (d).

Figure 5 Post-sentinel node seroma of the groin. Greyscale ultrasound showing a sharply demarcated anechoic fluid collection in the left groin, after sentinel node biopsy three weeks earlier; the fluid collection is compressible with the ultrasound probe as illustrated above; using sonographic guidance, the fluid content of seroma can be easily removed, leading to immediate shrinkage of the lesion (a, b).
Hidradenitis suppurativa (HS), a recurrent, chronic inflammatory skin condition of the terminal hair follicle of the apocrine gland-bearing skin (axillae, groins, inframammary, etc.), usually presents with multiple painful nodules, abscesses, and sometimes sinus tracts, leading to purulent discharge, scarring and significantly impaired quality of life. In US, patients with HS can present a thickened, hypoechoic dermis with enlargement of the hair follicles, hypoechoic dermal pseudocystic lesions, as well as anechoic fluid collections with centrally placed echoes, increased peripheral vascularization, and hypoechoic interconnected fistulous tracts [21, 66] (Figure 6B, c, d, e).

Depending on the disease severity, as assessed by specific scores (Hurley score, Sartorius, etc.), European guidelines
recommend topical, systemic antibiotics, or even monoclonal antibodies for inflammation control [67]. In severe cases with scarring and sinus tracts, however, surgical excision is required. Emerging evidence suggests that the current scores used for severity assessment of hidradenitis suppurativa often underestimate the extent of the disease since merely clinical inspection and palpation may not identify deeper lesions. Ultrasound could detect subclinical lesions of hidradenitis suppurativa with high precision, often resulting in the “upgrade” of the clinically assessed severity score. Hence, US before surgery can aid dermatosurgeons in precisely delimiting and excising the involved areas, lowering the risk of local recurrences [68].

Considering sonographic features, Wortsman et al. developed a scoring system for hidradenitis suppurativa according to subclinical lesions (presence of one or more fluid collections, fistulous tracts, or dermal changes). Accordingly, patients are distributed in three severity stages whereby some stage II and stage III patients are candidates for surgical excision [21].

**US in the preoperative evaluation of nail bed/nail matrix lesions**

The nail organ and subungual space can be affected by various types of tumors, including benign (glomus tumor, myxoid cysts, subungual exostosis, chondromas, warts, etc.) and malignant lesions (malignant melanoma, squamous cell carcinoma, etc.) [69].

Magnetic resonance imaging can differentiate nail lesions (e.g., subungual exostoses, osteochondromas); however, they involve high costs and are not always immediately available, leading to delayed diagnosis. Alternatively, radiography is performant in identifying subungual exostoses, as exophytic osteocartilaginous lesions on the dorsal aspect of the phalanx, but these might not be visible in early lesions due to their initial fibrocartilaginous nature, delaying diagnosis [70].

Ultrasoundography plays a significant role in the reliable detection, characterization, and diagnosis of subungual masses, optimizing surgical planning, sparing diagnostic biopsies, providing optimal presurgical counseling to our patients, and improving functional and cosmetic outcomes.

For subungual tumors, the preoperative sonographic identification of their relation/connection to the nail matrix is essential for planning the optimal surgical approach and discussing all potential, surgery-related complications with our patients, including damage to the nail matrix, in cases of submatricial location. Furthermore, it is essential to preoperatively establish the exact location and the size of the lesion to avoid incomplete excision and recurrence [71].

Studies have shown that US can identify nail tumors <2 mm diameter with high precision, avoiding misdiagnosis

| Table 3 Common benign lesions of the nail apparatus: clinical and sonographic aspects |
|-----------------------------------------------|
| **Lesion type** | **Clinical and sonographic aspects** |
| Glomus tumor | – Clinical appearance: solitary, painful nodule of the nail bed or surrounding area; pain exacerbation following change in temperature or pressure application |
| | – Sonographic aspect: single, hypoechoic lesion of the nail bed; development of a small bony erosion of the phalanx as the tumor increases in size (sonographic clue); present vascularization in color Doppler, facilitating a 100 % detection rate of glomus tumors localized at a digital level [73] (Figure 7a) |
| Myxoid cyst | – Clinical appearance: localized, enlarging, translucent mass arising between the proximal nail fold and distal interphalangeal phalanx (DIP), sometimes associated with longitudinal nail grooves or canaliform dystrophy of the nail plate, discharge of gelatinous material, and cosmetic impairment [74, 75] |
| | – Sonographic aspect: well-defined, round, or oval anechoic lesion with posterior acoustic enhancement and no vascularization, sometimes involving the ungual matrix and causing nail deformities; occasionally, small echoes can be identified in the lesions, corresponding to mucin heterogeneity [75] (Figure 7b) |
| Subungual exostosis | – Clinical appearance: firm osteocartilaginous nodule, often arising from the dorsomedial aspect of the phalanx of the great toe below the nail bed, leading to progressive onycholysis and tenderness; commonly misdiagnosed at initial presentation as warts, malignant tumors, or cysts [70] |
| | – Sonographic aspect: well-defined, heterogeneous, hyperechoic lesion with posterior acoustic shadowing, often located under the nail plate and connected to the bony surface of the involved phalanx (diagnostic clue); localized increase of the subungual space [69, 70] (Figure 7c) |
and delayed treatment [72]. Wortsman et al. showed in 103 patients with benign and pseudomalignant tumors of the nail organ that the diagnostic accuracy of ultrasound was significantly higher than that of clinical diagnosis alone, even challenging the initial clinical diagnosis in some cases. For benign lesions such as myxoid cysts, subungual exostosis, and glomus tumors, the diagnostic certainty of ultrasound was 100% compared to clinical diagnosis, making ultrasound an optimal diagnosis tool for these nail lesions [22]. The typical sonographic aspects of the most common benign lesions of the nail apparatus are described in Table 3 and Figure 7a, b, c.

For malignant tumoral pathology of the nail apparatus, ultrasound can be used as an additional imaging tool for characterizing tumor extension, vascularization, stiffness; it can, however, not provide a precise diagnosis since most lesions appear as hypoechoic areas with different patterns of vascularization; additional methods and histological confirmation of the diagnosis are mandatory [72].

Interventional sonography

Interventional sonography allows clinicians not only to perform guided biopsies of lesions of unclear origin but also to guide therapies or treat localized fluid collections or abscesses.

Ultrasound-guided fine-needle aspiration (FNA) is a well-tolerated procedure for evaluating and sampling cutaneous and subcutaneous lesions, efficiently replacing more invasive procedures. Fine-needle aspiration is less traumatic and has significantly lower complication rates than surgical biopsies [76]. In dermatology, FNA is increasingly used to evaluate and histologically assess suspicious lymph nodes and metastatic disease in patients with MM, SCC, MCC, etc. [77–79].

Figure 7 Sonography of benign subungual tumors. (a) Glomus tumor: hypoechoic oval-shaped lesion of the nail bed with increased vascularization on color Doppler and beginning bony erosion of the phalanx (courtesy of Dr. Wortsman) (a). Myxoid cyst: sharply demarcated, anechoic cystic lesion situated above the nail matrix, without any vascular signal (b). Subungual exostosis: heterogenous, hyperechoic lesion situated under the nail plate, connected to the bony surface of the distal phalanx; an increase of the subungual space due to the presence of the exostosis can be seen (courtesy of Dr. Alfageme) (c).
As previously mentioned, sonography can also be used for guided fluid collection removal in patients with seromas or lymphocele, providing immediate relief to the patients while avoiding more extensive surgery. Other applications include ultrasound-guided intralesional treatments for different conditions such as ganglion cysts, as described by Hadian et al. [80].

Intraoperatively, sterile-equipped ultrasound probes can also be employed to accurately detect small, clinically occult, non-palpable lesions that require removal and histological assessment, such as small subcutaneous metastases to confirm the progression of the disease.

Conclusions

Sonography is a valuable, highly efficient tool for the preoperative assessment of benign and malignant skin lesions, enabling clinicians to accurately diagnose, stage patients, and optimize the surgical approach, reducing recurrences and avoiding delays in diagnosis. The technique has significant growth potential in our daily practice, offering in vivo complementary and essential parameters which support the clinical diagnosis and can significantly improve the therapeutical management, especially in the field of dermatologic surgery and oncology, where it may aid in avoiding unnecessary procedures and increasing patients’ compliance.

One main limitation of US is that it is an operator-dependent examination, requiring extensive training and that it may provide clinicians with various artifacts that can lead to misinterpretation of the sonographic findings. However, we do consider the use of US in dermatologic surgery as an essential tool for an optimized, personalized diagnostic and therapeutic approach, especially in the hands of trained, experienced operators.

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