


Common Applications of Dermatologic Sonography

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In recent years, there has been growing use of sonography in the dermatologic field. Thus, this review analyzes the most common dermatologic applications of sonography with some technical considerations for performing this type of examination. Moreover, the sonographic findings in common benign and malignant skin tumors, inflammatory dermatologic diseases, and unguinal and cosmetic conditions, among others, are considered. Thus, this noninvasive technique may be a potent adjunctive tool in the diagnosis and management of dermatologic conditions in daily practice, delivering critical information otherwise unavailable to the clinical naked eye.

Key Words—dermatologic sonography; fillers; nail sonography; skin cancer; skin sonography; skin ultrasound

The skin is the largest organ of the body and is our visible presentation to society, playing a major role in the physiologic aspect as well as the psychological and social well-being of individuals. Therefore, any affliction in this organ may easily affect our quality of life and self-esteem.¹⁻³ Thus, cutaneous tissue, our first barrier to the hostile external environment, is a specialized organ that performs complex and multiple processes such as regulation of body temperature and storage of water, fat, and vitamin D and also contains pain and touch receptors. Moreover, this organ has the capability to heal itself after injury through sequential reparative phases that include hemostasis, inflammation, proliferation, and remodeling. All of these phases combine multiple and complex physiologic processes such as angiogenesis, granulation tissue formation, collagen deposition, and re-epithelialization, among others.⁴

Recent advances in the field of sonography have broadened the spectrum of applications to soft tissues, adding the skin layers among the possibilities for study. There is a growing number of reports in the literature about the use of sonography to assess anatomic changes in different dermatologic entities, covering not only skin conditions but also unguinal and scalp afflictions.⁵⁻⁷

The aim of cutaneous sonographic examination should be to qualify and quantify abnormalities within the skin layers and surrounding structures, being a reliable adjunctive tool not only in the diagnosis phase but also in the assessment of the activity and severity of cutaneous diseases. Likewise, this valuable information might ideally be different or complementary to that already deduced by the naked eye of a well-trained physician.⁸

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Among all of the imaging modalities, sonography has several advantages for studying the skin, in addition to the optimal penetration/resolution balance that permits good discrimination of the different cutaneous layers. Importantly, this technique lacks the secondary effects of radiation as with computed tomography and does not confine the patient in a reduced space as with magnetic resonance imaging. Moreover, dermatologic sonographic studies do not usually require the injection of a contrast medium, at least in baseline studies. Unlike sonography, other imaging techniques for studying the skin usually found in some departments of dermatology and research units, such as confocal microscopy and optical coherence tomography, provide high-resolution images but, at the same time, very low penetration (≤ 0.5 mm); in contrast, sonography (using variable-frequency probes) has a reasonable balance between high penetration and resolution without loss of definition when changing the depth. Fixed-frequency sonography (using 20- to 100-MHz probes), which is also used in some specialized dermatology and research units, also has high resolution but very low penetration (5–1 mm, respectively). Currently, magnetic resonance imaging and computed tomography have limited resolution for discriminating the epidermis and dermis and also low discrimination of cutaneous and ungual lesions that measure less than 3 mm.^{7,8} These low penetration and resolution issues may be critical in some cutaneous entities, such as skin cancer, in which the tumor depth can be an important point, and also because anatomically, the skin has variable thicknesses in different layers depending on the corporal region.⁹ Moreover, the same cutaneous disease could show different thickness, echogenicity, and vascularity patterns depending on the phase of disease activity, such as going from increased to decreased thickness, hypoechoic to hyperechoic, or hypovascular to hypervascular patterns. Examples of this wide range of anatomic changes are connective tissue disorders such as cutaneous lupus and morphea.^{9,10}

In addition, the intensive live interaction between the patient and the sonographer allows valuable information to be obtained, allowing an *in vivo* correlation of the visible lesion with the screen data. All of these capabilities allow the sonographer to make fast, important decisions during the course of the sonographic examination, such as extending the test to another corporal segment not previously requested. Thus, the anatomic information provided in the report should ideally actively support the treatment of the patient, providing objective and relevant data that can allow modification of important decisions such as management of a treatment (medical or surgical), the site of incision at surgery, and the performance of a sentinel node

study. Moreover, the anatomic data provided by sonography may support a better cosmetic prognosis, which usually has a high priority in the expectations of the patient.

The aim of this article is to review the common applications of sonography in the dermatologic field.

Technical Considerations

For an optimal examination, it is suggested that this type of sonography be performed with multichannel color Doppler machines and variable-frequency probes that reach frequencies of 15 MHz or higher. This suggestion does not detract from the good experiences using probes with lower frequencies; nevertheless, definition of the skin layers is usually better at higher frequencies. In addition, the extended field of view and compound reconstruction software can improve information delivery. Usually, a copious amount of gel is applied over the skin or nail surface to adjust the focus on the most superficial layers, evenly distributing probe pressure. Commonly, no standoff pads are required; moreover, cutaneous studies without any compression of the superficial vascularity can be recommended.

Sedation is commonly used in our department in children younger than 4 years to avoid artifacts derived from movement or crying in the color Doppler study. Chloral hydrate (50 mg/kg) orally administered can be used 30 minutes before the examination and after informed consent is signed by the parents or guardians. The modified Aldrete score can be used to monitor the sedation.⁷

All cases presented in this review were extracted from the database of the Department of Radiology at Clinica Servet, a national referral center for this type of examination, which contains 14,073 dermatologic sonographic examinations medically referred and performed between March 2001 and May 2011 by the same radiologist. The cases presented in the figures were confirmed histologically except in cases in which treatment was medical (eg, for hemangiomas) or a reference catalogue could be used (eg, for normal anatomy and fillers). The machines used for these cases were HDI 5000 and iU22 systems (Philips Healthcare, Bothell, WA) and MyLab Gold 70 XVG and Twice systems (Esaote SpA, Genoa, Italy) with variable-frequency probes (7–15, 5–17, or 6–18 MHz) and Doppler frequencies ranging from 7 to 14 MHz. In all cases, a gray scale examination was routinely followed by color Doppler sonography with spectral curve analysis of blood flow. Among the settings, power Doppler imaging was preferred to detect slow blood flow. In addition, the lowest pulse repetition frequencies and wall filters, as well

as color gain below the noise threshold that did not cause artifacts, were used to obtain better-quality images. Three-dimensional reconstructions were also performed for highlighting the dimensions of cutaneous lesions by making 5- to 8-second sweeps within the lesional area.

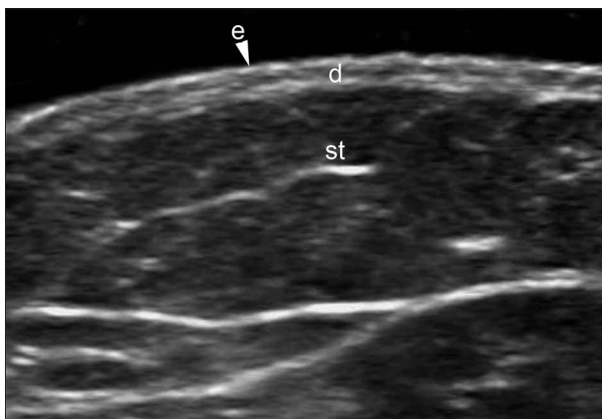
The Institutional Review Board of our institution waived the informed consent requirement for the purpose of this review. Nevertheless, all cases were analyzed under the Declaration of Helsinki principles for medical ethics.

Normal Sonographic Anatomy

The skin is composed of 3 layers: epidermis, dermis, and subcutaneous tissue or hypodermis. The echo structure of the skin layers depends on its main components. In the case of the epidermis, its echogenicity is influenced by the presence of keratin, the dermis by its content of collagen, and, last, the subcutaneous tissue by the amount of fat lobules. On sonography, the epidermis appears as a hyperechoic line in nonglabrous skin (ie, not from the palmar and plantar regions) and as bilaminar hyperechoic and parallel lines in glabrous skin (palms of the hands and soles of the feet). The dermis appears as a hyperechoic band, usually less bright than the epidermis, and the subcutaneous tissue appears as a hypoechoic fatty layer with hyperechoic fibrous septa in between (Figure 1).⁷⁻⁹

The nail unit is composed of the nail plates (dorsal and ventral), the nail bed (which includes the unguis matrix), and the periungual tissues (proximal and lateral nail folds). On sonography, the nail plates appear as bilaminar parallel hyperechoic structures, mostly due to the highly keratinous component. The nail bed appears hypoechoic and usually turns slightly hyperechoic in the proximal re-

Figure 1. Normal sonographic anatomy of the skin (nonglabrous skin, ventral forearm, transverse view). Abbreviations: d indicates dermis; e, epidermis; and st, subcutaneous tissue.



gion beneath the unguis matrix (Figure 2). The periungual skin has similar morphologic characteristics as the cutaneous layers of the rest of the body, although with less fat present in the subcutaneous tissue.^{11,12} Low-velocity arterial and venous vessels are usually detected in the subcutaneous tissue and the nail bed.^{7,13}

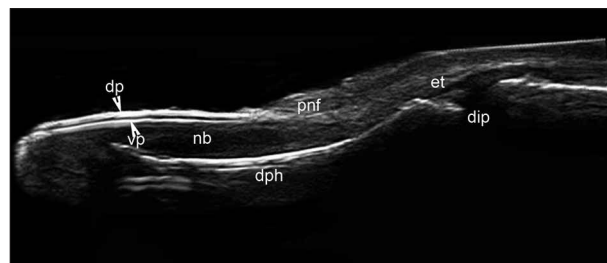
Benign Dermatologic Conditions

Epidermal Cysts

These cysts are generated by the implantation of epidermal components in the dermis. The causes can be embryonic, traumatic, or related to previous surgical procedures in the region by implantation of epidermal cells within the dermis and subcutaneous tissue. Epidermal cysts are covered by stratified squamous epithelium with a granular layer that does not have a sebaceous origin. Therefore, the common term “sebaceous cyst” is a misnomer and can be anatomically confusing. Clinically, patients usually have a palpable nodule, sometimes erythematous, that may discharge oily material.

On sonography, epidermal cysts can vary in their appearance according to the integrity of their walls. Thus, if the cyst is intact, it can appear as a round anechoic structure located in the dermis and subcutaneous tissue, usually containing a connecting tract to the epidermal surface, also called the “punctum.” Often, these cysts may show inner echoes (debris) and appear as round or oval hypoechoic structures. Occasionally, they can appear as giant structures with a “pseudotestis appearance” (ie, brighter inner echoes and anechoic filiform areas), mostly as a result of highly compacted deposits of keratin with cholesterol crystals and some dystrophic calcium deposits.¹⁴ Nevertheless, when the cyst becomes inflamed or ruptured, it may have more variable shapes¹⁵; hence, the borders can become irregular or blurry, and the keratin, mixed with inflammatory components, may be released to the surrounding tissues, pro-

Figure 2. Normal sonographic anatomy of the nail (index finger, longitudinal view). Abbreviations: dip indicates distal interphalangeal joint; dp, dorsal plate; dph, distal phalanx; et, extensor tendon; nb, nail bed; pnf, proximal nail fold; and vp, ventral plate.

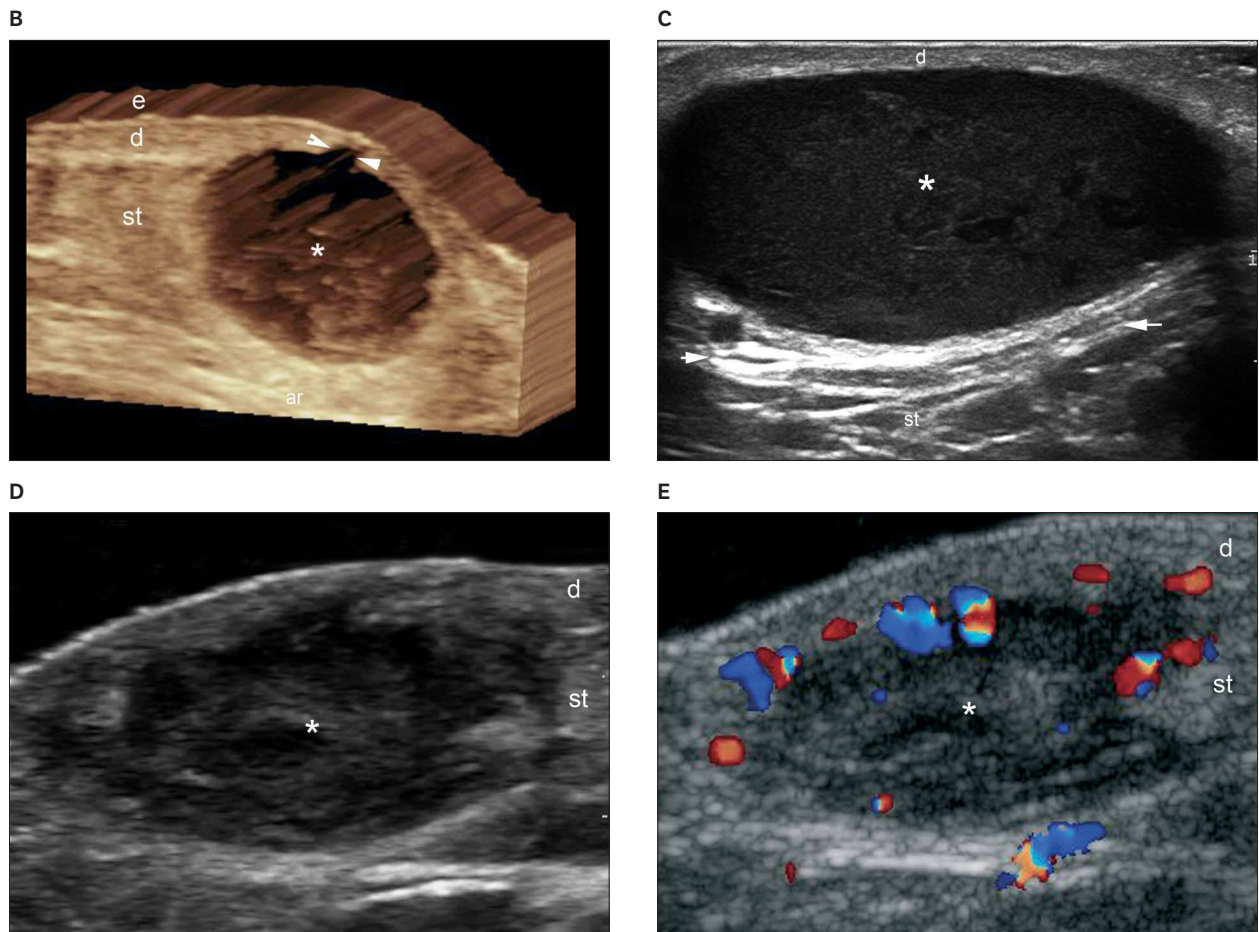


ducing a hypoechoic foreign body–like reaction. Usually, whatever the stage (intact or ruptured), epidermal cysts preserve the posterior acoustic enhancement artifact, typical of cystic structures, which can be a guide to their identification. On color Doppler sonography, increased blood

flow can be detected in the periphery of the cyst during the inflammatory and postrupture phases.

Sonography has been reported to significantly improve the sensitivity and specificity for diagnosing epidermal cysts preoperatively (Figure 3).¹⁶

Figure 3. Epidermal cysts with variable sonographic presentations. **A.** Gray scale sonography (left cheek, transverse view,) shows a well-defined (intact) anechoic round structure (asterisk) in the dermis and subcutaneous tissue. Notice some echoes (debris) within the cyst and a small communicating tract (arrows) to the subepidermal region. Posterior acoustic reinforcement is also shown (arrowheads). **B.** Three-dimensional sonography (transverse view, 5-second sweep) of the same lesion (asterisk) as in **A.** **C.** Gray scale sonography (right temple region, transverse view) shows a well-defined (intact) hypoechoic oval structure (asterisk) in the dermis and subcutaneous tissue with a pseudotestis appearance. Posterior acoustic enhancement is also shown (arrows). **D.** Gray scale sonography (left groin, transverse view) shows a heterogeneous structure (asterisk) with irregular borders in the dermis and subcutaneous tissue, corresponding to a ruptured and inflamed cyst. **E.** Color Doppler sonography (transverse view) of the lesion in **D** shows increased blood flow in the periphery of the cyst (asterisk). Abbreviations: d indicates dermis; e, epidermis; and st, subcutaneous tissue.



Pilonidal Cysts

These cysts are pseudocystic structures comprising a nest of hair fragments. The most common location is the sacrococcygeal region, and they usually affect young adults. Male sex, obesity, occupations requiring sitting, excessive body hair, and sweating are among the risk factors described for this condition.¹⁷ Usually, pilonidal cysts can easily become inflamed and turn into pilonidal abscesses. Moreover, palpation and methylene blue injection have been reported not to provide appropriate information in many patients.¹⁸ On sonography, these cysts appear as hypoechoic oval tracts in the dermis and subcutaneous tissue that contain hyperechoic lines, the latter being hair fragments. Thus, preoperative sonography can improve the identification of the sinus tract and its branches.^{7,18}

On color Doppler imaging, hypervascularity in the periphery of the cysts can be detected during the inflammatory phases. Because these cysts have a high rate of recurrence after surgery, assessment of the axes (upward, downward, oblique, and transverse) in correlation with the level of the cutaneous lesion, as well as the actual extension of the cysts, can provide valuable preoperative data (Figure 4).

Pilomatrixomas

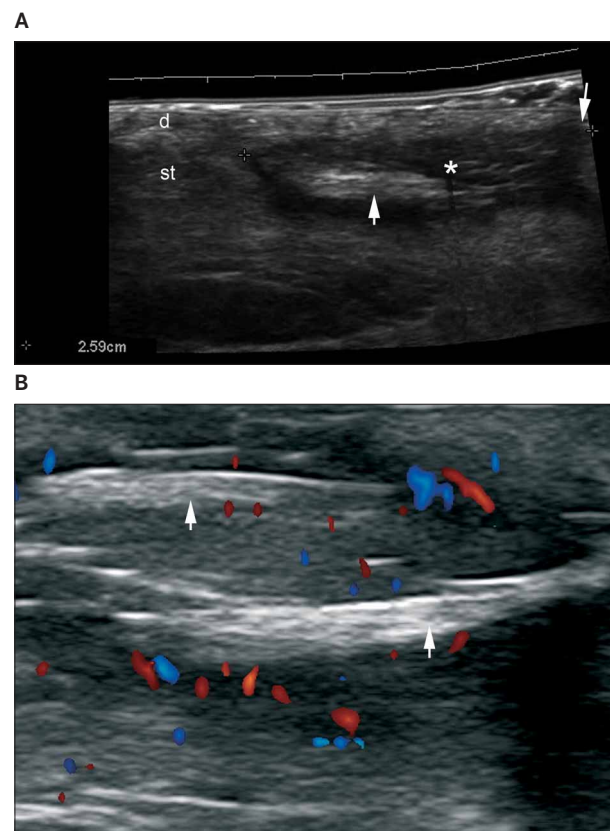
These tumors, also called pilomatricomas or calcifying epitheliomas of Malherbe, arise from the hair follicle matrix. The typical history is of a slowly enlarging mass, irregularly contoured, that is fixed to the skin but slides freely over the underlying tissues, often with a discoloration which varies from red to purple-bluish. Clinically, the misdiagnosis rate in pilomatrixomas had been reported to be up to 56% of cases,¹⁹ and sonography has been described as a useful tool in their diagnosis. The classic image is a target lesion with a hypoechoic rim and a hyperechoic center (Figure 5). Hyperechoic spots that correspond to calcium deposits are detected at the center of the lesion in 68% to 80% of cases.^{20,21} Occasionally, pilomatrixomas can show prominent vascularity with low-velocity arterial and venous vessels (color Doppler imaging), sometimes mimicking a vascular tumor such as a hemangioma in the clinical examination.^{22–24} In addition, there is a cystic variant of pilomatrixomas that appears as a solid-cystic structure with an eccentric nodular hypoechoic component surrounded by anechoic fluid. This cystic variant of usually has inner echoes and septa surrounded by a thick hypoechoic cortex.²⁴

Vascular Lesions

These entities are common causes of referral for sonographic examinations, mostly in the pediatric population.

The objective of the imaging test is to support the diagnosis and to discriminate conditions that may require different clinical management. Importantly, dermatologists often use the classification of Mulliken and Glowacki,²⁵ which differentiates these clinical entities on the basis of endothelial characteristics. Thus, hemangiomas, the most common tumors in infancy, have rapid growth after birth and then a plateau after a few years; however, they tend to regress later in most cases. In contrast, vascular malformations are errors of morphogenesis and are classified according to the type of vessel: arterial, venous, lymphatic, or capillary. In some cases, mixed vascular malformations may be detected. In addition, these vascular malformations can be classified according to the velocity of their flow: high or fast flow (arterial or arteriovenous) and low or slow flow

Figure 4. Pilonidal cyst. **A.** Gray scale sonography (intergluteal area, longitudinal view) shows a hypoechoic oval structure (asterisk) in the dermis and subcutaneous tissue that goes 2.59 cm upward to the level of the cutaneous lesion (arrow pointing down). There are hyperechoic linear structures within the structure that correspond to hair fragments (arrow pointing up). **B.** Color Doppler sonography shows increased blood flow in the periphery of a pilonidal cyst secondary to inflammation. Hyperechoic hair fragments are shown within the cyst (arrows). Abbreviations: d indicates dermis; and st, subcutaneous tissue.



(venous, lymphatic, or capillary). Vascular malformations usually grow proportionally with the child and may present few changes over the lifetime. Moreover, hemangiomas are commonly responsive to systemic treatments, and vascular malformations are usually unresponsive. Therefore, differentiation between these entities is crucial for proper treatment.²⁶

On sonography, hemangiomas are usually poorly defined solid masses that vary in their echogenicity and vascularization according to their phase. Thus, during the proliferative early phase, they tend to be hypoechoic and hypervascular, showing arterial and venous flow and sometimes arteriovenous shunts. Later, during the partial regression phase, the echogenicity turns heterogeneous, usually presenting a mix of hypoechoic-hypervascular and hyperechoic-hypovascular areas (Figure 6). In the total

regression phase, hemangiomas usually become fully hyperechoic and hypovascular. In addition, in the regression period, variable thickness (thinning or thickening) of the fatty component of the subcutaneous tissue may be noticed.

Vascular malformations can usually be detected as anechoic tubules (eg, arterial or venous), pseudocystic spaces (eg, venous or lymphatic), or hyperechoic areas (eg, capillary) depending on the type of vessel (Figure 7). Hyperechoic spots that correspond to phleboliths can be more commonly found in venous malformations. Assessment of the type, thickness, and velocity of the vessels is useful for planning noninvasive (eg, laser or percutaneous sclerotherapy) or invasive (eg, embolization) treatments. Thus, in addition to its diagnostic impact, sonography is also well suited to guidance of interventional treatments, usually reserving angiographic magnetic resonance imaging for lesions that have multiple or even deeper locations.^{27,28}

Figure 5. Pilomatrixoma. **A**, Gray scale sonography (right arm, transverse view) shows a well-defined round targetlike structure (asterisk between markers) in the dermis and subcutaneous tissue. Notice the hypoechoic rim and the hyperechoic spots (arrows, calcium deposits) within the lesion. **B**, Gray scale sonography (right lumbar region, transverse view) shows multiple hyperechoic spots (arrowheads) within a pilomatrixoma (asterisk) that generates a posterior acoustic shadowing artifact. Abbreviations: as indicates posterior acoustic shadowing; d, dermis; r, rim; and st, subcutaneous tissue.

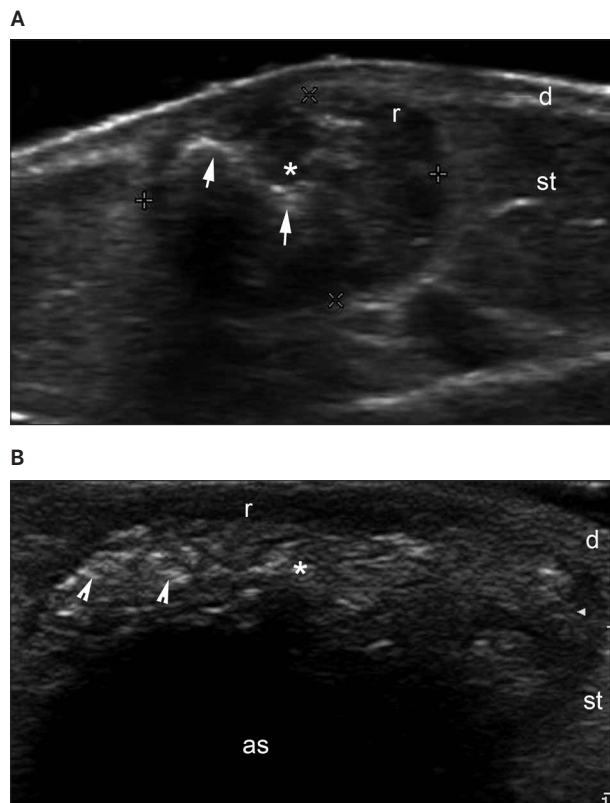
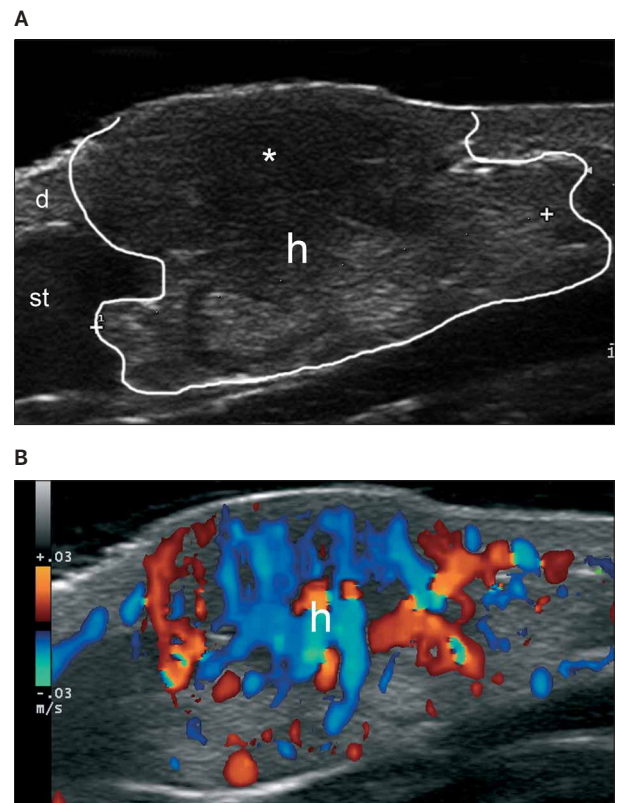


Figure 6. Hemangioma. **A**, Gray scale sonography (right dorsal region, transverse view) shows a poorly defined heterogeneous lesion (outlined) in the dermis and subcutaneous tissue. Notice the more hypoechoic area (asterisk) in the upper part of the lesion, which corresponds to the most proliferative zone. **B**, Color Doppler sonography shows increased vascularity within the same lesion. Abbreviations: d indicates dermis; h, hemangioma; and st, subcutaneous tissue.



Malignant Skin Conditions

Skin cancer is the most common malignant tumor among human beings, and among the subtypes, basal cell carcinoma is the most frequent, followed by squamous cell carcinoma.²⁹ These subtypes constitute what is called nonmelanoma skin cancer. Melanoma is the least frequent type but has the highest mortality rate. Usually, skin cancer affects areas highly exposed to the sun such as the face and also presents in regions where the skin is thin such as the nose, eyes, lips, and ears. In the latter areas, there is a greater probability of deep structure involvement (eg, muscles, cartilage, or bone).³⁰

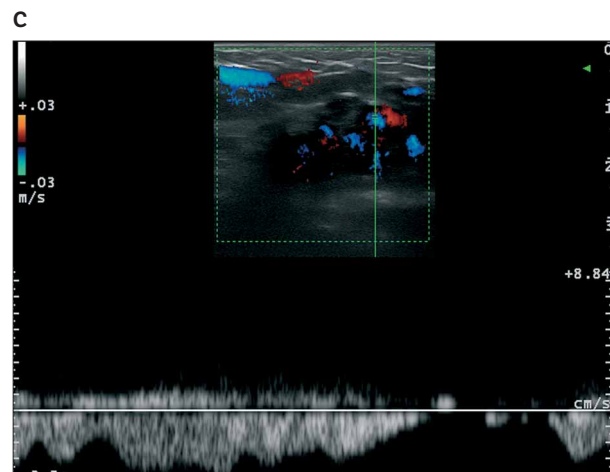
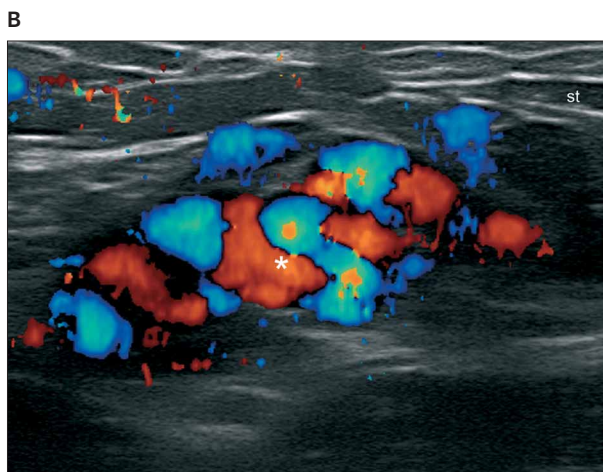
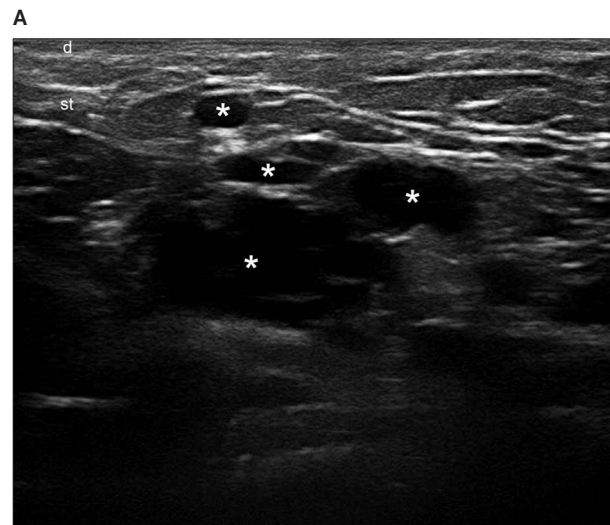
A good correlation has been reported between sonography and histologic assessment for tumor thickness, and these findings could be particularly critical in melanoma, in which the thickness of the primary lesion can affect im-

portant decisions such as performance of a sentinel node procedure and the size of the incision. Thus, sonography can reliably differentiate primary melanoma thicknesses of greater than 1 mm from those of 1 mm or less.³¹

On sonography, basal cell carcinoma lesions appear as hypoechoic solid lesions, commonly with hyperechoic spots. A slight increase in the vascularity at the bottom of the lesion has been reported (Figure 8).^{32,33} Squamous cell carcinoma is also hypoechoic and more aggressive on presentation. In this entity, involvement of deeper layers or lymph nodes is not uncommon.³⁴ On sonography, melanoma appears as hypoechoic and sometimes fusiform lesions, commonly showing increased vascularity, which may explain their high angiogenic power (Figure 9).³⁵

Sonography can also depict satellite (<2 cm from the primary lesions), in-transit (≥ 2 cm from the primary lesion), and nodal metastases. These secondary lesions of

Figure 7. Low-flow venous vascular malformation. **A.** Gray scale sonography (left groin, transverse view) shows anechoic tracts and lacunar areas (asterisks) in the subcutaneous tissue. **B.** Color Doppler sonography shows increased blood flow within the anechoic structures (asterisk). **C.** Color Doppler spectral curve analysis shows venous flow within the tracts. Abbreviations: d indicates dermis; and st, subcutaneous tissue.



melanoma may appear as hypoechoic or heterogeneous oval structures; however, occasionally they can be anechoic and mimic abscesses or fluid collections.^{35,36} Interestingly, in addition to the surgical option, there is an extensive and growing use of noninvasive treatments of skin cancer, such as photodynamic therapy and radiotherapy.³⁷ Therefore, assessment of the anatomic characteristics of the primary tumor and its secondary involvement can show an advantage in the monitoring of these noninvasive modes of treatment.

Inflammatory/Infectious Diseases

Psoriasis

This entity is an inflammatory disease that commonly affects the skin and nails. To date, the diagnosis of psoriasis has been based on both the clinical history and physical examination, and its severity is assessed by the Psoriasis Area and Severity Index. Nevertheless, continuous tech-

nological advances in the field of sonography have allowed us to obtain very detailed morphologic information regarding the cutaneous and unguinal changes in this condition, including sonographic monitoring of activity and treatment.³⁸

Thus, on color Doppler sonography, it is possible to detect the thickening of the epidermis and hypo-echogenicity of the upper dermis. In addition, psoriatic onychopathy shows detectable changes on sonography that, described from early to late phases, are usually thickening and decreased echogenicity of the nail bed, focalized hyperechoic deposits in the ventral plate (sometimes subclinical), wavy plates, and finally, thickening of both plates. Increased blood flow can be seen during the active phases of the disease within the dermis of the psoriatic plaques and the nail bed (Figure 10). Sonographic monitoring of the activity and severity of psoriatic involvement has already been reported in the literature.^{39–41}

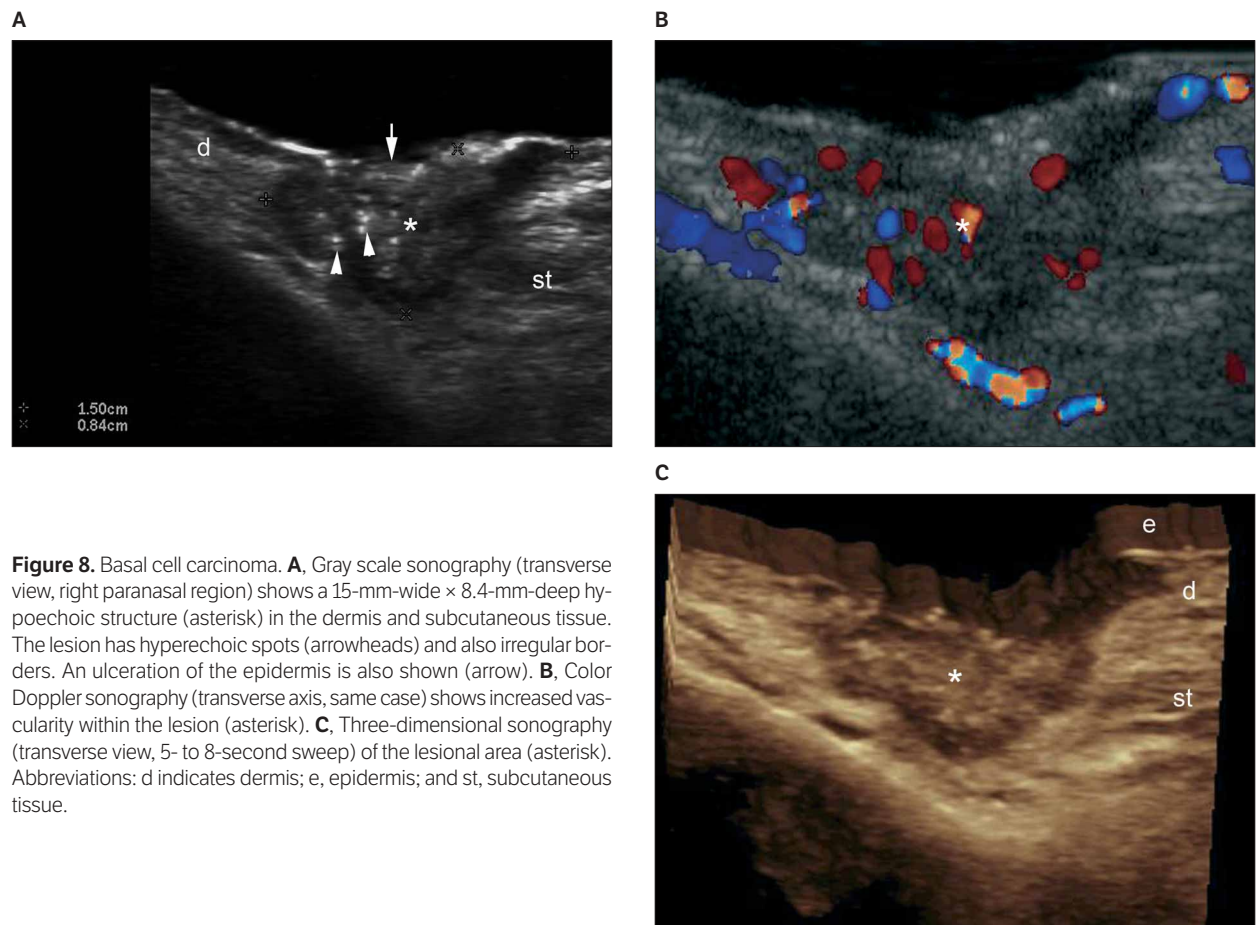


Figure 8. Basal cell carcinoma. **A.** Gray scale sonography (transverse view, right paranasal region) shows a 15-mm-wide × 8.4-mm-deep hypoechoic structure (asterisk) in the dermis and subcutaneous tissue. The lesion has hyperechoic spots (arrowheads) and also irregular borders. An ulceration of the epidermis is also shown (arrow). **B.** Color Doppler sonography (transverse axis, same case) shows increased vascularity within the lesion (asterisk). **C.** Three-dimensional sonography (transverse view, 5- to 8-second sweep) of the lesional area (asterisk). Abbreviations: d indicates dermis; e, epidermis; and st, subcutaneous tissue.

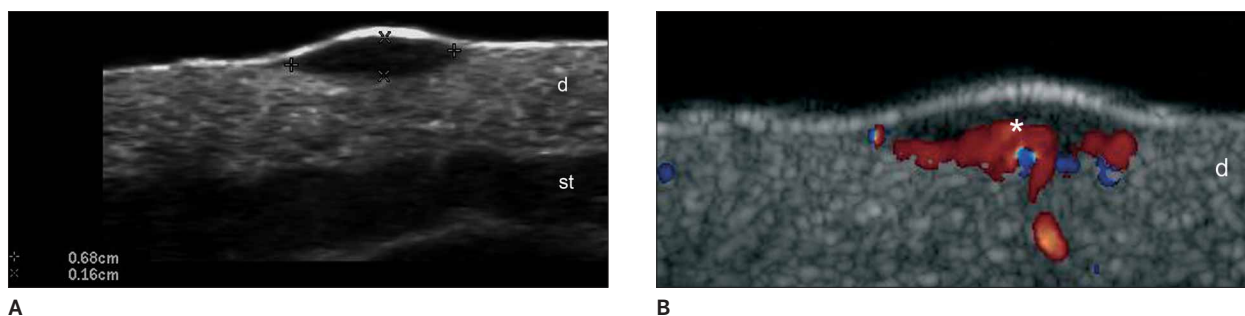


Figure 9. Melanoma. **A**, Gray scale sonography (dorsal region, transverse view) shows a 1.6-mm-deep × 6.8-mm-wide fusiform hypoechoic lesion (between markers) that involves the epidermis and dermis. There is increased thickness and echogenicity of the epidermis. Depth measurement was performed at the dermis by agreement with the pathologist. **B**, Color Doppler sonography shows increased blood flow within the same lesion (asterisk). Abbreviations: d indicates dermis; and st, subcutaneous tissue.

Morphea

This inflammatory disease corresponds to the cutaneous manifestation of scleroderma. The sonographic appearance of morphea can vary through the different phases of the disease, going from thickening and decreased echogenicity of the dermis and areas with increased echogenicity of the subcutaneous tissue during the active phases to substantial at-

rophy of the dermis and subcutaneous tissue during the late phases. In addition, increased dermal vascularity in the lesion may be detected on color or power Doppler imaging during the active phases. The most accurate sonographic signs of lesion activity that have been reported are increased subcutaneous tissue echogenicity and cutaneous blood flow (sensitivity and specificity of 100% and 100%, respectively,

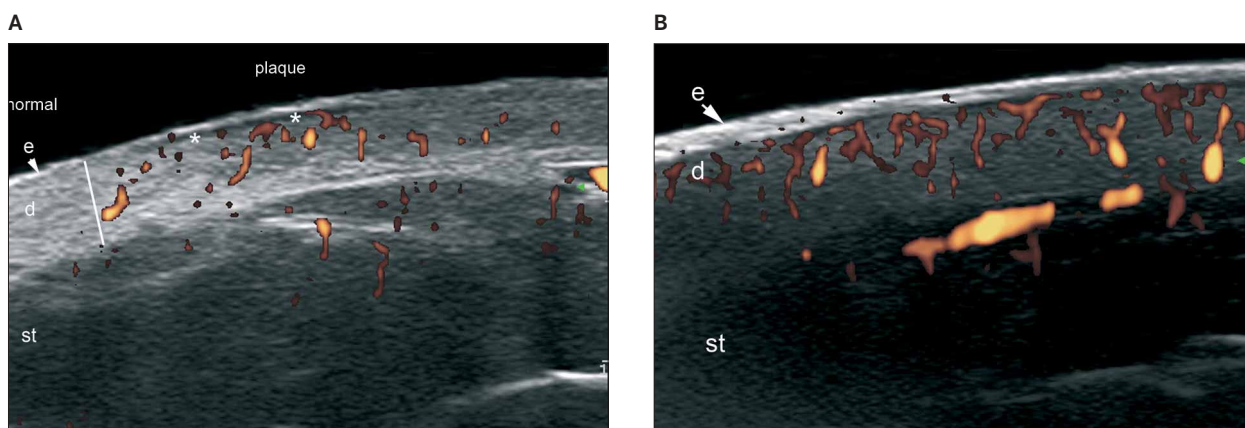


Figure 10. Psoriasis. **A**, Psoriatic plaque. Color (power) Doppler sonography (thoracoabdominal region, transverse view,) shows thickening of the epidermis and dermis in the psoriatic plaque. Decreased echogenicity of the upper dermis (asterisk) in the lesional area is also shown (in comparison with the normal skin on the left border of the image). There is increased blood flow within the dermal layer in the psoriatic plaque. **B**, Color (power) Doppler sonography (dorsal region, transverse view) in another case shows a substantial increase of the thickness of the epidermis and a highly vascular pattern within the psoriatic plaque. **C**, Color (power) Doppler sonography (right thumb, longitudinal view) in psoriatic onychopathy shows thickening of the nail bed and wavy nail plates. Increased vascularity is also shown within the nail bed. Abbreviations: d indicates dermis; dph, distal interphalangeal joint; e, epidermis; nb, nail bed; pl, nail plates; pnf, proximal nail fold; and st, subcutaneous tissue.

for both). Importantly, morphea lesions can show full- or partial-thickness activity; furthermore, lesions in the same patient can have an asynchronous presentation, being in different stages of activity. Additionally, chronic inflammatory signs in the ipsilateral parotid gland (decreased echogenicity or size) have been described in patients with Parry Romberg syndrome (facial hemiatrophy associated with ipsilateral facial morphea; Figure 11).^{42–44}

Plantar Warts

These lesions are the result of infection by the human papilloma virus and commonly present as hyperkeratotic points in the soles of the feet. Clinically, plantar warts can be very painful and therefore may mimic foreign bodies or Morton neuromas. On sonography, these lesions appear as fusiform hypoechoic structures that involve the epidermis and dermis. On color Doppler imaging, they can vary in their dermal vascularity from hypovascular to hypervascular with prominent arterial vessels (Figure 12). Plantar warts may be associated with other inflammatory signs in the surrounding tissues such as plantar bursitis. Thus, sonography allows noninvasive support of the diagnosis and also monitoring of therapeutic responses, especially in recurrent and difficult cases with persistent symptoms.^{45,46}

Hidradenitis Suppurativa

Also called acne inversa, this disease is characterized by a chronic inflammatory scarring condition involving the intertriginous skin of the axillary, inguinal, inframammary, genital, and perineal areas of the body.⁴⁷ On sonography, the involvement can be qualified and quantified and has been described in the literature as progressing from early to late phases as enlargement of the hair follicles, hypoechoic dermal nodules, anechoic dermal fluid collections, hypoechoic and connecting fistulous tracts, and dermal fluid collections. On color Doppler sonography, increased vascularity of the dermal and superficial subcutaneous tissue can be detected.⁴⁸ Usually, despite their extensive involvement, lymph nodes are not increased in size. However, they may show some cortical thickening and hypoechoogenicity.⁴⁹ Hence, sonography can support the diagnosis and assessment of the severity of this complex disease.⁵⁰

Ungual Lesions

The use of sonography in lesions of the nail can be important because biopsies can be difficult to perform in the unguinal tissue and may generate cosmetic sequelae. Among the anatomically relevant data, sonography can differenti-

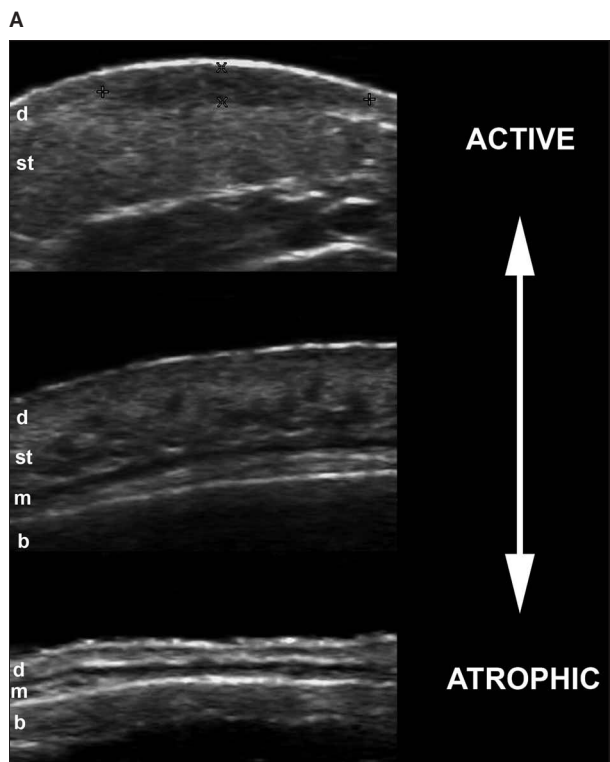
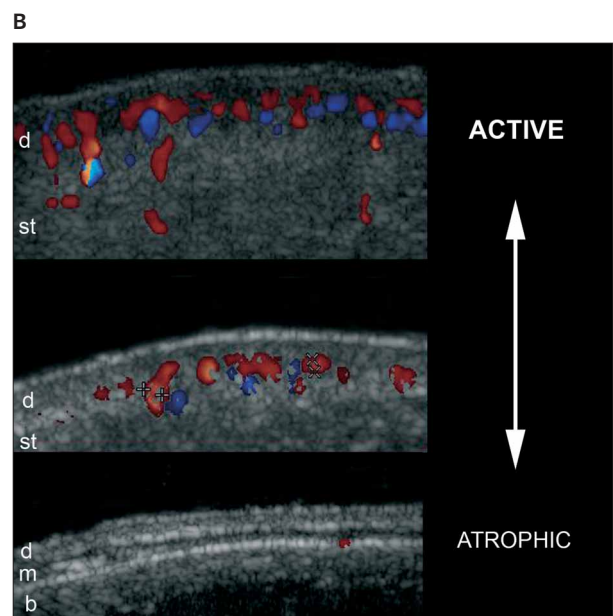
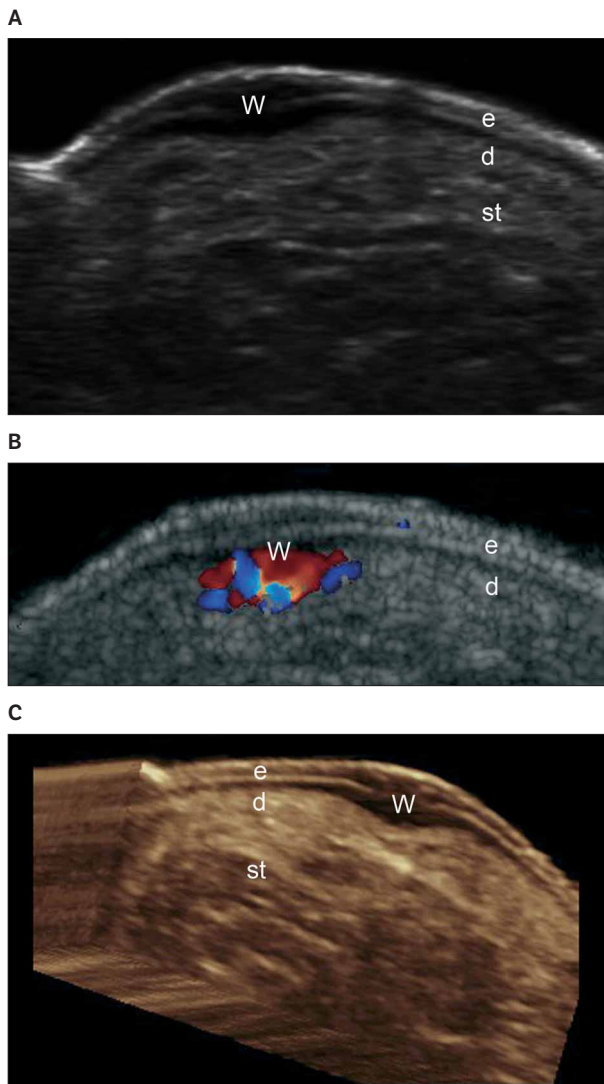


Figure 11. Morphea. **A**, Gray scale sonography shows the variable degrees of activity. Notice the different patterns of echogenicity and thickness of the dermis and subcutaneous tissue during the phases. **B**, Grading the vascularity in the different phases with color Doppler sonography. Abbreviations: b indicates bony margin; d, dermis; m, muscle; and st, subcutaneous tissue.



ate between an unguial or a periungual origin and indicate the exact location, extension, and vascularity of the lesions. This sonographic information may facilitate an incision at an appropriate site, perhaps decrease recurrences, and improve cosmetic outcomes.¹³

Figure 12. Plantar wart. **A**, Gray scale sonography (right foot, transverse view) shows a hypoechoic fusiform lesion affecting the epidermis and dermis in the plantar region. Also notice the typical bilaminar hyperechoic pattern of the epidermis in the normal glabrous skin (out of the lesional area). **B**, Color Doppler sonography (transverse view) shows increased blood flow within the dermal component of the lesion. **C**, Three-dimensional sonography (transverse view, 5- to 8-second sweep) shows the morphologic characteristics of the wart. Abbreviations: d indicates dermis; e, epidermis; st, subcutaneous tissue; and W, wart.



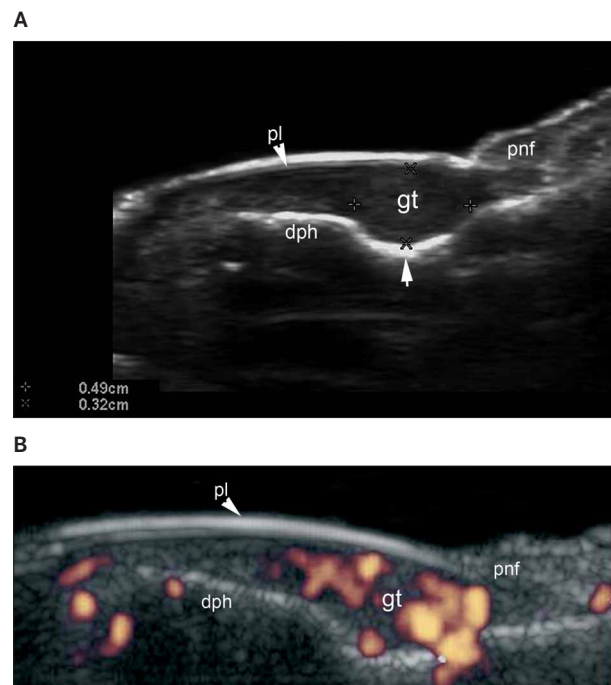
Glomus Tumors

These tumors are derived from the neuromyoarterial glomus and clinically are usually characterized by a symptomatic triad: paroxysmal pain, pinpoint pain, and hypersensitivity.⁵¹ On sonography, glomus tumors appear as hypoechoic and usually centrally located nodules within the nail bed. Increased vascularity in the tumors and a slight remodeling of the bony margin beneath the lesions are frequent findings (Figure 13). Moreover, very few recurrences have been reported in patients who underwent preoperative sonography.^{13,52,53}

Subungual Exostoses

These lesions are not true tumors but correspond to periungual protrusions that emerge from the bony margin of the distal phalanx. Subungual exostoses are more frequent on the feet, especially the great toe, but may clinically mimic an unguial origin. On sonography, these entities appear eccentric bandlike hyperechoic structures within the nail bed, which are connected to the bony margin of the distal phalanx and usually displace the nail plates upward.

Figure 13. Glomus tumor. **A**, Gray scale sonography (left thumb, longitudinal view) shows a 4.9-mm-long × 3.2-mm-deep hypoechoic nodule in the proximal nail bed. Notice the remodeling of the bony margin of the distal phalanx (arrow) and the upward displacement of the nail plates. **B**, Color (power) Doppler sonography (longitudinal view) shows increased vascularity within the lesional area. Abbreviations: dph indicates distal phalanx; gt, glomus tumor; pl, nail plates; and pnf, proximal nail fold.



Subungual exostoses may also be associated with hypoechoic granulomatous and scar tissue in the vicinity and differ from osteochondromas because the latter usually show a hypoechoic covering attached to the hyperechoic osseous band that corresponds to the cartilaginous cap.¹³

Exogenous Components

Foreign Bodies

These structures can be retained in the skin through different mechanisms, commonly related to trauma. Sometimes, patients may not be aware of retained material but frequently have inflammatory signs in the skin such as induration, erythema, and scarring.⁵⁴ Sonography has been reported to be useful for diagnosing foreign bodies, which is a matter of utmost importance when dealing with radiolucent structures. Moreover, this imaging technique may guide percutaneous removal of these objects. According to their composition, foreign bodies can be classified as organic (ie, derived from living organisms) or inert.

On sonography, splinters (eg, wood and thorns), fish hooks, and pieces of glass and metal usually appear as hyperechoic linear or bandlike structures. In the cases of glass and metal, a posterior reverberation artifact may be noticed. Frequently, these foreign bodies are surrounded by hypoechoic tissue that corresponds to a secondary inflammatory granulomatous reaction (Figure 14). In addition, associated fluid collections such as hematomas and abscesses or involvement of deeper structures may be ruled out. Occasionally, these foreign bodies may be found far from the puncture wound level; therefore, it is suggested that a wide area of tissue be examined. Thus, detection and assessment of the size, orientation, location, and anatomic relationships of the foreign body by sonography can help plan the removal procedure properly. In an acute setting, care should be taken to avoid contamination of the open wound with gel; therefore, the use of sterile gel is recommended. In addition, in the presence of soft tissue emphysema, a lateral approach to the wound or a water bath (when located in the distal arm or leg) can help.^{54,55}

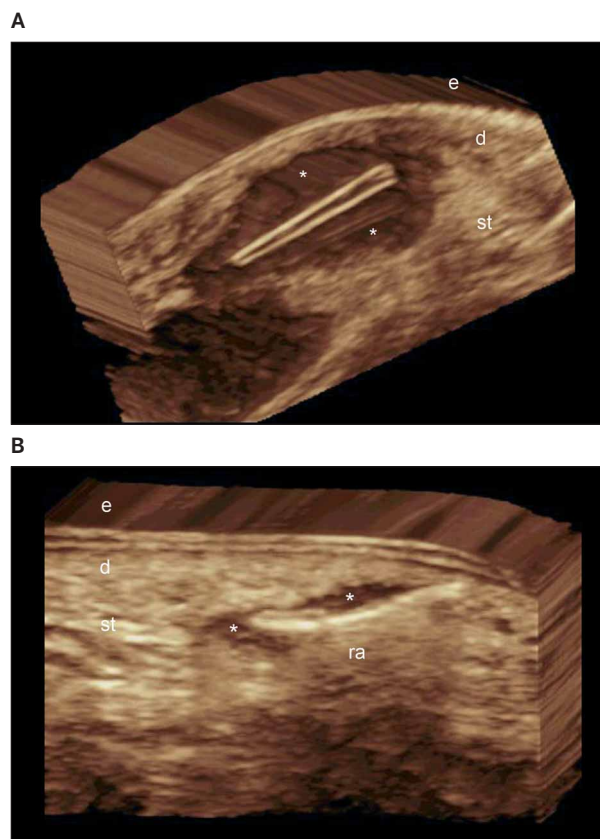
Cosmetic Fillers

These compounds correspond to nanoparticles used for augmentation of the soft tissues for preventing wrinkled or sagging skin, and their use has been growing explosively, particularly on the face. Sometimes these fillers generate complications that can mimic common dermatologic diseases; among them are nodules, erythema, edema, and morphea-like reactions. In addition, patients may not

spontaneously refer to the history of the injection, which may complicate the clinical diagnosis. There are two main types of fillers: biological (degradable) and synthetic (non-degradable). The main type of biologic filler is hyaluronic acid, pure or mixed with lidocaine. Among synthetic fillers there are several types, but commonly used materials are silicone (pure or oily formulations), polymethylmethacrylate, and calcium hydroxyapatite, among others.

On sonography, these fillers are usually extensively located in the subcutaneous tissue, as well as the dermal layer; therefore, the commonly used term “dermal fillers” seems not anatomically appropriate and could be confusing. Hyaluronic acid appears as anechoic pseudocysts that decrease in size over 3 to 6 months. The mixed formulation (hyaluronic acid and lidocaine) can additionally show

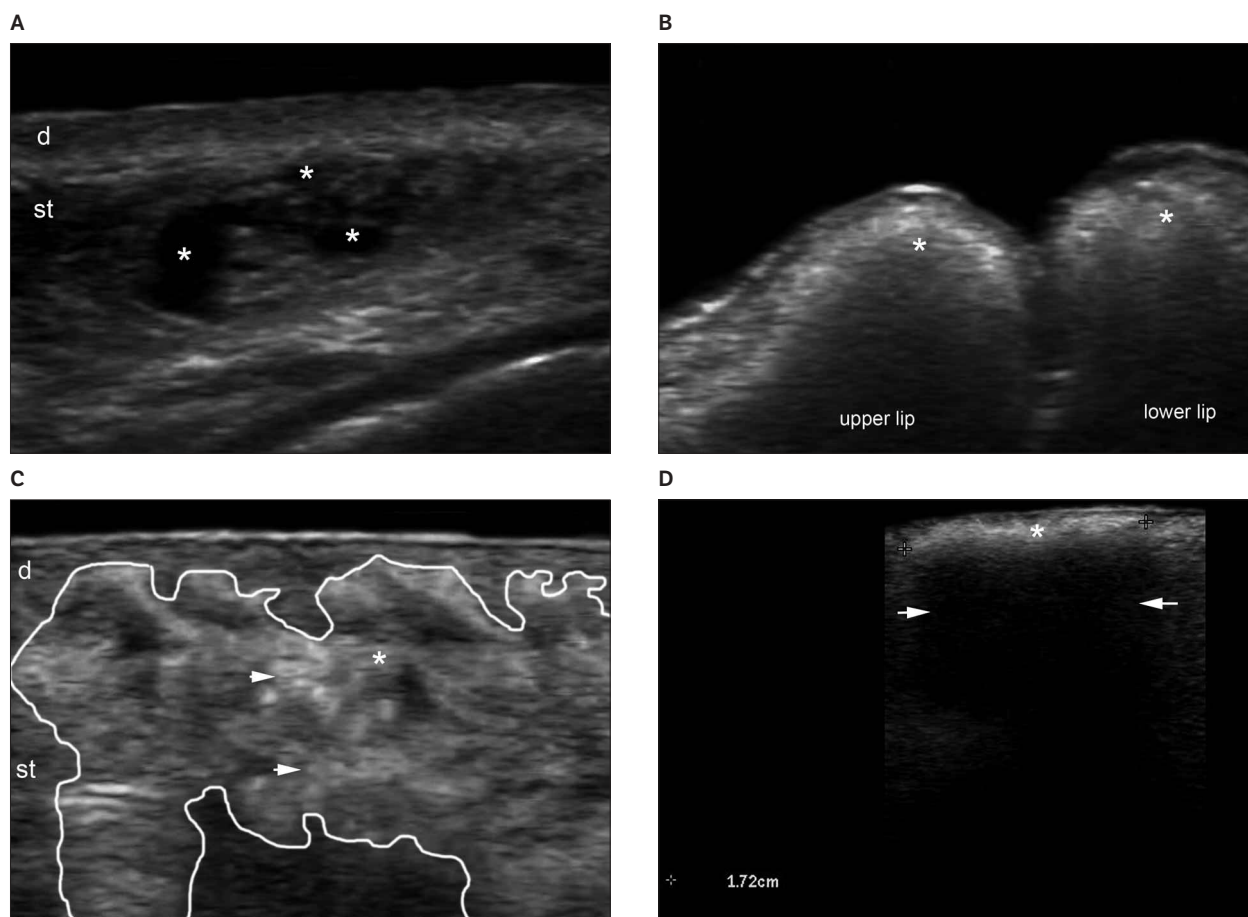
Figure 14. Foreign bodies (3-dimensional reconstructions, 5- to 8-second sweep). **A.** Splinter of wood (left thenar eminence, transverse view) appearing as a bilaminar hyperechoic structure surrounded by hypoechoic granulomatous tissue (asterisks). **B.** Glass fragment (right plantar region, longitudinal view) appearing as a hyperechoic linear structure with a reverberation artifact, also surrounded by hypoechoic granulomatous tissue (asterisks). Abbreviations: d indicates dermis; e, epidermis; ra, reverberation artifact; and st, subcutaneous tissue.



prominent echoes within the pseudocysts. In contrast, synthetic fillers usually do not modify their size or echo structure over time. Silicone echogenicity will depend on the formulation type⁵⁶; pure silicone is anechoic, similar to the echogenicity described in intact breast implants, and silicone oil is hyperechoic, showing a posterior reverberation or scattering artifact, similar to the one seen in ruptured silicone implants when the pure silicone is mixed with the fatty tissue of the breast. Polymethylmetacrylate appears as hyperechoic dots with a mini comet tail artifact, and calcium hydroxyapatite appears as hyperechoic bands with a posterior acoustic shadowing artifact⁵⁶; the latter artifact

is the one classically described in calcified structures. Polyacrylamide gel, another synthetic filler, appears on sonography as mostly oval anechoic pseudocysts with increased echogenicity of the surrounding subcutaneous tissue. Nevertheless, in contrast with the degradable hyaluronic acid deposits that disappear over a 6-month postinjection period, polyacrylamide gel deposits have been reported to not change in size at least for 1 year.⁵⁷ Thus, the provision of noninvasive detailed anatomic information in these patients can be greatly valued because these patients usually have a high cosmetic expectancy and try to avoid invasive procedures such as biopsies (Figure 15).⁵⁶⁻⁶⁰

Figure 15. Cosmetic fillers (gray scale sonography). **A**, Hyaluronic acid (right nasal fold line, transverse view) appearing as anechoic pseudocystic structures (asterisks) in the subcutaneous tissue. **B**, Silicone oil (upper and lower lips, longitudinal view) appearing as hyperechoic deposits (asterisks) with a posterior reverberation artifact that involves all of the lip layers. **C**, Polymethylmetacrylate (gluteal region, transverse view) appearing as hyperechoic deposits (asterisk, outlined region) with mini comet tail artifacts (arrows) in the dermis and subcutaneous tissue. **D**, Calcium hydroxyapatite (left nasal fold line, longitudinal view) appearing as a hyperechoic dermal band (asterisk) with posterior acoustic shadowing (arrows). Abbreviations: d indicates dermis; and st, subcutaneous tissue.



Conclusions

Sonography may provide reliable support in a wide range of common dermatologic conditions. It allows reasonable discrimination between lesional and nonlesional skin tissue, dermatologic and nondermatologic origins, hypovascular and hypervascular lesions, and exogenous and endogenous components. The assessment of objective information in dermatologic diseases seems to be a necessary field for further investigation that can save clinical time dedicated to complex scoring. Moreover, sonography can possibly guide otherwise blind common cutaneous procedures that may be susceptible to complications or recurrences. It can also show critical information otherwise invisible to the naked eye of a clinician, including, for example, depth and activity. Furthermore, used as presented, in frequent dermatologic entities, sonography can help improve the final cosmetic prognosis of patients.

References

- Klein R, Moghadam-Kia S, Taylor L, et al. Quality of life in cutaneous lupus erythematosus. *J Am Acad Dermatol* 2011; 64:849–858.
- Shah M, Mavers M, Bree A, Fosko S, Lents NH. Quality of life and depression assessment in nevoid basal cell carcinoma syndrome. *Int J Dermatol* 2011; 50:268–276.
- Matusiak L, Bieniek A, Szepietowski JC. Psychophysical aspects of hidradenitis suppurativa. *Acta Derm Venereol* 2010; 90:264–268.
- Farinelli N, Berardesca E. The skin integument: variation relative to sex, age, race, and body region. In: Serup J, Jemec GBE, Grove GL (eds). *Handbook of Noninvasive Methods and the Skin*. 2nd edition. Boca Raton, FL: Taylor & Francis; 2006:27–36.
- Sharman AM, Kimi O, Anslow P. Imaging of the skin, subcutis, and galea aponeurotica. *Semin Ultrasound CT MR* 2009; 30:452–464.
- 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; 25:375–382.
- Wortsman X, Wortsman J. Clinical usefulness of variable-frequency ultrasound in localized lesions of the skin. *J Am Acad Dermatol* 2010; 62:247–256.
- Wortsman X, Jemec G. Common inflammatory diseases of the skin: from the skin to the screen. *Adv Psoriasis Inflammatory Skin Dis* 2010; 2:9–15.
- Wortsman X, Gutierrez M, Saavedra T, Honeyman J. The role of ultrasound in rheumatic skin and nail lesions: a multi-specialist approach. *Clin Rheumatol* 2011; 30:739–748.
- Li SC, Liebling MS, Haines KA, Weiss JE, Prann A. Initial evaluation of an ultrasound measure for assessing the activity of skin lesions in juvenile localized scleroderma. *Arthritis Care Res (Hoboken)* 2011; 63:735–742.
- Wortsman X, Jemec GBE. Ultrasound imaging of nails. *Dermatol Clin* 2006; 24:323–328.
- Cecchini A, Montella A, Ena P, Meloni GB, Mazzarello V. Ultrasound anatomy of normal nails unit with 18 MHz linear transducer. *Ital J Anat Embryol* 2009; 114:137–144.
- Wortsman X, Wortsman J, Soto R, et al. Benign tumors and pseudotumors of the nail: a novel application of sonography. *J Ultrasound Med* 2010; 29:803–816.
- Huang CC, Ko SF, Huang HY, et al. Epidermal cysts in the superficial soft tissue: sonographic features with an emphasis on the pseudotestis pattern. *J Ultrasound Med* 2011; 30:11–17.
- Jin W, Ryu KN, Kim GY, Kim HC, Lee JH, Park JS. Sonographic findings of ruptured epidermal inclusion cysts in superficial soft tissue: emphasis on shapes, pericystic changes, and pericystic vascularity. *J Ultrasound Med* 2008; 27:171–176.
- Kuwano Y, Ishizaki K, Watanabe R, Nanko H. Efficacy of diagnostic ultrasonography of lipomas, epidermal cysts, and ganglions. *Arch Dermatol* 2009; 145:761–764.
- Harlak A, Menten O, Kilic S, Coskun K, Duman K, Yilmaz F. Sacrococcygeal pilonidal disease: analysis of previously proposed risk factors. *Clinics (Sao Paulo)* 2010; 65:125–131.
- Menten O, Oysul A, Harlak A, Zeybek N, Kozak O, Tufan T. Ultrasonography accurately evaluates the dimension and shape of the pilonidal sinus. *Clinics (Sao Paulo)* 2009; 64:189–192.
- Roche NA, Monstrey SJ, Matton GE. Pilomatricoma in children: common but often misdiagnosed. *Acta Chir Belg* 2010; 110:250–254.
- Hwang JY, Lee SW, Lee SM. The common ultrasonographic features of pilomatricoma. *J Ultrasound Med* 2005; 24:1397–1402.
- Choo HJ, Lee SJ, Lee YH, et al. Pilomatricomas: the diagnostic value of ultrasound. *Skeletal Radiol* 2010; 39:243–250.
- Solivetti FM, Elia F, Drusco A, Panetta C, Amantea A, Di Carlo A. Epithelioma of Malherbe: new ultrasound patterns. *J Exp Clin Cancer Res* 2010; 29:42.
- Wortsman X, Wortsman J, Arellano J, et al. Pilomatricomas presenting as vascular tumors on color Doppler ultrasound. *J Pediatr Surg* 2010; 45:2094–2098.
- Hassanein AH, Alomari AI, Schmidt BA, Greene AK. Pilomatricoma imitating infantile hemangioma. *J Craniofac Surg* 2011; 22:734–736.
- Mulliken JB, Glowacki J. Hemangiomas and vascular malformations in infants and children: a classification based on endothelial characteristics. *Plast Reconstr Surg* 1982; 69:412–422.
- Mulliken JB, Glowacki J. Classification of pediatric vascular lesions. *Plast Reconstr Surg* 1982; 70:120–121.
- Paltiel HJ, Burrows PE, Kozakewich HP, Zurakowski D, Mulliken JB. Soft-tissue vascular anomalies: utility of US for diagnosis. *Radiology* 2000; 214:747–754.
- Peer S. The place of sonography in the diagnostic work-up of haemangiomas and vascular malformations [in German]. *Handchir Mikrochir Plast Chir* 2009; 41:70–77.
- Kwasniak LA, Garcia-Zuazaga J. Basal cell carcinoma: evidence-based medicine and review of treatment modalities. *Int J Dermatol* 2011; 50:645–658.

30. Hong H, Sun J, Cai W. Anatomical and molecular imaging of skin cancer. *Clin Cosmet Investig Dermatol* 2008; 1:1–17.
31. Music MM, Hertl K, Kadivec M, Pavlović MD, Hocevar M. Pre-operative ultrasound with a 12–15 MHz linear probe reliably differentiates between melanoma thicker and thinner than 1 mm. *J Eur Acad Dermatol Venerol* 2010; 24:1105–1108.
32. Bobadilla F, Wortsman X, Muñoz C, Segovia L, Espinoza M, Jemec GBE. Pre-surgical high resolution ultrasound of facial basal cell carcinoma: correlation with histology. *Cancer Imaging* 2008; 22:163–172.
33. Uhara H, Hayashi K, Koga H, Saida T. Multiple hypersonographic spots in basal cell carcinoma. *Dermatol Surg* 2007; 33:1215–1219.
34. Aoyagi S, Izumi K, Hata H, Kawasaki H, Shimizu H. Usefulness of real-time tissue elastography for detecting lymph-node metastases in squamous cell carcinoma. *Clin Exp Dermatol* 2009; 34:e744–e747.
35. Catalano O, Caracò C, Mozzillo N, Siani A. Locoregional spread of cutaneous melanoma: sonography findings. *AJR Am J Roentgenol* 2010; 194:735–745.
36. Catalano O, Siani A. Cutaneous melanoma: role of ultrasound in the assessment of locoregional spread. *Curr Probl Diagn Radiol* 2010; 39:30–36.
37. Murchison AP, Walrath JD, Washington CV. Non-surgical treatments of primary, non-melanoma eyelid malignancies: a review. *Clin Exp Ophthalmol* 2011; 39:65–83.
38. Gutierrez M, De Angelis R, Bernardini ML, et al. Clinical, power Doppler sonography and histological assessment of the psoriatic plaque: short-term monitoring in patients treated with etanercept. *Br J Dermatol* 2011; 164:33–37.
39. Gutierrez M, Wortsman X, Filippucci E, De Angelis R, Filosa G, Grassi W. High-frequency sonography in the evaluation of psoriasis: nail and skin involvement. *J Ultrasound Med* 2009; 28:1569–1574.
40. Filippucci E, De Angelis R, Salaffi F, Grassi W. Ultrasound, skin, and joints in psoriatic arthritis. *J Rheumatol Suppl* 2009; 83:35–38.
41. Wortsman X, Holm EA, Jemec GBE, et al. Fifteen-megahertz high-resolution ultrasound examination of psoriatic nails [in Spanish]. *Rev Chil Radiol* 2004; 10:6–9.
42. Li SC, Liebling MS, Haines KA. Ultrasonography is a sensitive tool for monitoring localized scleroderma. *Rheumatology (Oxford)* 2007; 46:1316–1319.
43. Li SC, Liebling MS. The use of Doppler ultrasound to evaluate lesions of localized scleroderma. *Curr Rheumatol Rep* 2009; 11:205–211.
44. Wortsman X, Wortsman J, Sazunic I, Carreño L. Activity assessment in morphea using color Doppler ultrasound. *J Am Acad Dermatol* 2011; 65:942–948.
45. Wortsman X, Sazunic I, Jemec GBE. Sonography of plantar warts. *J Ultrasound Med* 2009; 28:787–793.
46. Wortsman X, Jemec GBE, Sazunic I. Anatomical detection of inflammatory changes associated with plantar warts by ultrasound. *Dermatology* 2010; 220:213–217.
47. Danby FW, Margesson LJ. Hidradenitis suppurativa. *Dermatol Clin* 2010; 28:779–793.
48. Wortsman X, Jemec GBE. High-frequency ultrasound for the assessment of hidradenitis suppurativa. *Dermatol Surg* 2007; 33:1–3.
49. Wortsman X, Revuz J, Jemec GBE. Lymph nodes in hidradenitis suppurativa. *Dermatology* 2009; 219:32–41.
50. Kelekis NL, Efstathopoulos E, Balanika A, et al. Ultrasound aids in diagnosis and severity assessment of hidradenitis suppurativa. *Br J Dermatol* 2010; 162:1400–1402.
51. Cigna E, Carlesimo B, Bistoni G, Conte F, Palumbo F, Scuderi N. The value of clinical diagnosis of digital glomus tumors. *Acta Chir Plast* 2008; 50:55–58.
52. Wortsman X, Jemec GBE. Role of high variable frequency ultrasound in preoperative diagnosis of glomus tumors: a pilot study. *Am J Clin Dermatol* 2009; 10:23–27.
53. Lin YC, Hsiao PF, Wu YH, Sun FJ, Scher RK. Recurrent digital glomus tumor: analysis of 75 cases. *Dermatol Surg* 2010; 36:1396–1400.
54. Halaas GW. Management of foreign bodies in the skin. *Am Fam Physician* 2007; 76:683–688.
55. Valle M, Zamorani MP. Skin and subcutaneous tissue. In: Bianchi S, Martinoli C (eds). *Ultrasound of the Musculoskeletal System*. Berlin, Germany: Springer-Verlag; 2007:27–31.
56. Wortsman X, Wortsman J, Orlandi C, Cardenas G, Sazunic I, Jemec GBE. Ultrasound detection and identification of cosmetic fillers in the skin [published online ahead of print March 21, 2011]. *J Eur Acad Dermatol Venerol*. doi:10.1111/j.1468-3083.2011.04047.x
57. Wortsman X, Wortsman J. Polyacrylamide fillers on skin ultrasound [published online ahead of print May 14, 2011]. *J Eur Acad Dermatol Venerol*. doi:10.1111/j.1468-3083.2011.04111.x
58. Young SR, Bolton PA, Downie J. Use of high-frequency ultrasound in the assessment of injectable dermal fillers. *Skin Res Technol* 2008; 14:320–323.
59. Grippaudo FR, Mattei M. High-frequency sonography of temporary and permanent dermal fillers. *Skin Res Technol* 2010; 16:265–269.
60. 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.