20-MHz B-mode Ultrasound in Monitoring the Course of Localized Scleroderma (Morphea)

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Ultrasonographic methods have recently provided us with the means for objective and non-invasive monitoring of the dynamics of chronic skin diseases.
We examined 34 patients with localized scleroderma (morphea) using a 20-MHz B-mode ultrasound scanner (DUB 20, Taberna pro Medicum, Lüneburg). In patients with plaque-type and linear band-type localized scleroderma intraindividual comparison of sclerotic skin with corresponding areas of healthy skin showed thickening of the corium. The increase in corium thickness was between 2% and 251%. The extent of the difference in corium thickness between sclerotic and healthy skin depended on the location – originally thin skin showed a greater degree of sclerosis. We also frequently found enhanced reflexes in the lower corium and hyperechoic, widened bands of connective tissue traversing the subcutaneous fatty tissue from the corium-subcutis border in the direction of the muscle fascia.
20 patients were examined several times in the course of one year. In nine patients we found ultrasonographic evidence of regression (decrease in thickness 26%) and in nine the ultrasound examination showed progression (increase in thickness 28%).
20-MHz B-mode ultrasound imaging is a suitable non-invasive method for monitoring the course and treatment of localized scleroderma. Its routine use is strongly recommended. ***Key words: Skin thickness; Therapy monitoring; B-scan; Sonography; morphea, scleroderma.***

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Technical aids play a minor role in dermatological diagnosis. In localized scleroderma, in particular, there are only few methods to quantify regression or progression objectively.

Presently the course of the disease is therefore usually described on the basis of clinical, i.e. subjective findings.

Procedures which permit direct examination of affected skin areas are of particular importance. Measurements of skin elasticity are suitable for determination of functional changes in sclerotic plaques. They do not, however, provide information on the histological changes (1). Measurements of skin thickness, on the other hand, permit us to quantify the sclerotic process and thus enable exact monitoring of the course of the disease. Histological examination, as an invasive method, is only of limited application and has the additional disadvantage that excision and further histological workup lead to morphological changes in the skin area to be examined (2, 3).

Measurement of skinfold thickness with the Harpenden skinfold caliper (4, 5) contains possible sources of error such as inclusion of subcutaneous fatty tissue in the skinfold to be measured. Because of its inadequacies this method has only a limited use in routine clinical practice.

A very precise method of measuring skin thickness is the radiographic technique of Black (6). Xeroradiography (2) led to even better results but the problem of exposure to radiation remained.

Ultrasonographic determination of skin thickness was first performed using a 15-MHz A-mode scanner (7). Ultrasound has also been used for examination of patients with progressive systemic and localized scleroderma (3, 8, 9, 10). Unfortunately the scanners used were difficult to handle and the information provided was of limited value.

The recently developed high-resolution 20-MHz B-mode ultrasound scanners provide morphological information on physiological and pathological skin structures and on the subcutaneous fatty tissue (11, 12).

The aim of this study was to examine whether this scanner generation permits efficient, quantitative monitoring of localized scleroderma.

*This paper contains material from the dissertation of Uwe Gerbaulet

Table I. *Clinical classification of localized scleroderma (ADF) used in this study*

Type	Name	Number of patients	%
Type 1 plaque type		n = 29	85.3
Type 1a < 5 lesions		n = 13	38.2
Type 1b > 5 lesions		n = 16	47.1
Type 3	erythematous localized scleroderma (progressive idiopathic atrophoderma)	n = 2	5.9
Type 4	linear band-type localized scleroderma	n = 2	5.9
Type 8	localized sclerofascia	n = 1	2.9

MATERIAL and METHODS

Patient population

In the course of one year we performed ultrasound examinations in 34 patients, 28 women and 6 men, with localized scleroderma. The average age of the patients was 49 years, the youngest being 9 years and the oldest 74 years of age. The duration of the disease was between one month and 15 years with a mean of 2.5 years. The patients were classified clinically according to the ADF Classification (13) (Table I). 85% were classified as having plaque-type localized scleroderma. The areas of skin most frequently affected were the chest, the abdomen, the lower back and the groin. Sclerotic skin changes were rarely found on the face or the upper extremities.

The majority of the patients with a long duration of illness were treated with sulphasalazine (Azulfidine^R, Pharmacia). The patients in whom the disease was in an early stage were treated mainly with penicillin.

To study the sclerotic plaques, ultrasound examination of corresponding contralateral areas of healthy skin was also performed in all 34 patients. In some cases we were able to compare the ultrasound B-scan image and the histological section from exactly the same skin location.

In 20 patients several ultrasound examinations were performed in the course of one year in combination with regular outpatient examinations in order to follow the course of the sclerotic plaques. Exact anatomical description and photographic documentation ensured unambiguous topographic definition of the plaques examined and the planes of examination. In order to permit comparison of the ultrasound scans obtained at the various examinations, exactly identical sclerotic skin areas were studied at each examination. The ultrasound and the clinical findings were compared.

Scanner

The 34 patients were examined with a digital 20-MHz ultrasound scanner (DUB 20, Taberna pro medicum, Lüneburg, Germany). The scanner consists of a Panametrics 20-MHz transreceiver, a digital Tectronix 2430 oscilloscope with GPIB interface, a stepper motor control unit and a Tandon 80286 computer with a 320-MB hard disk. The applicator contains a transducer which is moved over the skin 12.8 mm using a stepper motor. Water is used as coupling medium. The usable depth of signal penetration is about 7 mm, the lateral resolution ≈200 µm and the axial resolution ≈80 µm. The amplitudes of the echo signals were divided into 256 levels according to size. For easier optical evaluation the computed B-scan is colour-coded using 255 colours, light colours (white, light blue) corresponding to strong, dark colours (black, dark green) to weak reflexes. Computer-aided measurement can be performed using a graticule which can be placed on the screen. For these calculations the system assumes of a mean velocity of sound in the skin of 1580 m/s.

Statistics

The data processing and statistical analysis were performed on a second computer system (HCT 286). Student's t-test and Chi-square test were used for the statistical analysis.

RESULTS

Case Descriptions

Case Study 1: Sclerotic plaque on the right flank (examination plane: black bar) of a 66-year-old

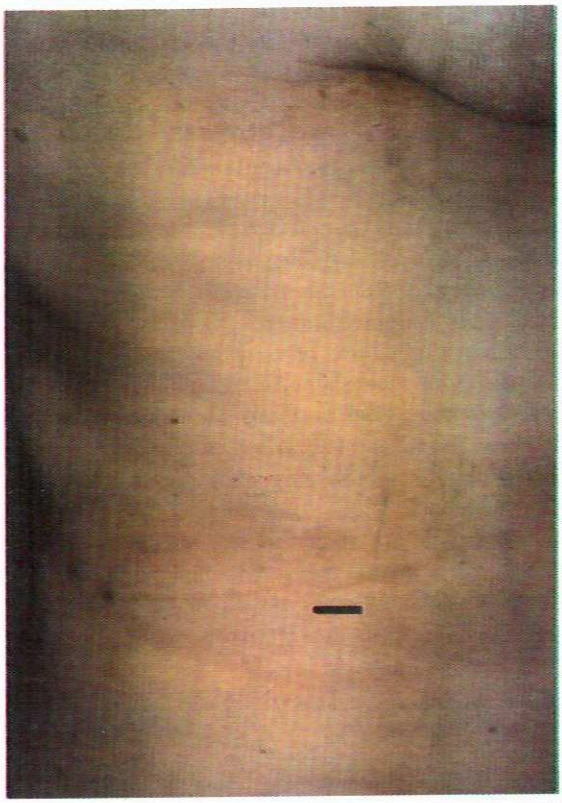

Fig. 1. Sclerotic plaque on the right flank of a 66-year-old woman (Case Study 1) (black bar: examination plane).

woman with a two-year history of localized scleroderma, plaque-type 1b (Fig. 1).

The ultrasound scan of healthy skin on the left flank (Fig. 2) shows a highly reflective (white) band-shaped skin entry echo (E) underlying a hypoechoic (greenish blue) border. Beneath the entry echo is a moderately reflective zone (greenish black) containing light-coloured (blue) spots (black arrow) (C). The almost completely echolucent (black) area below is limited at greater depth by a highly echogenic (white) band. The entry echo is composed of reflexes occurring at the water/stratum corneum interface and echo signals from the epidermis itself. The following area, which contains multiple light-coloured scattered reflexes, corresponds to the corium (C). The echolucent (black) area represents the subcutaneous fatty tissue (S). The highly reflective band at the bottom of the picture corresponds to muscle fascia (F).

In comparison to this, the ultrasound scan of sclerotic skin (Fig. 3) shows a narrower homogeneous (white) entry echo (E) and marked widening of the corium (C). Only immediately below the entry echo does the corium show a looser texture (greenish black), otherwise it contains enhanced reflexes (bluish white) (black arrows) which are particularly marked at the border with the echolucent (black) subcutaneous fatty tissue (S). The subcutis, which is thinner, is traversed by highly reflective (whitish blue) bands (white arrows) which originate at the corium-subcutis border. At the bottom of the picture the moderately reflective (bluish green) muscle fascia (F) is just identifiable.

Case Study 2: Ultrasound scan (Fig. 4) and corresponding histological section (Fig. 5) from a sclerotic plaque in the right groin of a 74-year-old woman with a 2-month history of localized scleroderma, plaque-type 1b. The ultrasound scan shows a largely homogeneous band-shaped (white) entry echo (E). The moderately reflective (greenish black) corium (C), in particular directly at the border with the almost echolucent (black) subcutaneous fatty tissue (S), exhibits highly reflective (white) spots (small

Fig. 2. Ultrasound B-scan of healthy skin on the left flank (Case Study 1) (E: entry echo; C: corium; S: subcutaneous fatty tissue; F: muscle fascia; black arrow: reflex spots).

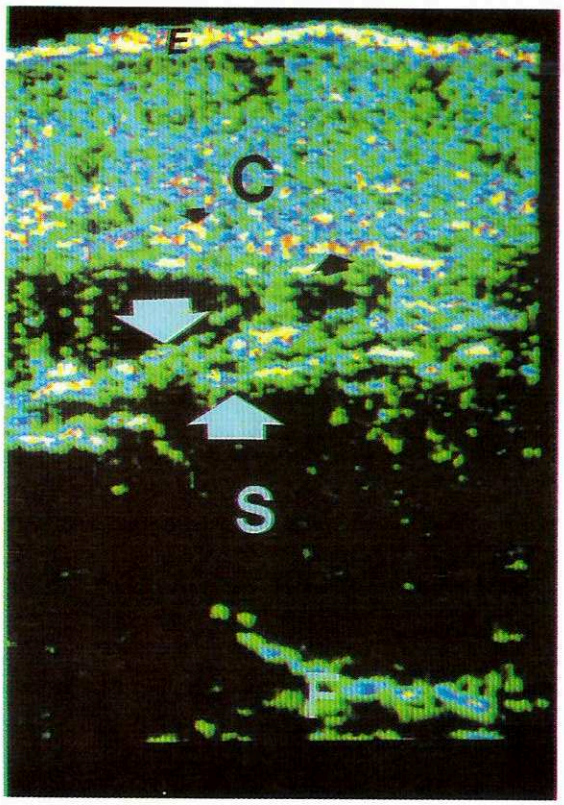

Fig. 3. Ultrasound B-scan of diseased skin on the right flank (Case Study 1) (E: entry echo; C: corium; S: subcutaneous fatty tissue; F. muscle fascia; black arrow: enhanced reflexes; white arrows: echorich bands).

white arrow) from which echorich bands (large white arrow) extend into the subcutaneous fatty tissue. The corium measures 1.98 mm and is thus thickened. At the bottom edge of the picture the strong reflection from the muscle fascia can be seen (F).

The histological section (HE, 25 x) shows a moderately acanthotic epithelium. The corium contains focal perivascular and periadnexial round cell infiltrates. The subcutaneous fatty tissue is traversed by broad eosinophilic bands of connective tissue (black arrow). The muscle fascia shown in the ultrasound scan does not appear in the histological section.

Case Study 3: A 53-year-old man with a two-year history of progressive idiopathic atrophoderma (Pasini and Pierini) (Fig. 6) (examination plane: black bar). The ultrasound scan of clinically healthy skin from the right lower leg (Fig. 7) shows a narrow, relatively homogeneous (white) band-shaped entry echo (E). The corium (C) is loosely structured (black arrow) mainly in the upper region and becomes more compact towards greater depth. At the left of the picture a diagonal echopoor band (white arrow) can be seen which corresponds to a hair follicle. As the muscle fascia is not depicted, the distal border of the echolucent (black) subcutaneous fatty tissue (S) cannot be identified.

The ultrasound scan of diseased skin (Fig. 8) also shows a narrow homogeneous (white) band-shaped entry echo (E). Beneath the epithelium is an almost completely echolucent (black) zone (white arrow) containing individual (green) reflex spots. Below this there are slightly denser (bluish green) areas so that it is impossible to determine the exact border between the corium (C) with its reduction in density and the hypoechoic (black) subcutaneous fatty tissue (S). The oedematous infiltration of the corium is responsible for the fact that the corium in the diseased skin appears wider than that in the healthy skin. The other plaques did not show such marked corial oedema so that in comparison with the corre-

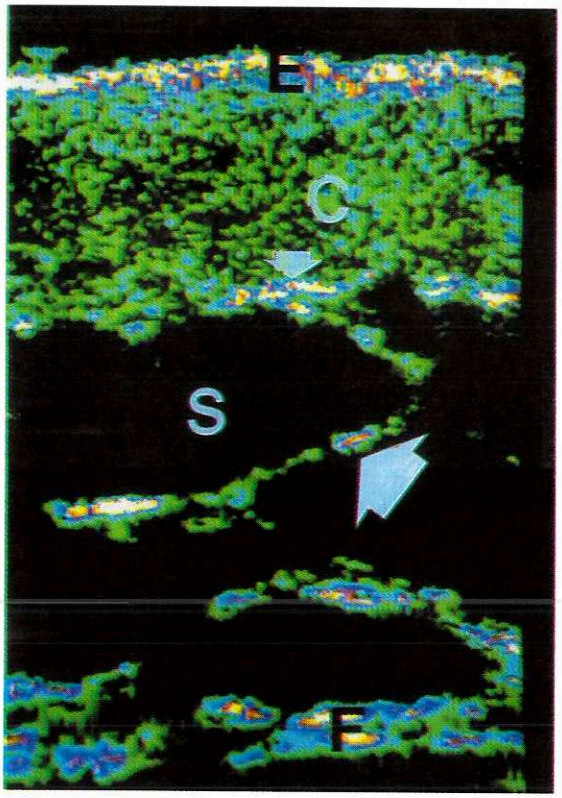

Fig. 4. Ultrasound B-scan of a sclerotic plaque in the right groin (Case Study 2) (E: entry echo; C: corium; S: subcutaneous fatty tissue; F: muscle fascia; small white arrow: reflex spots; large white arrow: echorich bands).

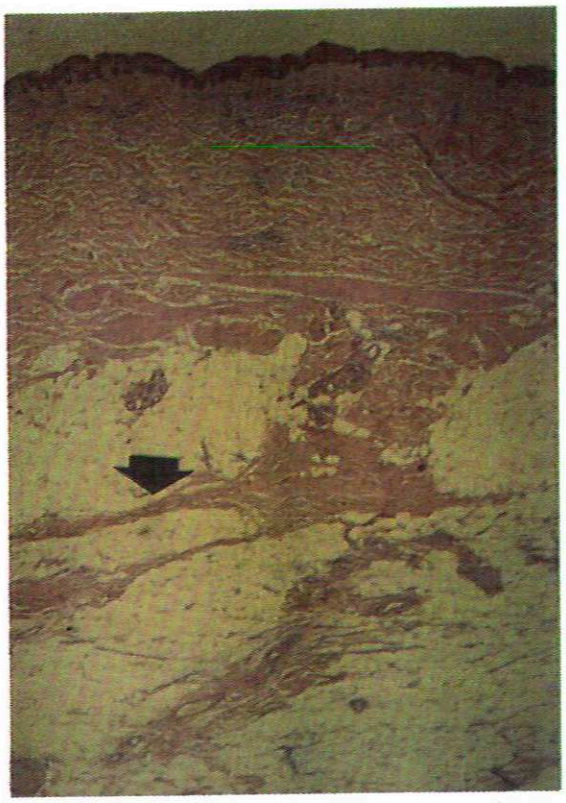

Fig. 5. Histological preparation of the ultrasonographically examined plaques from Fig. 4 (Case Study 2, HE, 25 x) black arrow: bands of connective tissue.

sponding areas of healthy skin no increase in corium thickness could be seen.

In the monitoring of localized scleroderma types 1a and 1b were analysed visually by comparing the ultrasound findings of the initial examination with those obtained at an examination performed four months later.

Case Study 4: A 66-year-old woman with a 20-month history of localized scleroderma, plaque-type 1b.

The ultrasound scan of a sclerotic plaque from the patient's abdomen (Fig. 9) shows a very inhomogeneous entry echo (E) with elongated highly reflective (white) islands. Below this is a thickened corium (C) measuring 1.77 mm containing distinct enhanced reflexes (white) particularly in the lower region (black arrow). The echolucent (black) subcutaneous fatty tissue is traversed by sometimes quite broad, highly reflective bands (white arrow). The same sclerotic plaque four months later (Fig. 10) shows a wide homogeneous (white) entry echo (E). The corium (C) is now only 1.22 mm thick and shows a wide (white) band of reflexion (open black arrow) at the border with the subcutis. There is a marked reduction in the highly reflective bands of connective tissue (small white arrow) in the hypoechoic (black) subcutaneous fatty tissue (S).

With the exception of one plaque from the patient's right shoulder in which the corium thickness increased by 0.1 mm, all the other sclerotic skin changes examined also showed a marked reduction in corium thickness in the course of two months.

Case Study 5: An 18-year-old woman with a two-month history of morphea type 1b.

The ultrasound scan of a sclerotic plaque from the right groin (Fig. 11) shows a band-shaped entry echo (E) with a homogeneous reflex pattern (white). The corium (C), which has a fairly loose structure in the upper region, contains streaks (white) of enhanced reflectivity (small white arrow) in the lower third. The echopoor (black) subcutaneous fatty tissue (S) is traversed by highly reflective bands (large white

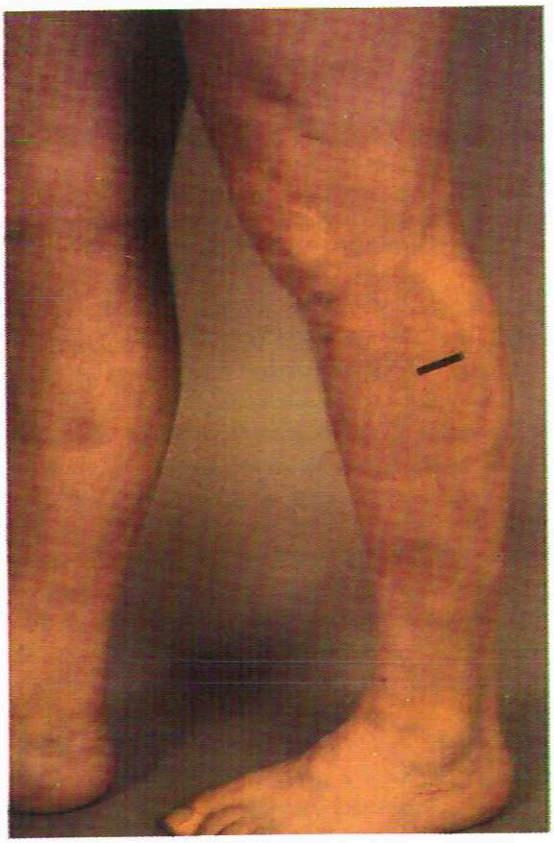

Fig. 6. Plaque from the left lower leg of a 53-year-old man with progressive idiopathic atrophoderma (of Pasini and Pierini) (Case Study 3) (black bar: examination plane).

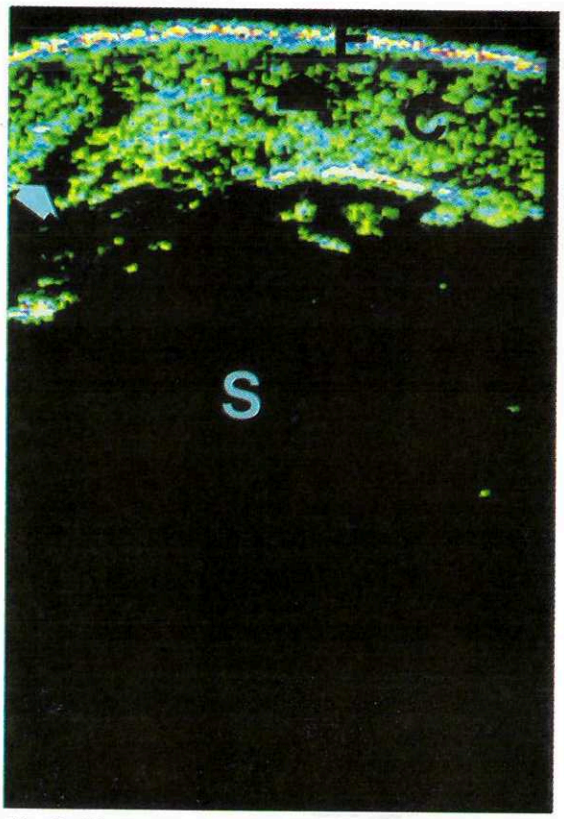

Fig. 7. Ultrasound B-scan of healthy skin on the right lower leg (Case Study 3) (E: entry echo; C: corium; S: subcutaneous fatty tissue; black arrow: loosely structured subepithelial region; white arrow: hair follicle).

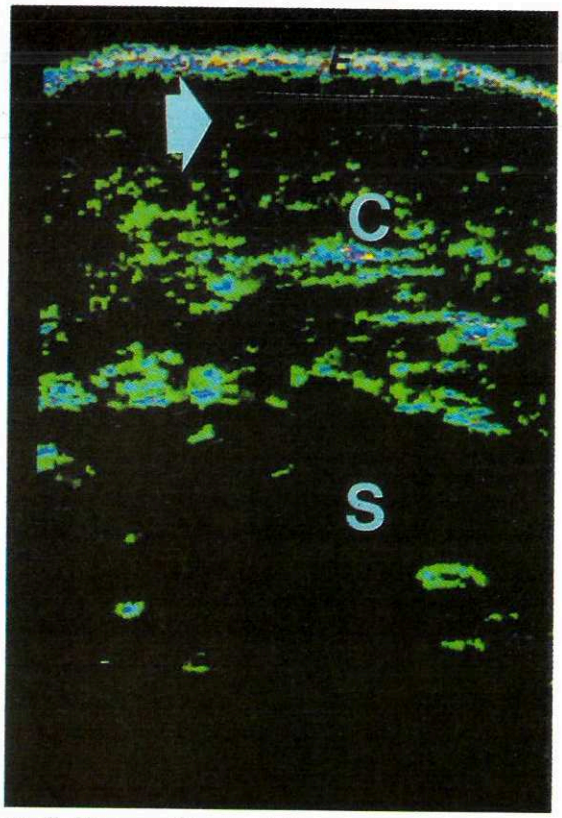

Fig. 8. Ultrasound B-scan of diseased skin on the left lower leg (Case Study 3) (E: entry echo; C: corium; S: subcutaneous fatty tissue; white arrow: loosely structured subepithelial region).

arrow). The wide reflex (F) at the bottom of the picture corresponds to the inguinal ligament.

The ultrasound scan made four months later (Fig. 12) shows a homogeneous (white) band-shaped entry echo (E). On account of the massive increase in the bands of connective tissue (closed white arrow) which almost completely fill the subcutaneous fatty tissue (S) a border between the corium (C) and the subcutis is discernible only in the right half of the picture. Compared with the scan described above we find no increase in corium width, the streaks (white) of enhanced reflection in the lower corium are still visible. In the left half of the picture the lower corium and the echorich subcutaneous bands fuse to form a practically homogeneous area (open white arrow). The massive increase in the bands of connective tissue in the subcutaneous fatty tissue is clear ultrasonographic evidence that the patient's sclerosis has undergone further progression in the course of two months. The ultrasound findings agreed with the clinical ones as palpation of the sclerotic plaques revealed increased induration.

General results

With the exception of the two patients with progressive idiopathic atrophoderma (Pasini and Pierini) and the patient with circumscribed sclerofascia the sclerotic plaques showed an increase in corium thickness compared with the corresponding contralateral area of healthy skin ($p \leq 0.001$). The increase in corium thickness depended on the site affected and varied from region to region (Table II). The average increase in corium thickness was greatest in plaques in the groin, reaching 55% (Fig. 13). The degree of increase in corium thickness also depended on the original thickness of the healthy skin. In the groin, where the skin is thinnest compared with the other regions examined here, the relative increase in corium thickness was particularly marked. With further increase of healthy skin the average sclero-

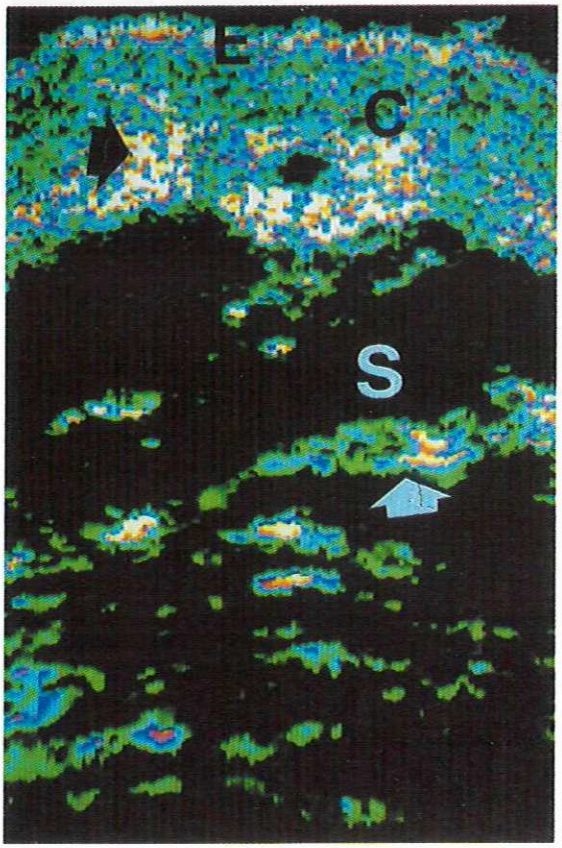

Fig. 9. Ultrasound B-scan of a sclerotic plaque on the abdomen (Case Study 4) (E: entry echo; C: corium; S: subcutaneous fatty tissue; black arrow: enhanced reflexes; white arrow: hyperechoic bands).

Fig. 10. Ultrasound B-scan of the plaque from Fig. 9 two months later (Case Study 4) (E: entry echo; C: corium; S: subcutaneous fatty tissue; open white arrow: enhanced reflexes; small white arrows: hyperechoic bands of connective tissue).

derma-induced percentage increase in corium thickness decreased in the order groin – lower leg – thigh – abdomen – chest – back. On the lower back the average thickness of healthy skin was 2.03 mm and the mean increase in corium thickness only 19%.

In comparison with healthy skin, ultrasound examination of sclerotic plaques types 1 and 4 showed an increase in the occurrence of enhanced reflexes in the lower corium. The frequency of this occurrence was related to the skin site examined (Fig. 11). The ultrasound examination of sclerotic skin changes in the groin showed enhanced reflexes in the lower corium in 94% of the plaques, while such reflex enhancement was found in 50% of the corresponding areas of healthy skin. Such phenomena were also found more frequently in sclerodermic lesions on the chest and the lower back.

A further feature of localized scleroderma types 1 and 4 in 20-MHz B-mode ultrasound images was the increased occurrence of echorich bands which originated at the corium-subcutis border and traversed the subcutaneous fatty tissue (Fig. 15).

The echorich bands were particularly frequent in sclerotic lesions in the groin. Such structures were found in 58% of the sclerotic plaques examined and in only 14% of the healthy skin areas.

In the case of both regression and progression the corium thicknesses in the sclerotic plaques at the time of the first examination were compared with the corium thicknesses in the same plaques at the last examination. In this study the monitoring of the sclerotic plaques showed reduced thickness in nine patients and in nine other patients increased thickness of the corium as a sign of progression of the disease. In one patient the progression was documented by an unusually marked increase in the

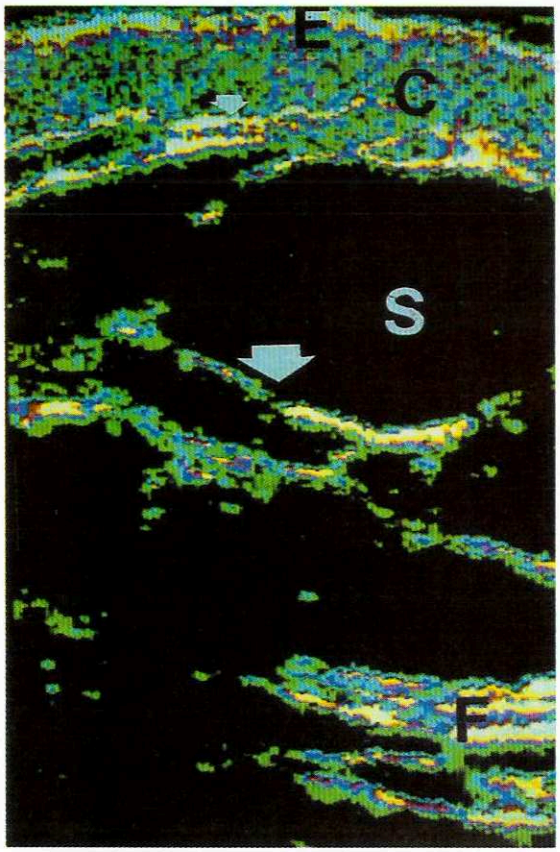

Fig. 11. Ultrasound B-scan of a sclerotic plaque in the groin (Case Study 5) (E: entry echo; C: corium; S: subcutaneous fatty tissue; F: inguinal ligament; small white arrow: enhanced reflexes; large white arrow: hyperechoic bands of connective tissue).

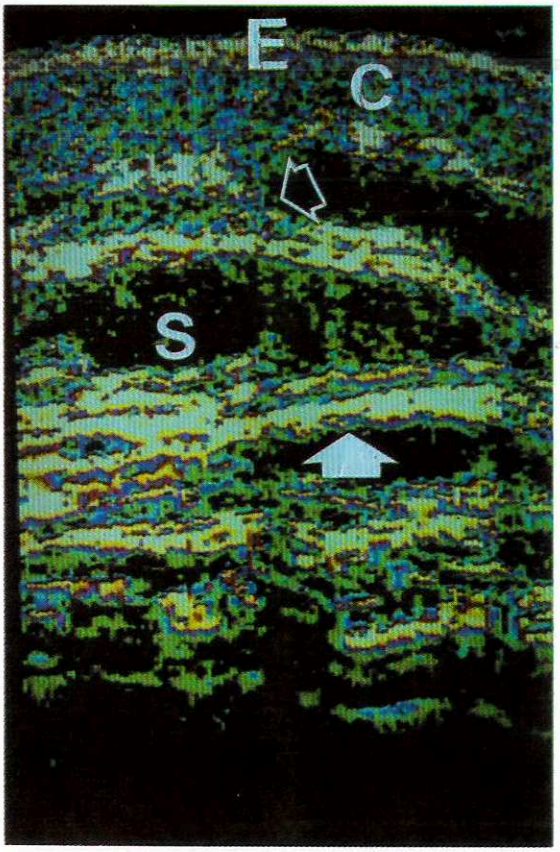

Fig. 12. Ultrasound B-scan of the plaque from Fig. 11 two months later (Case Study 5) (E: entry echo; C: corium; S: subcutaneous fatty tissue; closed white arrow: hyperechoic bands of connective tissue; open white arrow: homogeneous area).

bands of connective tissue in the subcutaneous fatty tissue without increase of the corium tissue.

The average decrease in corium thickness in the sclerotic plaques of all nine patients with regression was 0.52 mm, equivalent to a relative average decrease of 26% ($p \leq 0.001$) (Table III). In the region of the abdomen and chest the average reduction in corium thickness was 0.55 mm, equivalent to a percentage regression of 28% ($p \leq 0.001$) (Table IV). The locations groin and lower extremities showed a mean decrease in corium thickness in the sclerotic plaques of 0.48 mm, equivalent to a percentage regression of 24% ($p \leq 0.001$) (Table V).

In the patients with a duration of illness of less than 32 months the average reduction in corium thickness was 0.25 mm, the mean percentage regression 14% ($p \leq 0.001$) (Table V).

In the patients with a longer history the reduction in corium thickness averaged 0.69 mm which is equivalent to a mean regression of 33% ($p \leq 0.001$) (Table V).

The corium of the sclerotic plaques in all nine patients with progression showed an average increase in thickness of 0.40 mm, equivalent to a relative average increase in corium thickness of 28% ($p \leq 0.001$) (Table III).

In the abdomen and chest region the average increase in corium thickness was 0.43 mm, equivalent to a mean percentage progression of 28% ($p \leq 0.001$) (Table IV).

The groin and lower extremities showed a mean increase in corium thickness in the sclerotic plaques of 0.39 mm, equivalent to a relative progression of 29% ($p \leq 0.001$) (Table IV).

In the patients with a duration of illness of less than 16 months the average increase in corium thick-

Table II. *Relationship between location and average increase in corium thickness*

	Chest		Abdomen		Groin		Back		Lower leg		Thigh	
	h	s	h	s	h	s	h	s	h	s	h	s
Thickness	1.51	1.81	1.40	1.72	0.95	1.46	2.03	2.41	1.36	1.89	1.08	1.57(mm)
SD	0.28	0.41	0.25	0.29	0.11	0.35	0.21	0.22	0.19	0.46	0.30	0.66 (mm)
Increase	20%		24%		55%		19%		39%		46%	

(h: healthy skin; s: sclerotic skin; thickness: mean corium thickness; increase: mean increase in corium thickness in the sclerotic skin; SD: standard deviation)

ness was 0.46 mm, the relative average progression 33% ($p \leq 0.001$) (Table V). In the patients in whom the localized scleroderma had been present longer the average increase in corium thickness was 0.29 mm, equivalent to a mean progression of 20% ($p \leq 0.001$) (Table V).

With one exception, the patients with a greater tendency towards progression had only been treated with penicillin or sulphasalazine (Azulfidine^R) for a short time. In one patient with localized scleroderma type 1b the ultrasound examination showed neither regression nor progression of the disease. The plaques of one patient with progressive idiopathic atrophoderma (Pasini and Pierini) likewise showed no change in the observation period of one year.

The ultrasound findings agreed with the clinical data in ten cases, in three cases the results of the ultrasound examination and the clinical findings contradicted each other and in seven cases the clinical data showed no change in the disease while the ultrasound examination showed regression in three patients and progression in four.

DISCUSSION

Non-invasive ultrasound methods have gained increasing significance recently. They are suitable for exact measurement of skin thickness and are helpful to study skin tumours (3, 7, 8, 12, 14–23). B-mode scanning in particular, which compared with the one-dimensional A scan has the advantage of providing a two-dimensional image, permits clear identification of physiological and pathological skin structures and unambiguous assignment of the ultrasound phenomena to histological features (12, 18). Especially 20-MHz B-mode ultrasound, which has a resolution comparable to low light microscopic magnifications, is an important procedure in preoperative tumour diagnosis. This applies particularly to

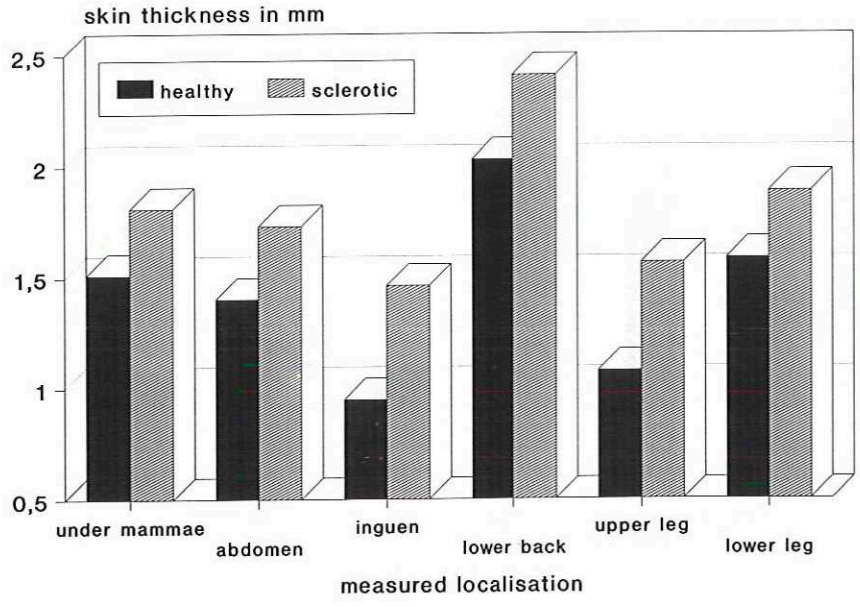

Fig. 13. Relationship between average increase in corium thickness and locality.

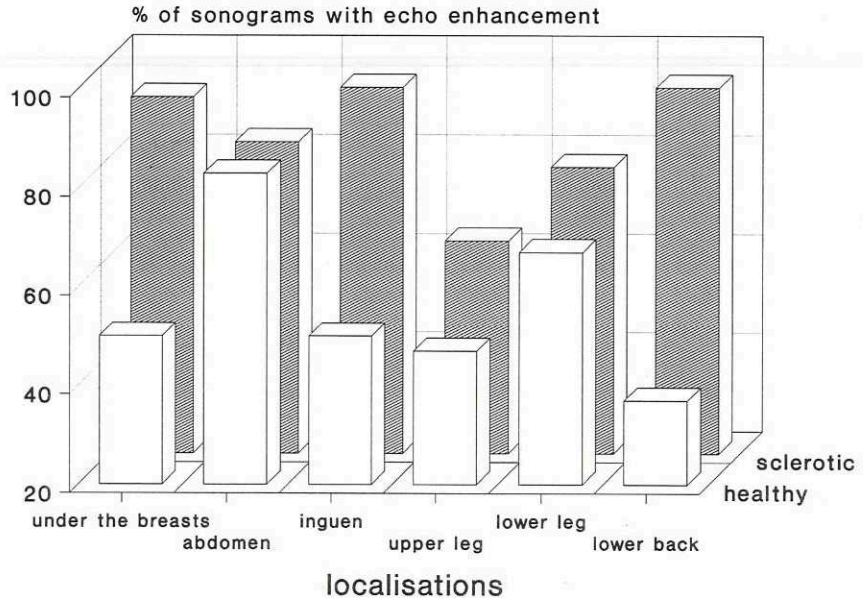

Fig. 14. Enhanced reflexes in the lower corium (comparison between healthy and sclerotic skin in various locations).

the exact determination of tumour thickness and surface area (5, 15, 16, 18, 24, 25).

In progressive systemic and localized scleroderma ultrasound examination has up to now been used to determine the thickness of sclerotic plaques (3, 8, 9, 10, 23). All working groups found that ultrasound showed increased skin thickness in the affected areas.

For quantification of acrosclerosis the thickness of sclerotic by other study groups skin was compared interindividually with the skin thickness in healthy subjects (3, 9, 10). The findings of our study show that it is imperative to compare the ultrasound scan of the sclerotic plaque with corresponding areas of healthy skin in the same patient as skin thickness is subject to considerable interindividual variability (27).

The patients with progressive idiopathic atrophoderma (Pasini and Pierini) and localized sclerofascia which were examined showed no increase or decrease in corium thickness in the affected areas using ultrasound. A Danish working group, however,

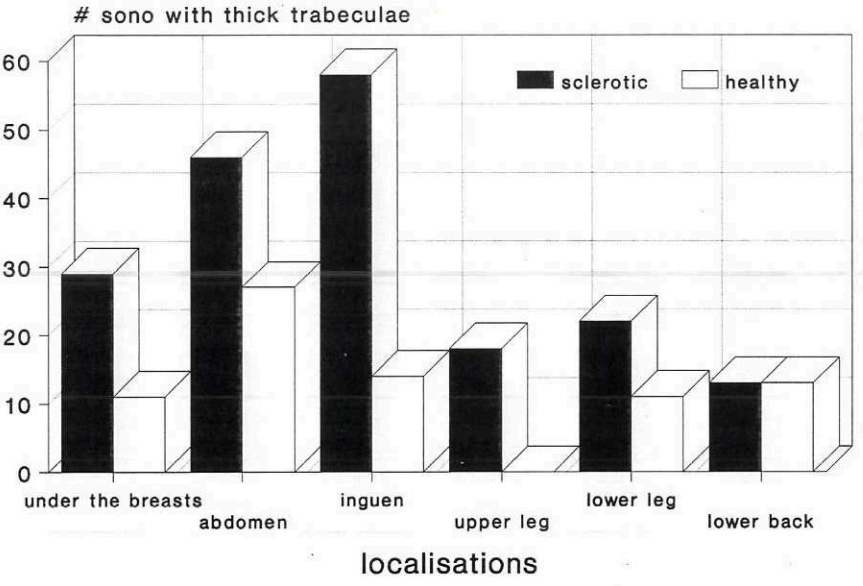

Fig. 15. Subcutaneous bands of connective tissue (comparison between healthy and sclerotic skin in various locations).

Table III. *Regression and progression Comparison between first and last examination*

	Regression		Progression	
	FE	LE	FE	LE
Thickness (mm)	1.97	1.54	1.43	1.83
SD (mm)	0.43	0.44	0.50	0.50
Change	- 26%		+ 28%	

(FE: first examination; LE: last examination; change: average change; SD: standard deviation)

found a reduction in skin thickness in the plaques of progressive idiopathic atrophoderma (of Pasini and Pierini) (26).

The lesions in the patients with plaque-type localized scleroderma and linear band-type localized scleroderma show an increased corium thickness between 2% and 251%. Other studies in similar cohorts found increases in skin thickness of between 13% and 310% (8).

The degree of difference in corium thickness between healthy and sclerotic skin depended on the region affected. Originally thin skin, such as that found in the groin and the lower extremities, showed a greater degree of sclerosis than the comparatively thicker skin of the abdomen, chest and back. In the groin where, at an average thickness of 0.95 mm, the healthy skin was thinnest of all regions examined, the mean increase in corium thickness was greatest, amounting to 55%. This was followed by the lower extremities and finally the trunk. The group around Serup found the same relationships and they, too, established that the sclerosis in the originally thin skin of the extremities was greater than that in the comparatively thicker skin of the trunk (8). They measured a mean thickness of 1 mm in healthy skin on the lower extremities and of 1.5 mm on the trunk, which agrees well with our own measurements. However, we divided the trunk and the lower extremities into various regions which we examined separately, as the skin thickness on the chest differs from that on the abdomen and that on the thigh from that on the lower leg.

A further ultrasound feature of localized scleroderma types 1 and 4 was the increased occurrence of enhanced reflexes in the lower corium and the echorich bands in the subcutaneous fatty tissue. These phenomena are also found, to a considerably lesser extent, in healthy skin. As our investigations have shown, the tautness of the collagen fibres in the lower corium depends on the site of the skin examined and the posture of the patient. This variability in tension evidently leads to the enhanced reflexes found in the lower corium.

Table IV. *Degree of regression and progression; chest and abdomen versus groin and lower extremities*

	Chest/Abdomen		Groin/Lower extremities	
	FE	LE	FE	LE
Regression				
Thickness	1.94	1.40	2.01	1.52
SD	0.26	0.43	0.58	0.45
Change	− 28%		− 24%	
Progression				
Thickness	1.55	1.98	1.31	1.69
SD	0.46	0.39	0.52	0.56
Change	+ 28%		+ 29%	

(FE: first examination; LE: last examination; thickness: mean corium thickness; SD: standard deviation)

In localized scleroderma the inflammatory progression zone is found in the lower corium (28). The homogenized, tightly packed collagenous connective tissue produced during the inflammatory processes also leads to marked enhancement of reflectivity in the lower corium in the ultrasound image. These strong reflexes were found particularly often in the sclerotic plaques of the groin compared with healthy skin. This is due to the evidently massive sclerosis of the skin in the groin since this region also showed the greatest increase in corium thickness of all the locations examined. The strong tendency towards progression shown by localized scleroderma in the groin

Table V. *Regression and progression; relationship with length of illness*

	FE	LE	FE	LE
Regression	< 32 months		> 32 months	
Thickness	1.82	1.57	2.05	1.36
SD	0.41	0.40	0.48	0.50
Change	− 14%		− 33%	
Progression	< 16 months		> 16 months	
Thickness	1.40	1.86	1.47	1.76
SD	0.61	0.57	0.47	0.47
Change	+ 33%		+ 20%	

(FE: first examination; LE: last examination; thickness: mean corium thickness; change: average change; SD: standard deviation)

region also explains the more frequent and more marked appearance of echorich subcutaneous bands of connective tissue in this region. These highly reflective subcutaneous fibrous bands, which have also been described by another working group (23), are also found in healthy skin but they are more frequent and more marked in areas of sclerosis (29). There are two explanations for this. On the one hand, in localized scleroderma massive de novo synthesis of collagen takes place not only in the lower corium but also in the region of the fatty tissue septa (28, 29, 30). On account of their scleroderma-induced increase in width the subcutaneous bands of connective tissue in sclerotic skin thus appear more highly reflective than in healthy skin. On the other hand the upper subcutis is replaced by collagenous connective tissue which is formed in considerable amounts in the lower corium in localized scleroderma. This leads to thickening of the corium at the expense of the subcutaneous fatty tissue (28, 29, 31). However, evidently not all newly synthesized collagen fibres are deposited directly at the corium-subcutis border but some fibre bundles move away from their original site and traverse the subcutaneous fatty tissue in the direction of the muscle fascia.

In many cases the entry echo and the subcutaneous fatty tissue were thinner in the sclerotic skin areas than in the healthy skin. However, the entry echo is often irregularly structured and is scarcely comparable with the epidermis in respect of thickness, as is shown by the fact that our working group found little correlation comparing the width of the entry echo and the histologically determined epidermal thickness (27). In our opinion the entry echo is the result of the "impedance jump" water/stratum corneum. The distal border of the subcutaneous fatty tissue is often indistinguishable as, on account of high absorption, the 20-MHz signal does not always depict the muscle fascia in its entirety. In addition, the highly reflective bands of connective tissue often found in the sclerotic plaques also reduce the acoustic energy able to reach the muscle fascia. The inadequate resolution of the entry echo and the limitations on its evaluation, together with the fact that it is frequently impossible to determine the borders of the subcutaneous fatty tissue, indicate that the quantification of these two structures is of limited value in localized scleroderma using 20 MHz ultrasound.

Using 20-MHz ultrasound it was possible to distinguish between progressive idiopathic atrophoderma (Pasini and Pierini) (= erythematous localized scleroderma) and localized scleroderma types 1 and 4. However we studied a small nutrient norulation.

The quantitative evaluation and follow-up of the disease in 20 patients was based on ultrasound changes in corium thickness in the sclerotic plaques. In one patient, however, the progression was indicated by a dramatic increase in the bands of connective tissue.

The mean progression was 28% in the chest and abdomen region and 29% in the groin and the lower extremities. This almost identical degree of progression indicates that there is no correlation between progression and the location of the sclerotic plaques; the same applies to regression. In the patients with regression and a more than 32 month history of disease, the reduction in corium thickness was about 20% greater than in patients with a shorter history. In the patients with progression and a history of less than 16 months the increase in corium thickness of the sclerotic plaques was 13% greater than in the patients with a longer duration of illness. Thus, an increasing period of illness and treatment was accompanied by an increase in the degree of regression of the sclerotic plaques and a decrease in the degree of progression. These results and general clinical experience indicate that localized scleroderma has a marked tendency towards progression particularly in the initial stages. The decreasing tendency and the progressive regression with increasing length of illness can be explained by the fact that even in scleroderma the collagen synthesis is not completely uncontrolled but merely enhanced. After a phase of progression, self-limiting mechanisms lead to a steady state between collagen synthesis and degradation. After a steady state phase of varying duration regression phenomena then predominate so that the sclerosis of the plaques gradually decreases again, experienced by an detectable decrease of skin thickness in ultrasound. Long-term treatment with sulphasalazine (Azulfidine®), the mechanism of action of which is largely unclear, may promote this process.

The advantage of non-invasive ultrasound monitoring of localized scleroderma lies in the objective evaluation of the development of the sclerotic skin changes (9, 10, 32).

20-MHz B-mode ultrasound has important advantages over the examinations of scleroderma hitherto performed mainly in A-mode. The recently available

two-dimensional 20-MHz B-mode ultrasound imaging is able to provide information not only on skin thickness but also on micromorphological structures and changes in the subcutaneous fatty tissue. Although the increase in corium thickness is the most frequently found ultrasound criterion of localized scleroderma, other important features such as enhanced reflexes in the lower corium and the highly reflective subcutaneous bands of connective tissue (Case Study 5) are difficult to discern in the A-scan.

Finally, it must be said that, of the ultrasound procedures currently available, 20-MHz ultrasound is particularly suitable to monitor the course of localized scleroderma as it visualises other important structures apart from skin thickness. The information provided by high-frequency B scan on the changes in the corium, subcutaneous fatty tissue and muscle fascia permits important statements on the extent of the sclerotic process which were hitherto not possible.

OUTLOOK

In the foreseeable future ultrasound will be used in routine dermatological diagnostics. It is simple, non-invasive and objective method which is suitable for the follow-up of chronic inflammatory dermatoses such as localized scleroderma. Finally, since this imaging method can be repeated easily, it is suitable for therapeutic monitoring of chronic skin diseases.

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