Color Doppler ultrasound assessment of morphology and types of fistulous tracts in hidradenitis suppurativa (HS)

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Background: Fistulous tracts in hidradenitis suppurativa (HS) are key signs of severity and their clinical evaluation alone may be limited for assessing their presence and morphology. There is also a need to determine the factors that allow reversibility of the anatomic changes in HS.

Objective: We sought to categorize fistulous tracts in HS.

Methods: A retrospective study of color Doppler ultrasound images of cases with positive clinical and sonographic criteria of HS with fistulous tracts was performed. The sonographic staging of HS, location, and anatomic characteristics of the tracts were registered and graded. Statistical analysis for correlating variables was performed using bivariate and multivariate studies.

Results: In all, 52 patients presenting 96 fistulous tracts met the criteria. Morphology was defined and a sonographic classification into 3 types of fistulae was developed. Type 3 concentrated 71% of the cases presenting communicating tracts, and type 2, 29%. Types 2 and 3 represented 63% of patients with multiple fistulous tracts. Fistulous tracts types 2 and 3 were significantly correlated with age 35 years or older and groin location.

Limitations: Ultrasound cannot detect lesions less than 0.1 mm.

Conclusion: Fistulous tracts in HS can be categorized using ultrasound, which may support earlier and more precise management. (J Am Acad Dermatol 2016;75:760-7.)

Key words: dermatologic ultrasound; fistula hidradenitis; hidradenitis; hidradenitis sonography; hidradenitis suppurativa; hidradenitis suppurativa imaging; hidradenitis suppurativa ultrasound; hidradenitis ultrasound; skin ultrasound; tunnels hidradenitis.

Fistulous tracts seem to be key signs of severity in hidradenitis suppurativa (HS); their mere presence can alter the clinical staging of the severity of the disease.[1] In addition, as reported, subclinical fistulous tracts have been detected on ultrasound and can modify sonographic scoring (SOS)-HS,[2] which can indicate the need to move to more aggressive treatment or switch to surgical management. However, these fistulous tracts can show different anatomic characteristics that could affect the reversibility of the physiopathological process. Among these features is presence of fibrotic scarring, because this may not be easily resolved by current medical treatments for HS. Other factors that can add complexity to fistulous tracts are the presence of edema and hypervascularity, which may indicate the level of inflammation to which an individual is exposed. Retained hair tract fragments

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within fistulous tracts[3] can also generate a chronic irritation factor in the region because they may present difficulties for their reabsorption.

The sonographic definition of fistulous tracts in HS has been described in the literature as the presence of dermal and/or hypodermal anechoic or hypoechoic bandlike structures connected to the base of hair follicles.[2] These fistulous tracts commonly contain echoes as a result of debris or inflamed tissue and some hyperechoic linear structures that are suggestive of fragments of hair tracts.[3]

The aim of the study was to assess the sonographic morphology of fistulous tracts in HS and categorize their anatomic patterns.

CAPSULE SUMMARY

- Clinical examination may not detect fistulous tracts in patients with hidradenitis suppurativa.
- Ultrasound examination may assist in the detection and categorization of fistulas.
- Noninvasive anatomic information can improve the staging and management of this condition.

METHODS

A retrospective analysis of the color Doppler ultrasound images of patients with HS presenting fistulous tracts was performed at our institution. Inclusion criteria were the last consecutive referrals from dermatologists between January 2015 and January 2016 that showed positive clinical and sonographic criteria of HS[2] and demonstrated fistulous tracts on ultrasound examination. Exclusion criteria were patients with HS under biological treatment or with a history of surgery or procedures in the affected regions. All patients had been staged on sonography using the SOS-HS scoring system.[2]

The presence of fistulous tracts was defined according to the previously reported definitions on ultrasound.[2] Their location, number, and maximum diameters (length and thickness in centimeters) were recorded. The presence of multiple and communicating tracts was also registered. In patients with multiple fistulous tracts, the longest fistula was measured.

For the purpose of this analysis body locations were classified as axillary, groin (groin, pubic, perineal, and genital areas), gluteal (including the intergluteal region), thoracic (anterior thoracic wall and mammary-inframammary areas), and occipito-cervical.

Fibrotic scarring has been reported in the literature as hyperechoic[4] and hypoechoic[5] in different tissues. Therefore, the presence of fibrotic scarring of the fistulous tracts was defined as hyperechoic or hypoechoic tissue with a laminar or bandlike disposition. This was graded according to the following categories (Fig 1): 0 = absent; 1 = at the periphery of the fistulous tracts; and 2 = invading part of the fistulous tract generating a halo in the periphery (the latter in transverse view) (Fig 2).

Edema was defined as hyperechogenicity of neighboring hypodermal tissue and was categorized into the following degrees (Fig 3): 0 = absent; 1 = hypodermal hyperechogenicity; and 2 = hypodermal hyperechogenicity and anechoic fluid between the fatty lobules of the hypodermis.

The registration of vascularity was categorized as absent, peripheral, or internal (ie, within the fistulous tract) using color Doppler (colored pixels) and confirmed under spectral curve analysis (Fig 4).

The presence of hyperechoic linear structures suggestive of hair tract fragments was categorized as being absent or present.

All examinations were performed with multichanneled color Doppler ultrasound equipment (Logic XD Clear, General Electric Health Systems, Milwaukee, WI) using variable compact linear and linear variable frequency probes with an upper range up to 18 MHz and by the same radiologist with more than 15 years of experience in dermatologic ultrasound. The fistulous tracts were examined in at least 2 perpendicular axes for assessing their long and short axes. Gray-scale and color Doppler examinations with spectral curves analysis (vascularity) were carried out in all cases. Extended field-of-view software was used for measuring large fistulous tracts.

Statistical analysis of the factors associated with the development of fistulous tracts was performed by bivariate and multivariate ordered logistic regression and logistic regression (Stata v12.1, StataCorp, College Station, TX). Significance was assessed at P value less than 5% (.05) for bivariate and P value less than 20% (.2) for multivariate (stepwise) regression. Correlation analyses between fibrosis and/or scarring, edema, and internal vascularity were performed through a Spearman test considering significance at P values less than 5% (.05).

The institutional review board approved the study and waived the need for informed consent from patients. All the ultrasound examinations were performed following the Helsinki principles of medical ethics.

RESULTS

A group of 52 patients with HS (36 female, 16 male; mean age 26 [SD 13] years, age range

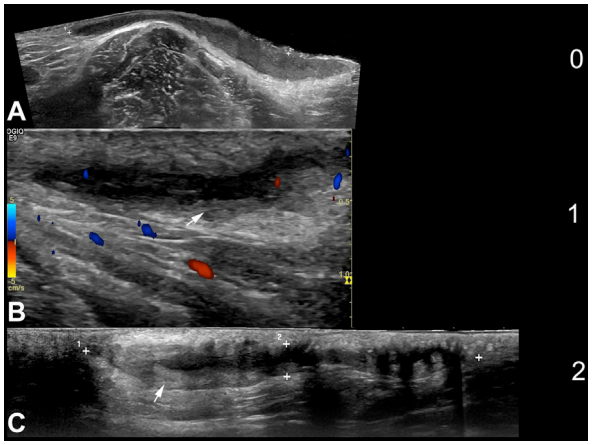

Fig 1. Hidradenitis suppurativa (HS). Grading of fibrotic scarring in HS fistulous tracts. Longitudinal axes of fistulae (**A** and **C**, grey scale ultrasound; **B**, color Doppler ultrasound) demonstrates the grades of fibrotic scarring (*white arrows*). Notice the increased vascularity (colors) in the periphery of the fistula in (**B**). +, Markers of the borders of the fistulous tracts in **A** and **C**.

12-59 years) presenting a total of 96 fistulous tracts met the inclusion criteria.

The predominant location of fistulae in the group of patients was by far the groin region, with 54% of cases and then the axillary region with 19%. When gathering all the fistulous tracts (including multiple tracts) according to body region, 54% of them were in the groin region and 26% were axillary. The details of the data of fistulous tracts (fistulae per patient group, per body region, multiple and communicating) are shown in Table I.

The presence of a pattern suggestive of fibrotic scarring surrounding the fistulous tracts was present in 98% (n = 51) of patients and in all these cases there was hypoechoic appearance.

Multiple fistulous tracts in the same patient were present in 37% of cases (n = 19) and in 37% (n = 7) of these latter patients the tracts were connected.

All the fistulous tracts ran through the dermal and hypodermal layers. The average major axis length of the fistulous tracts was 4.6 cm (mean 4 [SD 2.6] cm; range 1-13.1 cm) and their average thickness was 0.6 cm (mean [SD 0.4] 0.4 cm; range 0.2-1.6 cm).

The mean level of fibrotic scarring and edema was 2 (SD 0.5 for fibrotic scarring; SD 0.6 for edema).

Hypervascularity only in the periphery of fistulous tracts was detected in 98% (n = 51) and internal (ie, within the tracts) in 50% (n = 26) of the patients. All patients with internal vascularity also presented peripheral vascularity.

In 98% (n = 51) there were images suggestive of hair tract fragments within the fistulous tracts.

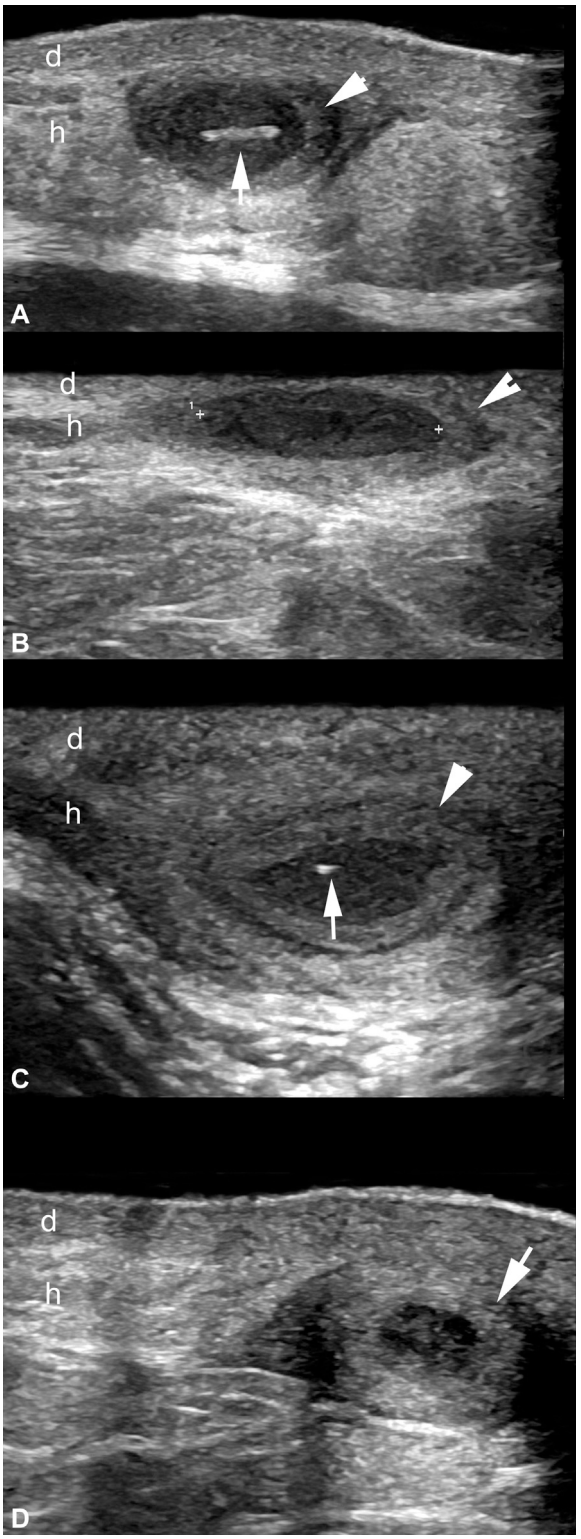

Fig 2. Hidradenitis suppurativa. Halo sign (*arrows*) in HS fistulous tracts presenting fibrotic scarring grade 2. Cross sectional (transverse) views of different fistulous tracts presenting fibrotic scarring grade 2 (**A** to **D**). Notice the hypoechoic rim (fibrosis, oblique arrowheads, and arrow) surrounding the fistulae. The hyperechoic linear fragments in some of the fistulae are suggestive of hair tract fragments (vertical arrows in **A** and **C**). *d*, Dermis; *h*, hypodermis; +, markers of the borders of the cavity of the fistula.

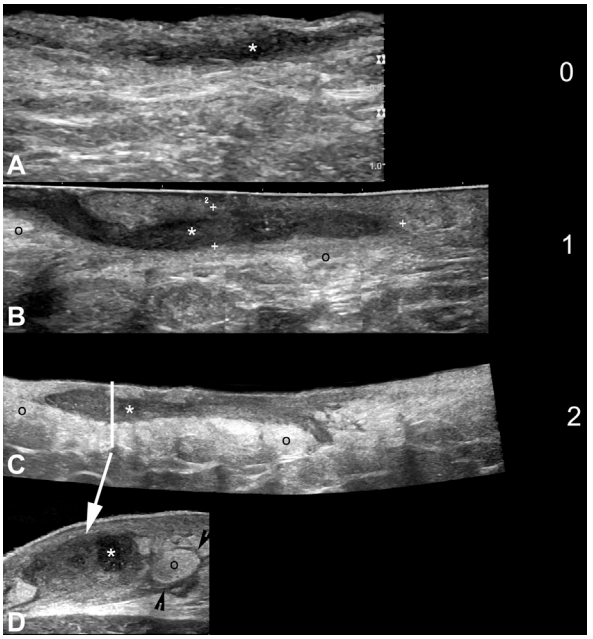

Fig 3. A to **D**, Hidradenitis suppurativa. Grading of hypodermal edema (*o*) surrounding HS fistulous tracts. Grey scale ultrasound; extended field of view of the long axis of fistulae (*). In **D**, a cross-sectional view (transverse axis) of the fistulous tract (*) with edema (*o*) grade 2 is shown. Notice the hypoechoic fluid (*black arrowheads*) in between the fatty lobules in **D**. *, Center; +, markers of the borders of the fistulous tract.

The sonographic scores of these cases was SOS-HS II in 60% (n = 31) and SOS-HS III in 40% (n = 21).

According to these anatomic characteristics, fistulous tracts were grouped into 3 main types that are shown in Table II and Fig 5.

Using this classification of fistulous tracts, 40% of cases were type 1, 25% type 2, and 35% type 3. The detailed data on these types of fistulous tracts (quantity, communicating, and multiple) are shown in Table III.

Type 3 concentrated 71% of communicating tracts and 47% of multiple tracts. Moreover, the sum of type 2 and 3 accounted for 63% of patients presenting multiple fistulous tracts in our series.

Type 3 represented 72% (n = 13) of cases with fistulous tracts measuring 4 cm or longer, and 89% (n = 16) of cases showing 0.4 cm or thicker.

In type 2 and 3 fistulae, increased peripheral vascularity was detected in 100% of the patients and both peripheral and internal vascularity in 83% of cases.

For the bivariate regression analysis, the factors significantly associated with the development of fistulous tracts were age range 19 to 26 years, 35 years or older, and groin location. With the multivariate regression analysis only the communicating tracts factor was significant.

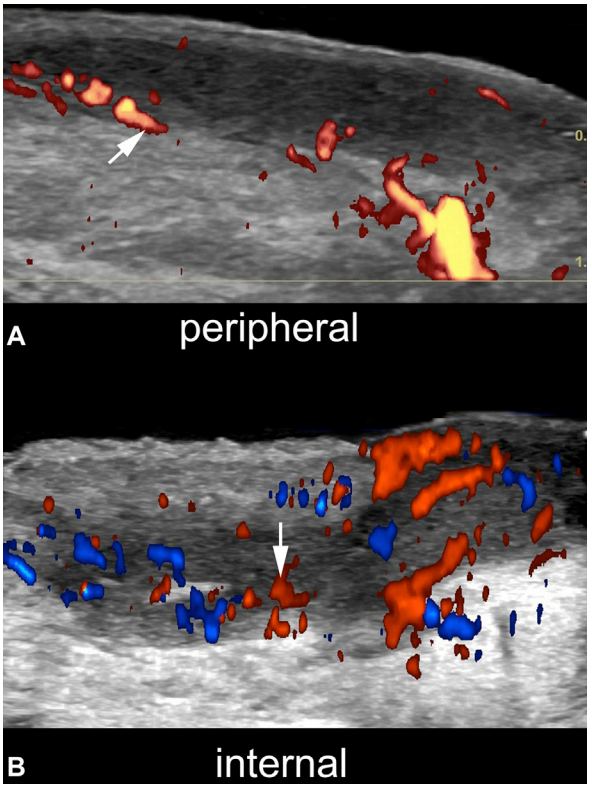

Fig 4. Hidradenitis suppurativa. Types of vascularity patterns in HS fistulous tracts. (**A**, Peripheral; **B**, internal). Notice in **B** that internal vascularity is also associated to peripheral vascularity. *Oblique arrow*, peripheral; *vertical arrow*, internal vascularity.

When grouping fistulous tracts types 2 and 3 versus type 1, the categories of age 35 years or older and groin location were significant factors on bivariate analysis. However, with multivariate analysis only groin location was significant. Tables IV and V show the bivariate and multivariate results with odd ratios and 95% confidence intervals.

The degree of fibrotic scarring was not significantly correlated with the degree of edema or internal vascularity. However, the presence of internal vascularity was significantly correlated with the presence of edema (Tables VI and VII).

DISCUSSION

To our knowledge, assessment of the variability of anatomic characteristics of fistulous tracts in HS including a classification of the tracts has not been previously reported. This assessment could be relevant for determining the reversibility of the physiopathological process or the early need for more aggressive therapies.

The categorization of these fistulae was mainly determined by the presence of fibrotic scarring, which could be an underestimated factor for

Table I. Data on location of fistulae

	%	n
Fistulae per patient group		
Groin	54	28
Axillary	19	10
Gluteal	10	5
Thoracic	8	4
Occipito-cervical	6	2
Mixed axillary-gluteal	3	3
Fistulae per body region		
Groin	54	52
Axillary	26	25
Gluteal	10	10
Thoracic	5	5
Occipito-cervical	5	4
Multiple fistulae per body region		
Groin	51	32
Axillary region	22	14
Mixed axillary-gluteal	16	10
Occipito-cervical	5	3
Gluteal	3	2
Thoracic	3	2
Communicating fistulae per body region		
Groin	43	3
Axillary	29	2
Mixed axillary-gluteal	14	1
Occipito-cervical	14	1

Table II. Types of fistulous tracts

Type	Definition
1	Low fibrotic scarring (grades 0-1) with high or low edema (grades 0-2)
2	High fibrotic scarring (grade 2) with low edema (grades 0-1)
3	High fibrotic scarring (grade 2) with high edema (grade 2)

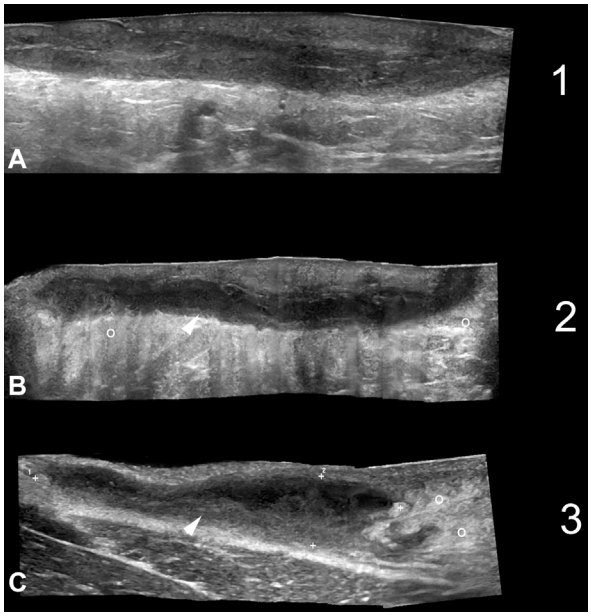

Fig 5. **A** to **C**, Hidradenitis suppurativa. Types of fistulous tracts in HS as delineated in Table II. Notice in type 3 (**C**) the thick hypoechoic rim (*arrowhead*) suggestive of fibrotic scarring in the periphery of the fistulous tract and the edema (*o*) of the fatty hypodermal tissue in comparison with the previous types. (*o*) Hypodermal edema; +, markers of the borders of the fistulous tract.

Table III. Data on types of fistulous tracts

Data	%	n
Quantity		
Type 1	40	21
Type 2	25	13
Type 3	35	18
Communicating		
Type 1	0	0
Type 2	29	2
Type 3	71	5
Multiple		
Type 2	16	3
Type 3	47	9

assessing the complexity or nonreversibility of the alterations in the lesional tissue. Conversely, the presence of edema may be reversed and can vary according to the level of inflammation which could be monitored under ultrasound.

The groin location shows a higher frequency of fistulae and communicating tracts and was the only location significantly correlated with the development of fistulous tracts types 2 and 3. This could be related to the presence of a thinner dermis and hypodermis in this region in comparison with other corporal segments or maybe to greater mechanical stress or a greater density of hair follicles in this region.

Fistulae were significantly more common in young adults than in children, which is in agreement with the epidemiologic description of the disease in literature.[6]

The presence of communicating fistulous tracts was significantly associated with fistulous tracts types 2 and 3, which is in agreement with the severity of the disease.

Greater length (≥3 cm) and thickness (≥0.4 cm) were much more frequent in fistulous tracts types 2 and 3, which may be a result of the more chronic or complex stage of the disease.

The hypervascularity in the periphery of fistulous tracts, present in 100% of cases of types 2 and 3, is a

Table IV. Factors associated with the development of fistulous tracts

Analysis	Factor	Scale	OR (95% CI)	*P* value
Bivariate	**Age**	≤18 y	1	
		19-26 y	**4.23 (0.97-18.28)**	**.053***
		27-34 y	3.59 (0.82-15.76)	.090
		≥35 y	**8.03 (1.66-38.86)**	**.010***
	Sex	Male	1	
		Female	1.23 (0.41-3.67)	.709
	Number of fistulae	-	0.95 (0.66-1.34)	.758
	Communicating fistulae	No	1	
		Yes	4.89 (0.67-35.59)	.117
	Maximum length	<4 cm	1	
		≥4 cm	1.24 (0.45-3.43)	.676
	Maximum thickness	<0.4 cm	1	
		≥0.4 cm	2.62 (0.92-7.43)	.069
	SOS-HS	2	1	
		3	0.85 (0.3-2.4)	.767
	Location	Axillary	1	
		Gluteal	6.37 (0.81-50.18)	.079
		Groin	**5.29 (1.18-23.76)**	**.03***
		Thoracic	1 (0.07-14.24)	.999
		Occipito-cervical	10.96 (0.65-184.88)	.097
Multivariate	Communicating fistulae	No	1	
		Yes	**4.9 (0.68-35.52)**	**.117***

Significant features are set in bold.
Multivariate analysis shows only the significant factor.
CI, Confidence interval; *HS*, hidradenitis suppurativa; *OR*, odds ratio; *SOS*, sonographic scoring.
*Significant ($P < .05$ for bivariate and $P < .2$ for multivariate analyses).

sign of inflammation; however internal vascularity, only present in 26% of types 2 and 3, which could be a manifestation of inner granulatory and inflammatory tissue, might indicate a more severe level of inflammation or activity.

The presence of fibrotic scarring was not correlated with internal vascularity; nevertheless, the degree of edema was significantly correlated with the presence of inner vascularity of the fistulous tracts. This may mean that an increase in the level of inflammation (edema and vascularity) does not necessarily imply appearance or increase in the degree of fibrotic scarring.

Retained hair tract fragments within the fistulous tracts may also add complexity or chronicity to the fistulous tracts but were not significantly correlated with the development of fistulae.

Sex was not significantly associated with the presence of fistulous tracts types 2 and 3. This is intriguing because this disease tends to more commonly affect females according to the literature,[6,7] which may not be related per se with the severity of the fistulous tracts.

Interestingly, the ultrasound characteristics of fibrotic scarring differ from the usual pattern of end-stage scarring described for internal structures such as muscle, kidney, or the uterus, which is predominantly hyperechoic.[4,8,9] The bright appearance of fibrosis has been detected in the skin by other imaging modalities such as optical coherence tomography.[10] Conversely, at fistulous sites the pattern is mostly hypoechoic. This echostructure has also been described for fibrotic scarring in superficial structures such as the breast.[5] However, this may mean that the repair process in these superficial structures could be done through an increased production of a different type of collagen or cross-linking.[11,12] The latter fact may be relevant because the type of collagen cross-linking has been reported to determine the reversibility of skin fibrosis.[11]

Furthermore, the presence of collagen type IV in fibrotic autoimmune diseases such as scleroderma and other fibrotic conditions has been previously reported[12,13] and the hypoechoic appearance of the dermis in morphea sonography has been described during the active and inactive stages of the disease.[14]

Therefore, the prominent laminar hypoechogenicity in the periphery of fistulous tracts that generates a halo could mean that, in addition to the possible autoimmune background or effects on the follicular unit in this disease, an unregulated healing process may be present. Perhaps this should be

Table V. Factors associated with fistulous tracts type 2 and 3

Analysis	Factor	Scale	OR (95% CI)	*P* value
Bivariate	**Age**	<18 y	1	
		19-26 y	4.05 (0.81-20.19)	.088
		27-34 y	2.88 (0.60-13.75)	.185
		≥35 y	**5.39 (0.98-29.67)**	**.052***
	Sex	Male	1	
		Female	1.22 (0.37-4.03)	.742
			0.86 (0.59-1.25)	.437
	Number of fistulae	No	1	
	Communicating fistulae	Yes	2.5 (0.3-18.3)	.367
	Maximum length	<3 cm	1	
		≥3 cm	1.17	
	Maximum thickness	<0.5 cm	1	
		≥0.5 cm	1.52 (0.5-4.7)	.464
	SOS-HS	2	1	
		3	0.60 (0.19-1.87)	.383
	Location	Axillary	1	
		Gluteal	3.6 (0.48-26.28)	.214
		Groin	**8.0 (1.65-38.79)**	**.010***
		Thoracic	0.89 (0.1-12.25)	.930
		Occipito-cervical	-	-
Multivariate	**Age**	<18 y	1	
		19-26 y	**7.68 (1.19-49.24)**	**.031***
		27-34 y	**3.63 (0.57-23.12)**	**.172***
		≥35 y	**5.87 (0.87-39.79)**	**.083***
	Maximum length	<3 cm	1	
		≥3 cm	**3.72 (0.84-16.38)**	**.083***
	Location	Axillary	1	
		Gluteal	-	
		Groin	**6.24 (1.54-25.24)**	**.010***
		Thoracic	-	
		Occipito-cervical	-	

Significant features are set in bold.
Multivariate analysis shows only the significant factors.
CI, Confidence interval; *HS*, hidradenitis suppurativa; *OR*, odds ratio; *SOS*, sonographic scoring.
*Significant ($P < .05$ for bivariate and $P < .2$ for multivariate analyses).

Table VI. Correlation between fibrotic scarring versus edema and internal vascularity

	Fibrotic scarring	
Feature	ρ	*P* value
Edema	0.0781	.5821
Internal vascularity	0.0539	.7041

ρ, Rho.

Table VII. Correlation between internal vascularity and edema

	Internal vascularity	
Feature	ρ	*P* value
Edema	0.5112	.0001*

ρ, Rho.
*Significant.

considered in the treatment of patients, and particularly in patients presenting fistulous tracts type 3.

Nevertheless, in our experience, the hyperechoic laminar pattern of fibrotic scarring can be observed in other areas (without fistulous tracts) in patients with HS.

The current limitations of dermatologic ultrasound are its lack of sensitivity to detect lesions localized to the epidermis or extremely thin (less than 0.1 mm) and the presence of pigment deposits.[15] None of this is relevant for the detection of the usually large fistulous tracts in HS.[2,16,17]

In future investigations, the role of other clinical factors in the development or evolution of fistulous tracts such as the presence of obesity or diabetes, types of treatments, immunologic status, and concomitant diseases should be assessed.

The sonographic categorization of fistulous tracts into 3 types may also serve as an additional tool for assessing severity in these cases, and perhaps may help to predict a future early need for, or the response to, more aggressive types of treatment such as biologic drugs or surgery. Also, it may allow noninvasive testing of treatments particularly directed to fistulous tracts or the inclusion of the evaluation of these structures in clinical trials.

Noninvasive and real-time sonographic assessment of these detailed anatomic characteristics—which would be difficult to determine using physical examination alone—may be of paramount importance for proper, more complete, and anatomic management of this complex and devastating disease.

Conclusion

Color Doppler ultrasound can allow categorizing fistulous tracts in HS, which can add relevant data for assessing the severity of the disease; may support the prognosis of reversibility of physiopathological changes; and may perhaps help to predict a future need for, or response to, more aggressive treatments. This can help to achieve more anatomically oriented, early, and precise management in HS.

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