

Evaluation of Very-High-Frequency Ultrasound Imaging Characteristics of Dermatofibroma

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Background: Dermatofibroma (DF) is one of the common dermatosis, which is so challenging to diagnose that its misdiagnostic incidence is quite high. The very-high-frequency (VHF) ultrasound is particularly relevant to the diagnosis of DF. Herein, we analyze the sonographic features and application value of VHF ultrasound in the diagnosis of DF.

Methods: Clinical data from 153 patients with pathologically confirmed DF from January 2019 to December 2023 were retrospectively analyzed using high-resolution VHF ultrasound, including size, location, shape, edge, boundary, interior echo, blood supply and so on.

Results: The VHF sonographic features of DF showed that the maximum diameter of the lesions was about 7.29 ± 2.85 mm (mean \pm standard deviation). In addition, most lesions were located in the middle and lower part of dermis (49%), with ill-defined (84%) and irregular shape (51%), 19% of which were serrated. Forty-four percent of lesions were hypo-echoic and heterogeneous, and 8% were complicated with calcifications. Nineteen percent of lesions presented as thickened dermal epidermal junction. Dermatofibroma are mostly hypovascular on color Doppler ultrasound. Forty-three percent of lesions were detected with punctate dotted blood flow signals. The correlation analysis showed blood flow classification and maximum diameter were not relevant.

Conclusion: The DF based on VHF ultrasonographic findings is characteristic, such as <10mm, ill-defined, located in the dermis, thickened DEJ, serrated shape, punctate or no flow on Doppler, which provide crucial indicators for differential diagnosis, potentially reducing the rate of DF misdiagnosis.

Keywords: dermatofibroma, very-high-frequency ultrasound, dermatosis

Introduction

Dermatofibroma, also known as benign fibrous histiocytoma, is one of the common dermatosis but challenging to diagnose,¹ which is generally characterized by slow-growing painless solid nodules but difficult to distinguish it from other skin diseases such as dermatofibrosarcoma protuberans (DFSP). The mechanism of DF is not clear at present. There is a view that DF is a reactive inflammatory process to mechanical stimuli such as injury, and another view is neoplastic theories.² Most researchers prefer the latter, but it is still controversial. DF is not a rare disease, but with a high misdiagnosis incidence³ which is not only related to the diverse clinical manifestations but also the lack knowledge of DF.

As a convenient and non-invasive examination method, ultrasonography has been widely applied to the diagnosis of dermatosis. Several domestic and international scholars have summarized the standard high-frequency (HF) sonographic features of DF. HF ultrasound with limited resolution has difficulty in clearly differentiating the skin structure, therefore it is difficult to locate and characterize the lesions. VHF ultrasound with a higher resolution is especially suited for skin lesions imaging and relevant to DF diagnosis.

Given this, We herein analysed 153 DF cases and summarized the VHF⁴ sonographic features through a large sample study attempting to boost the cognition of DF and provided more valuable reference for clinical diagnosis and treatment. We aim to identify unique VHF ultrasound features that aid in accurate DF diagnosis.

Materials and Methods

Study Population

Clinical data from 153 patients (154 lesions) with pathologically confirmed dermatofibroma admitted from January 2019 to December 2023 were retrospectively analyzed using high-resolution VHF ultrasound. This study complies with the Declaration of Helsinki and was approved by the Medical Ethics Committee of Hangzhou Third People's Hospital (approval number: 2024KA099). As a retrospective study of anonymised imaging and clinical data, the medical ethics committee of Hangzhou Third People's Hospital waived the need of obtaining informed consent.

Inclusion/Exclusion Criteria

Inclusion criteria: 1) Patients with DF confirmed by pathology. 2) The data of VHF ultrasound examination are complete. Exclusion criteria: 1) Patients whose lesions had been medically or surgically treated prior to the acquisition of ultrasound images. 2) The data of VHF ultrasound examination are incomplete.

Ultrasound Equipment and Imaging Protocols

All patients were examined with Esaote MyLabOne Color Doppler Ultrasound Diagnostic Apparatus (Esaote MyLabOne, Italy), equipped with 22 MHz VHF ultrasonic probe. The lesions were fully exposed and the examinations were carried out gently to avoid the influence of probe pressure on the lesion on the observation of internal blood supply.

Observational Index

The VHF ultrasonographic manifestations of 154 lesions were analyzed retrospectively, including size, location, shape, edge, boundary, interior echo and blood supply,⁵ which was performed by two senior physicians with more than 5 years of experience in dermatologic ultrasound diagnosis independently of each other. If there was no consensus, a third would be invited to join the analysis. Kappa values were calculated and variables with poor consistency were eliminated.

Statistical Analysis

SPSS 22.0 statistical software was used to analyze the data. Enumeration data is expressed as frequency and rate (%) and measurement data are expressed as mean \pm standard deviation ($\bar{x} \pm s$). Consistency analysis was performed by *Kappa* test and Spearman correlation analysis was used for correlation test. A value of $P < 0.05$ was considered statistically significant.

Results

Clinical Features

There were 153 DF patients, including 43 males and 110 females, who are in the range 7–73 years (average age 33.43 \pm 11.87). The most predilection sites of lesions were limbs 75 (48%), followed by truncus 66 (43%). Table 1 shows the

Table 1 The Predilection Sites of DF

Predilection Sites		Quantity (n=154)		Proportion (%)	
Limbs	Upper limbs	75	42	48	27
	Lower limbs		33		21
Truncus		66		43	
Neck		6		4	
Face		4		3	
Periauricular region		3		2	

predilection sites. The macroscopic clinical photographs of these 154 lesions were analyzed, while they had no obvious characteristics.

The VHF Sonographic Features of DF

1. Among the 154 lesions, the maximum diameter was 1.9–19.0 (7.29±2.85) mm, 133 (86%) of which were within 10 mm.
2. 138 (90%) lesions were confined to the dermis, 58 (38%) were involved and confined to dermis (Figure 1A), 5(3%) were located in the middle and upper dermis (Figure 1B), 75 (49%) were located in the lower part of dermis (Figure 1C) and 16 (10%) broke through the dermis and involved the subcutaneous tissue (Figure 1D).
3. There were 24 (16%) well-defined (Figure 2A), 130 (84%) ill-defined (Figure 2B), 76 (49%) regular (Figure 2C) and 78 (51%) irregular, 29 (19%) were serrated and all ill-defined (Figure 2D).
4. Table 2 shows the statistic of typical DF lesions with different internal echo. The heterogeneous hypoechoic lesions (Figure 3A) were the most common, followed by homogeneous hypoechoic (Figure 3B), mixed echo (Figure 3C and D) and iso-echoic (Figure 3E). 13 (8%) lesions were complicated with calcifications (Figure 3F), 29 (19%) of lesions presented as thickened dermal epidermal junction (DEJ) (Figure 3G), and 10 (9%) lesions were accompanied by posterior acoustic enhancement (Figure 3H).
5. Color Doppler ultrasound mainly revealed hypovascular. Sixty three (41%) lesions showed no flow, Adler grade 0 (Figure 4A), the maximum diameter of which ranged from 3.1 to 19 (6.85±2.83) mm. Sixty six (43%) lesions were detected with punctate dotted flow, Adler grade 1 (Figure 4B), the maximum diameter of which ranged from 1.9 to 14.6 (7.41±2.77) mm. Thirteen (8%) lesions were detected with moderate flow, Adler grade 2 (Figure 4C), the maximum diameters of which ranged from 4.5 to 17.5 (8.62±3.19) mm. Twelve (8%) lesions were detected with marked flow, Adler grade 3 (Figure 4D), the maximum diameters of which ranged from 3.6 to 12.5 (7.54±2.79) mm.

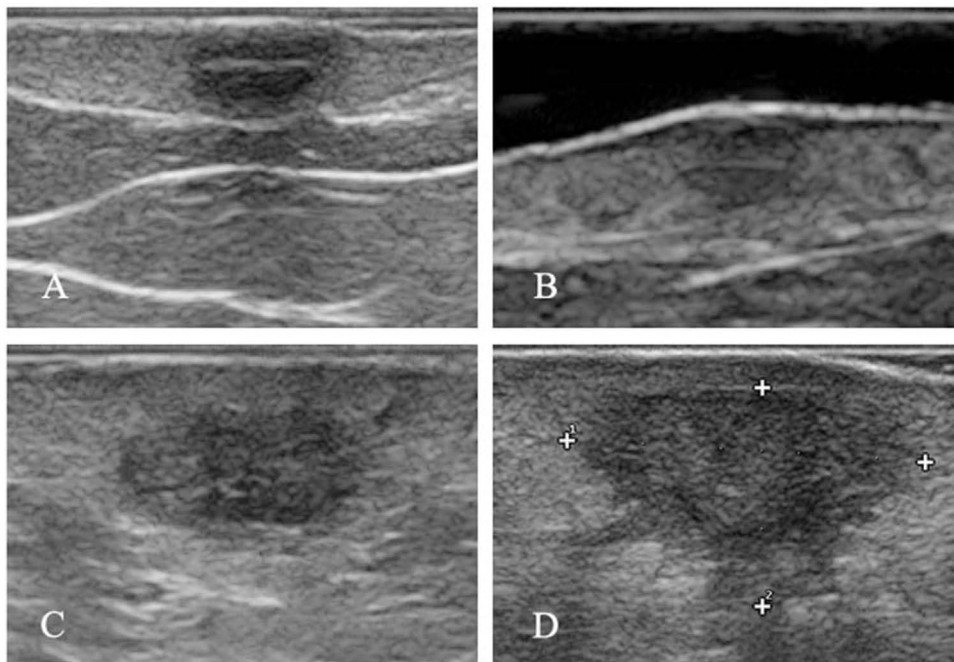


Figure 1 Typical DF lesions distributed in different skin layers. (A) A lesion confined to the whole dermis. (B) A lesion located in the middle and upper dermis. (C) A lesion located in the lower part of dermis. (D) A lesion involved the subcutaneous soft tissue. The symbols “+”, “1”, “2” are the measuring scales on ultrasonic instrument.

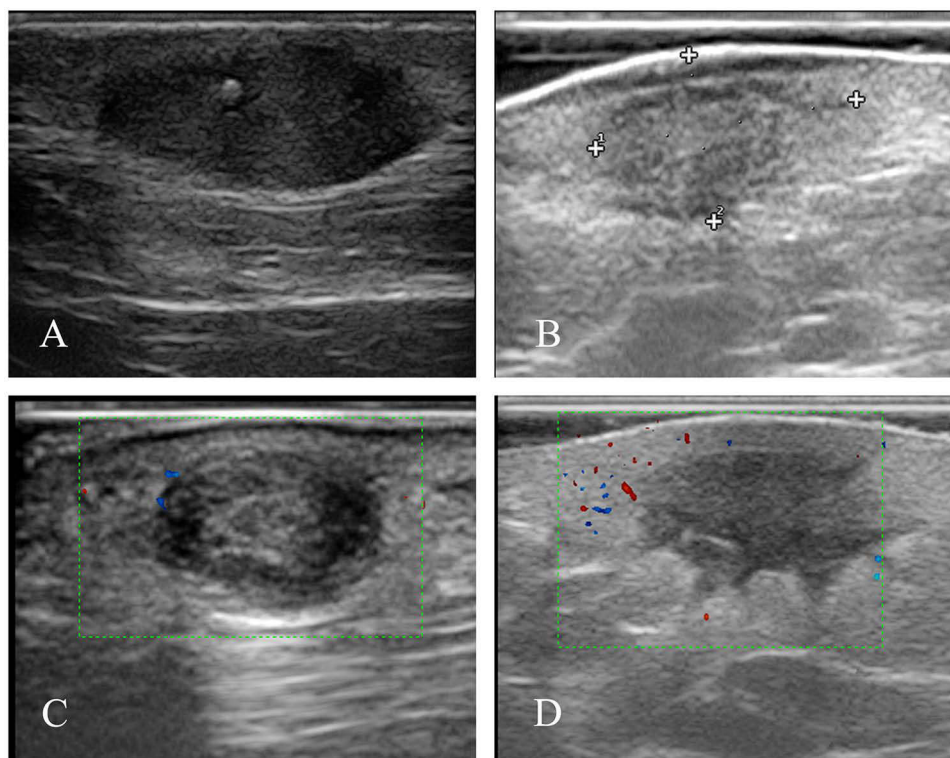


Figure 2 (A) A well-defined lesion. (B) An ill-defined lesion. The symbols “+”, “1”, “2” are the measuring scales on ultrasonic instrument. (C) A regular lesion is roundish in shape. (D) An irregular lesion is serrated in shape.

6. Kappa analysis Table 3 lists Kappa-test result which shows good consistency of the above ultrasonic image analysis results. Kappa values >0.75 were considered to indicate substantial consistency, values of $0.40-0.75$ indicated moderate consistency, and values <0.40 indicated poor consistency.
7. The correlation analysis showed Adler grading and maximum diameter were not relevant (Figure 5). Correlation coefficient $r > 0$, Adler grading was positive correlated with maximum diameter. Correlation coefficient $r < 0$, a negative correlation existed. The higher the absolute value of r , the higher the correlation degree.

Discussion

Among 153 patients in our research, predilection age is 20 to 40 years, and the incidence of female is about 2.6 times higher than that of male. The most predilection sites of lesions were upper limbs, followed by lower limbs, truncus and neck. The lesions are usually relatively small, mostly less than 1 cm in diameter, which is consistent with the pathological

Table 2 The Internal Ultrasonographic Features of 154 Lesions

Internal Ultrasonographic Features		Number (n=154)		Proportion (%)	
Hypoecho	Heterogeneous	110	42	65.58	27.27
	Homogeneous		68		44.16
Isoecho		11		7.14	
Mixed echo	Hyperecho in the center, hypoecho around the perimeter	33	23	24.68	14.94
	Hypoecho in the center, hyperecho around the perimeter		10		6.49

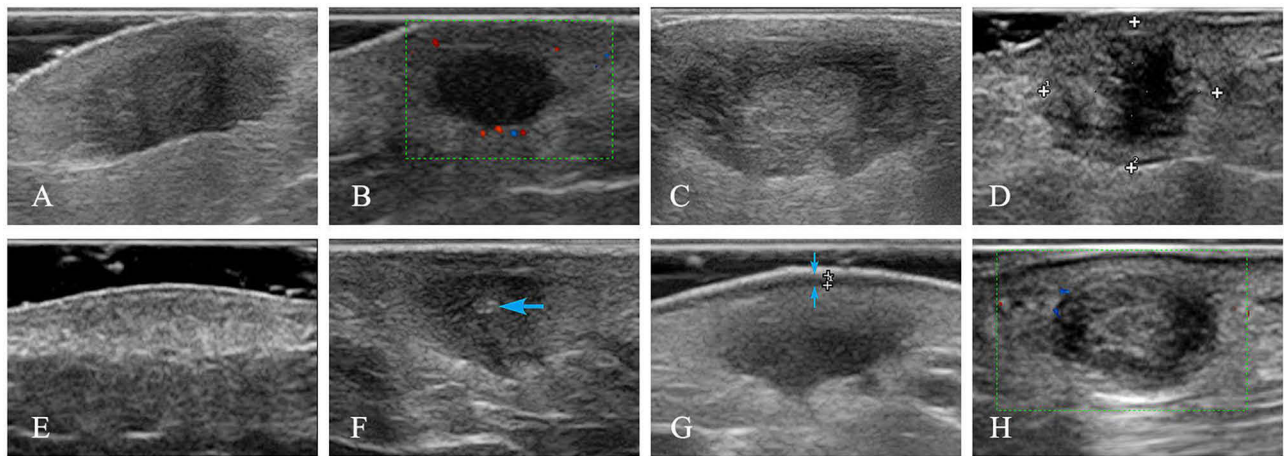


Figure 3 DF lesions with different internal echo. **(A)** A heterogeneous hypoechoic lesion. **(B)** A homogeneous hypoechoic lesion. **(C)** A lesion with mixed echo-hyperecho in the center, hyperecho around the perimeter. **(D)** A lesion with mixed echo-hyperecho in the center, hyperecho around the perimeter. The symbols “+ , 1, 2” are the measuring scales on ultrasonic instrument. **(E)** An iso-echoic lesion. **(F)** A lesion complicating with calcifications (blue arrow). **(G)** A lesion presented as thickened DEJ (blue arrow). The symbols “+ , 1, 2” are the measuring scales on ultrasonic instrument. **(H)** A lesion accompanying by posterior acoustic enhancement.

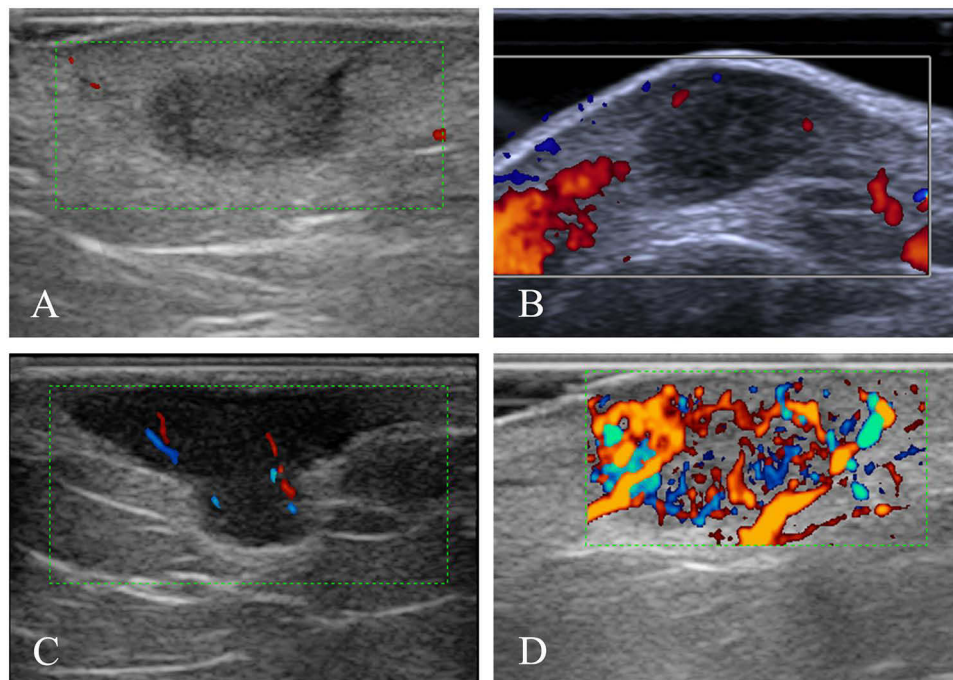


Figure 4 DF lesions with different Adler grades. **(A)** An lesion of Adler grade 0 with no flow. **(B)** An lesion of Adler grade 1 with punctate dotted flow. **(C)** An lesion of Adler grade 2 with moderate flow. **(D)** An lesion of Adler grade 3 with marked flow.

results. 86% of the lesions are less than 1 cm in diameter,^{6,7} and the maximum diameter of all lesions is less than 2 cm. Among the 153 patients in our study, most patients had isolated lesions and only one patient was detected two lesions. The location of the two lesions was different, but the sonographic features were similar, which was also consistent with their histological characteristics.^{8–10}

High-frequency (HF) ultrasound is the preferred choice for auxiliary diagnosis of dermatosis, which is more and more widely used recently. Under the guidelines on ultrasound examination of skin diseases (2022 Edition),⁴ VHF is clearly defined as 20–30 MHz, which has a higher resolution and is more suitable for the penetration depth of skin tissue. In our

Table 3 Consistency Analysis of the Above Ultrasonic Image Analysis Results of 154 Lesions

Ultrasonographic Features	Ultrasonographic Features	Position	Boundary	Shape	Internal Echo	Calcifications	Thickened DEJ	Posterior Acoustic Enhancement	Adler Grade
Kappa value	0.905	0.831	0.825	0.793	0.756	0.892	0.803	0.862	0.734
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

study, DF is mainly located in dermis observed by VHF ultrasound, yet this is not consistent with Kainan Li’s research.¹¹ Based on analysis, it was determined that there may be misjudgment about the location and type of echo, because HF ultrasound is relatively limited in the clear observation of skin structures and internal echo, whose resolution is not as high as VHF ultrasound. Comparative analysis of the HF and VHF ultrasound, it is found that sonographic features of the same lesion exist difference. Histologically, DF is a lesion originating from the dermis, the DF tumor cells are primarily located in the middle part of dermis and only a few may invade subcutaneous tissue,⁶ which is consistent with the findings of our research.

The boundary between the lesions and the surrounding dermis is not clear, which is consistent with the pathology. DF has two kinds of histological growth patterns,³ one grows downward with well-defined edges and expansions, and the other grows radially along the adipose space, which is the most common pattern. Thirty-seven percent of the irregular lesions in our study have serrated appearance and unclear edges. In addition, the thickening of dermal epidermal junction (DEJ) observed in 30 lesions was reported for the first time. The possible reason is that the structure of DEJ could not be identified by HF ultrasound in previous researches. The 30 lesions above-mentioned were all located in the dermis, 27 of which occupied the whole layer of dermis and 3 occupied the middle-upper part of dermis. We consider that it may be due to the inflammatory reaction of DF or the proliferation of tumor cells invading the DEJ structure.

Owing to the existence of multiple subtypes and variants of DF, the various characteristics of different types of DF, the individual differences and uneven development of lesions,^{3,12} the internal echoes of 154 lesions are diversified. Mainly composed of hyperplastic collagen fibers, DF is principally heterogeneous hypoechoic, followed by homogeneous hypoechoic, hybrid echoic and isoechoic. Among them, 13 were associated with punctate calcification, and 62.5% lesions that broke through the dermis and involved subcutaneous tissue were accompanied with enhanced echo of

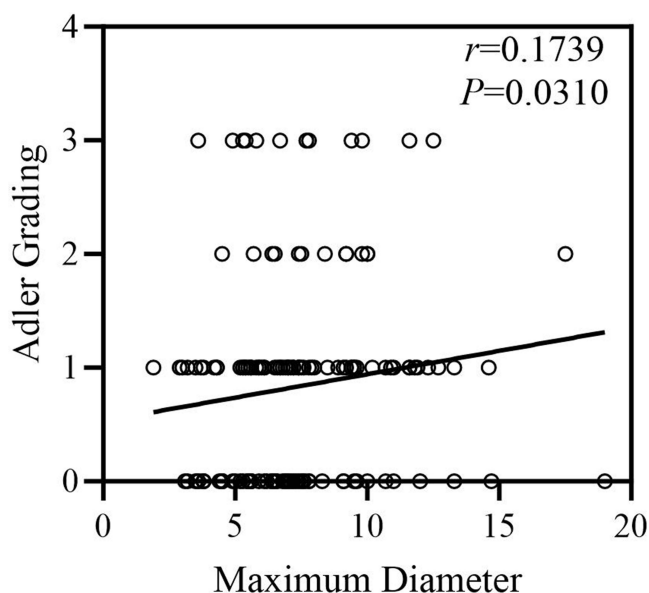


Figure 5 The correlation analysis of Adler grading and maximum diameter. The correlation analysis showed Adler grading and maximum diameter were not relevant. Correlation coefficient $r>0$, Adler grading was positive correlated with maximum diameter. Correlation coefficient $r<0$, a negative correlation existed. The higher the absolute value of r , the higher the correlation degree.

surrounding tissue, which was associated with reactive fibroplasia and chronic inflammatory infiltration in adjacent tissues.¹³ Some domestic scholars have pointed out that the internal echo of DF is uniform as a result of the single pathological component.⁶ However, the highest proportion in our study is not homogeneous hypoechoic, but heterogeneous hypoechoic. That's likely because the HF ultrasound with comparatively low resolution can not well displayed the internal structure of lesions, and previous studies have had relatively small sample size resulting in the accuracy of the research data is relatively low. In addition, pathological studies in recent years have pointed out that the histological composition of DF is not uniform, but complex, thus pathological manifestations are different.¹⁴

The majority lesions presented as hypovascular, which was consistent with the research results of Zhong Lin and other scholars.^{10,15} In previous studies, most cases had no detectable flow, which is more than that in our study. It may be due to the fact that HF ultrasound could not well display the microvessels of lesions, and the sample sizes of past researches were all small. In addition, some scholars believe that the larger the lesion, the more angiogenesis.³ However, the correlation analysis of our study shows that there is no correlation between the maximum diameter and the blood flow grade. According to the analysis of scholars in the field of pathology in recent years, the blood flow of the lesion is actually related to its histological type, such as aneurysmal DF is rich in capillaries.

Conclusion

VHF ultrasound characteristics of DF are as follows: small in size, ill-defined boundary, located in the dermis, thickened DEJ and serrated shape, which provides vital clues for ultrasonic diagnosis and differential diagnosis of DF. When a lesion is associated with calcification or posterior acoustic enhancement, the diagnosis of DF should be taken into account. Compared with HF ultrasound, VHF ultrasound can provide more accurate information for assistant diagnosis of DF.

Data Sharing Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Statement of Ethics

This study complies with the Declaration of Helsinki and was approved by the Medical Ethics Committee of Hangzhou Third People's Hospital (approval number: 2024KA099).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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