Quality Improvement Study

Medicine®

OPEN

MR imaging features and a redefinition of the classification system for nodular fasciitis

Shi-Yong Wu, MD[a], Jin Zhao, MD[b], Hai-Yan Chen, MD[b], Miao-Miao Hu, MD[a], Yin-Yuan Zheng, MD[a], Ji-Kang Min, MD[c], Ri-Sheng Yu, MD[b,*]

Abstract

To analyze magnetic resonance imaging features of nodular fasciitis and redefine the system for classifying this class of lesions.

Twenty-seven patients with nodular fasciitis and 71 patients with other soft tissue lesions who underwent surgery or biopsy were retrospectively analysed. Demographic information, medical history, and magnetic resonance imaging features were collected. Classification of nodular fasciitis was performed based on a redefined system. Comparison between 2 groups was performed with Chi-square or Fisher exact test.

For nodular fasciitis, the longest average lesion diameter was 1.87 cm (range, 0.52–5.46 cm), and 40.7% of lesions were located in the upper extremities, while 29.6% were located in the head and neck. Compared with skeletal muscle, most lesions exhibited isointensity on T1-weighted imaging and hyperintensity on T2-weighted imaging, and 45.5% of the lesions exhibited rim enhancement, 40.9% showed obvious homogenous enhancement, while 13.6% showed no enhancement or slight enhancement. The subcutaneous type accounted for 25.9% of cases, the fascial type 25.9%, the intramuscular type 29.6%, and the unclassified type 18.5%. The "fascia tail sign" was more frequently observed in nodular fasciitis than in other soft tissue lesions ($P < .001$). Nodular fasciitis was slightly more likely to present with the "inverted target sign" and "solar halo sign" than other soft tissue lesions ($P > .05$). The "cloud sign" only appeared in nodular fasciitis ($P < .05$).

The "fascia tail sign" and "cloud sign" could help differentiate nodular fasciitis from other soft tissue lesions. A new classification may improve understanding about nodular fasciitis.

Abbreviations: MRI = magnetic resonance imaging, T1WI = T1-weighted imaging, T2WI = T2-weighted imaging.

Keywords: magnetic resonance, nodular fasciitis, retrospective study

1. Introduction

Nodular fasciitis is a self-limiting soft tissue lesion originating from fibrous tissue that is characterized by the proliferation of fibroblasts and myofibroblasts.[1,2] It is considered a benign lesion of the fibroblastic/myofibroblastic tumor class according to the 2013 World Health Organization (WHO) classification.[3] This lesion mainly occurs in the subcutaneous tissue and underlying fascia of patients between 20 and 40 years old and may cause tenderness and pain.[4,5] These lesions are typically fast-growing small nodules with well-defined margins; 46% of lesions are located in the upper extremities, followed by the trunk, head and neck and lower extremities, and most (71%) are <2 cm in diameter and rarely exceed 4 cm.[5–7] Due to their rapid growth, mitotic activity, high cellularity, and infiltrative tendencies, these lesions have been mistaken for sarcoma, leading to unnecessarily aggressive surgical treatments.[6] Radiological features might be useful to identify nodular fasciitis. However, sensitive radiological markers for nodular fasciitis are currently unavailable.

Furthermore, according to the present classification system, nodular fasciitis is divided into 3 subtypes (subcutaneous, intramuscular, and fascial), based on the location of the lesion.[5] After reviewing more than 30 previous studies, we noticed that different authors had different levels of understandings of this standard, suggesting a lack of clear definitions in the classification system. For example, a nodular fasciitis lesion adjacent to the fascia within the subcutaneous tissue has been classified as a subcutaneous type or fascial type, according to different levels of understandings; a similar situation has been described for a lesion in the muscle but attached to the adjacent fascia.[6,8] Furthermore, this classification system does not include lesions in the parotid glands or joints.[9,10] Therefore, clear and unambiguous definitions are warranted. We hope that this study will reduce the

Editor: Ismaheel Lawal.

SYW and JZ contributed equally and are co-first authors.

The authors have no conflicts of interests to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

[a] Department of Radiology, The First Affiliated Hospital of Huzhou University, Huzhou, [b] Department of Radiology, Second Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, [c] Department of Orthopedics, The First Affiliated Hospital of Huzhou University, Huzhou, China.

[*] Correspondence: Ri-Sheng Yu, Department of Radiology, Second Affiliated Hospital, Zhejiang University School of Medicine. Jiefang Road 88#, Hangzhou 310009, China (e-mail: risheng-yu@zju.edu.cn).

How to cite this article: Wu SY, Zhao J, Chen HY, Hu MM, Zheng YY, Min JK, Yu RS. MR imaging features and a redefinition of the classification system for nodular fasciitis. Medicine 2020;99:45(e22906).

Received: 6 June 2020 / Received in final form: 4 September 2020 / Accepted: 25 September 2020

http://dx.doi.org/10.1097/MD.0000000000022906

confusion of readers and improve the present understanding of nodular fasciitis.

Radiological research on nodular fasciitis is relatively scarce, and reports often contain a limited number of cases. An exception is the study of Coyle et al,[8] who reported findings from 29 patients with nodular fasciitis. Therefore, to the best of our knowledge, our study containing 27 patients is the second largest series to focus on the MR imaging features of nodular fasciitis, and we also included another 71 patients with soft tissue lesions that are easily confused with nodular fasciitis to compare their typical imaging features. Thus, the purpose of our study was to analyze the imaging features of nodular fasciitis and to introduce a redefinition of the classification system for this class of lesions.

2. Materials and methods

This study was approved by the Medical Ethics Committee of the Second Affiliated Hospital of Zhejiang University School of Medicine, and the requirement for informed consent was waived.

Patients with nodular fasciitis confirmed by surgery or biopsy from January 2011 to March 2020 were retrospectively analyzed; these patients were selected from consecutive pathology records. Initially, 37 patients were included. Six patients who only underwent a computed tomography examination, 3 patients who only underwent an ultrasound examination, and 1 patient who underwent a magnetic resonance imaging (MRI) that did not contain the lesion were excluded. Ultimately, 27 patients were available for further analysis. Among these patients, 22 underwent contrast-enhanced MRI scans, while the remaining patients only underwent conventional MRI scans. Twenty-four patients received surgery, and three patients received a biopsy alone. Before surgery, only 4 lesions were considered nodular fasciitis based on the MR imaging data, while the other 23 were misdiagnosed as other soft tissue lesions. The average interval between the last MRI examination and surgery or biopsy was 7.5 days (2–13 days).

Regarding comparisons of the other MR imaging features, 71 consecutive patients diagnosed with other soft tissue lesions, including benign and malignant lesions, from May 2017 to February 2018 were retrospectively analyzed. Ten of these patients were underwent conventional MRI, and the others underwent contrast-enhanced MRI (n = 61). Detailed information about the diseases is presented in Table 1.

Table 1

Types of other soft tissue lesions.

Other soft tissue lesions	Number (n)
Hemangioma	8
Neurinoma	4
Lipomyoma	1
Leiomyoma	1
Hamartoma	1
Fibroma, including desmoid fibroma	11
Chronic inflammation	2
Myxoma	3
Giant cell tumor of tendon sheath	1
Fibrosarcoma	7
Pleomorphic undifferentiated sarcoma	10
Liposarcoma	11
Leiomyosarcoma	3
Synovial sarcoma	2
Lymphoma	2
Rhabdomyosarcoma	2
Other rare sarcoma	4

2.1. Imaging acquisition

MRI was conducted with the same imaging protocol on different platforms (SIEMENS Aera 1.5 T; SIEMENS Avanto 1.5 T; GE Healthcare Signa HDxt 1.5 T; GE Healthcare Discovery 750 3.0 T) using different coils based on the location of the lesion. However, the following standard pulse sequences were used for each patient: axial T1-weighted imaging (T1WI), fat-suppressed T2-weighted imaging (T2WI), proton-density-weighted imaging (PdWI), and contrast-enhanced T1WI with or without fat suppression. Furthermore, for each patient, longitudinal images (coronal or sagittal) were acquired.

2.2. Image analysis

All images were reviewed by 2 musculoskeletal radiologists (with 5 and 10 years of experience in musculoskeletal radiology). Both radiologists were unaware of the diagnosis of nodular fasciitis or other soft tissue lesions before reviewing the images. Divergence in the evaluations was settled by establishing a consensus after a discussion with a third radiologist with 31 years of clinical experience in imaging-based diagnosis.

When analyzing nodular fasciitis, the demographics (age and sex), medical history (clinical symptoms, the course of the disease, and history of trauma and recurrence), location and shape of the lesion, time interval between the last MRI examination and surgery or biopsy, and surgical and pathological information were recorded. Further details of the MR imaging features of nodular fasciitis were collected as follows: the longest diameter of the lesion, peritumor oedema, T2WI signal at the center of the lesion compared with the peripheral signal within the lesion (hypo-, iso-, or hyperintensity), and the enhancement pattern (none/slight, obvious, or rim). For other soft tissue lesions, only age, sex, location, and related MR imaging signs were recorded.

Special imaging signs (inverted target sign, fascia tail sign, solar halo sign, and cloud sign) were assessed in both nodular fasciitis and other soft tissue lesions. The 4 special signs were defined as follows:

(1) the inverted target sign[8]: a T2WI high-intensity area without any enhancement at the center of the lesion along with a peripheral component with obvious enhancement;
(2) the fascia tail sign[5]: linear extension of the lesion that resembles a tail;
(3) the solar halo sign: marked irregular enhancement of the fascia around the lesion, with only slight or no enhancement of the lesion, resembling a halo around the sun; and
(4) the cloud sign: the growth of the lesion along the fascia in the muscle, resembling a cloud covering the sun.

Nodular fasciitis was classified based on a redefinition and readjustment of the classification system, which was defined using the criteria listed below based on both the location of the lesion and its relationship with the adjacent fascia, of which the latter is the most important.

1. Subcutaneous type: The lesion is completely located subcutaneously and is not attached to the adjacent fascia.
2. Fascial type: The lesion is attached to the fascia via the wide base connected to the fascia, and the lesion may be growing into the subcutaneous region or the muscle.

3. Intramuscular type: The lesion is completely located within muscle and is not attached to the adjacent fascia.
4. Unclassified type: In contrast to the 3 types listed above, the lesion may be located in the parotid gland, tongue, spinal canal, blood vessel, etc.

2.3. Statistical analysis

Qualitative variables are presented as frequencies (%), and quantitative data are presented as means ± standard deviations or medians (25%–75% interquartile ranges) based on the distribution. Chi-square test or Fisher exact test were conducted to test potential differences in the distributions of the 4 signs between the patients with nodular fasciitis and patients with other soft tissue lesions. All tests were 2-sided, and $P < .05$ was considered a significant difference. SPSS V.23.0 (SPSS Inc., an IBM company, Chicago, IL) was used for analyzing.

3. Results

3.1. Clinical findings of nodular fasciitis

Fourteen males and 13 females were included in the study; the mean age was 36.8 years old, with a range of 7 to 67 years. An incidentally discovered mass was a frequent chief complaint among these patients. In addition, 29.6% (n = 8) of patients presented with clinical symptoms, including six patients experiencing pain and 2 experiencing local tenderness. The course of the disease ranged from 5 to 180 days, with an average of 64.8 days. No patient had a local history of trauma, and only 2 patients experienced recurrence after local excision. One patient experienced recurrence in the subcutaneous tissue of the scalp, and another patient experienced recurrence in the knee joint with bone destruction.

3.2. Imaging findings of nodular fasciitis

All lesions in this study were solitary. The average longest diameter was 1.87 cm, with a range of 0.52 cm to 5.46 cm, and 59.3% (n = 16) of lesions measured no more than 2.0 cm along their longest diameter, while 96.3% (n = 26) of lesions measured less than 4.0 cm.

All lesions presented with an oval or rounded shape. The margins of the lesions were sharply defined, except for 2 lesions with poorly demarcated margins, a phenomenon designated the "cloud sign" (Fig. 1). Furthermore, no peritumor oedema was observed. Regarding the signal intensity, compared with skeletal muscle, 81.5% (n = 22) of the lesions displayed a homogenous and isointense signal in T1WI, while three lesions exhibited hypointensity, and 2 showed slight hyperintensity relative to the adjacent skeletal muscle. Regarding the T2WI signal, all of the lesions exhibited hyperintensity compared to the adjacent tissue. However, regarding the T2WI signal at the center of the lesion, 25.9% (n = 7) of the lesions exhibited hypointensity, and 14.8% (n = 4) displayed hyperintensity compared to the peripheral signal within the lesion. In other words, the rest of the lesion (59.3%, n = 16) appeared homogenous. Regarding the pattern of enhancement (only 22 patients underwent contrast-enhanced MRI), approximately half of the lesions (n = 10) demonstrated rim enhancement, and 40.9% (n = 9) of the lesions showed obvious homogenous enhancement, and 13.6% (n = 3) showed no enhancement or slight enhancement.

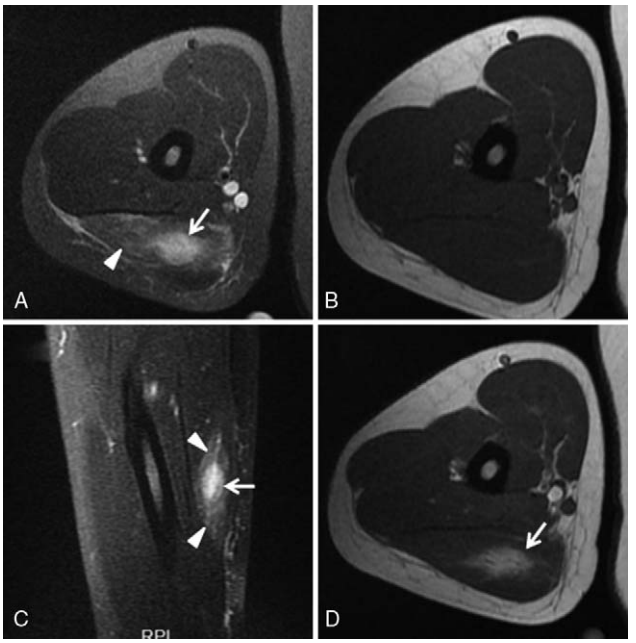

Figure 1. A 48-year-old female was diagnosed with nodular fasciitis (intramuscular type) in her right upper arm. (A) Fat-suppressed T2WI shows an oval hyperintense nodule (white arrow) with a poorly demarcated margin, and the lesion grows along the fascia in the muscle, forming the cloud sign (white arrowhead). (B) T1WI shows an isointense, barely visible lesion compared to the adjacent muscle. (C) Coronal contrast-enhanced T1WI with fat suppression presents a lesion (white arrow) with obvious enhancement, and the involved fascia around it is also slightly enhanced. (D) Contrast-enhanced T1WI without fat suppression shows obvious enhancement (white arrow).

3.3. Special imaging signs detected among nodular fasciitis and other soft tissue lesions

The information obtained from patients with nodular fasciitis and other soft tissue lesions is described in Table 2. Sex differences were not observed between the groups. The average age of patients with nodular fasciitis was 36.8 years, which was much younger than the age of patients with other soft tissue lesions ($P < .001$). Regarding anatomical sites, 40.7% (n = 11) of nodular fasciitis lesions were located in the upper extremities,

Table 2

Comparison between nodular fasciitis and other soft tissue lesions.

Characteristics	Nodular fasciitis (n = 27)	Other soft tissue lesions (n = 71)	*P* value
Gender			.599
Male	14 (51.9)	41 (57.7)	
Female	13 (48.1)	30 (42.3)	
Age	36.8 ± 16.6	49.9 ± 17.3	**<.001**
Location			**<.001**
Head and neck	8 (29.6)	2 (2.8)	
Upper extremity	11 (40.7)	10 (14.1)	
Trunk	2 (7.4)	11 (15.5)	
Lower extremity	6 (22.2)	48 (67.6)	
Fascia tail sign	7 (26.0)	2 (2.8)	**<.001**
Inverted target sign	3 (11.1)	2 (2.8)	.096
Cloud sign	2 (7.4)	0	**.021**
Solar halo sign	1 (3.7)	0	.10

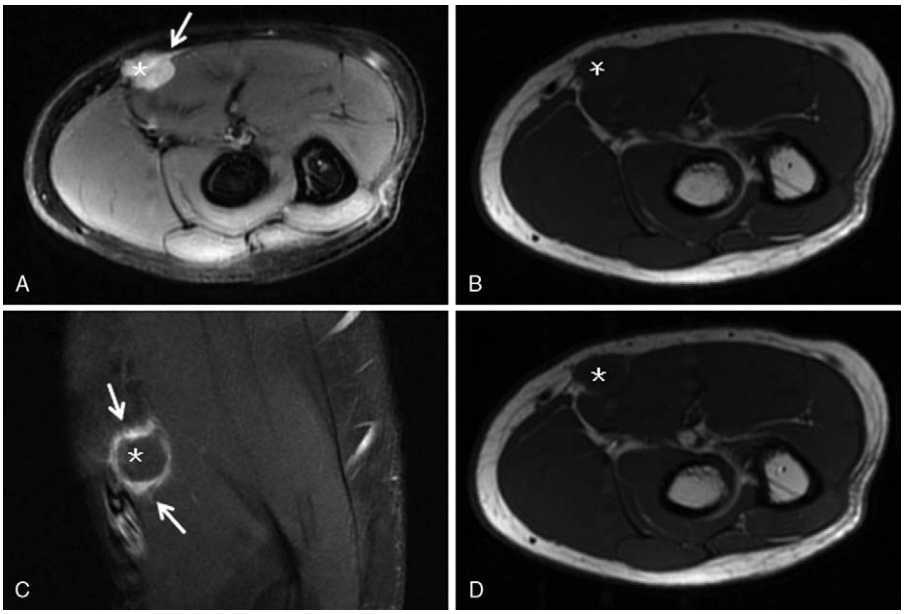

Figure 2. A 25-year-old male diagnosed with nodular fasciitis (fascial type) in his left forearm. (A) Fat-suppressed PdWI shows a round hyperintense nodule (asterisk) along the fascia with the fascial tail sign (white arrow); the margin is very clear and has no oedema. (B) T1WI shows an isointense lesion (asterisk) compared to the adjacent muscle. (C) Coronal contrast-enhanced T1WI with fat suppression presents a lesion (asterisk) without any enhancement, but the fascia around the lesion shows marked irregular enhancement, forming the solar halo sign (white arrow). (D) Contrast-enhanced T1WI without fat suppression shows no enhancement within the lesion (asterisk).

particularly the left forearm (n = 5), while other soft tissue lesions were mainly located in lower extremities (67.6%) ($P < .001$).

Regarding the 4 special imaging signs, only one nodular fasciitis presented the solar halo sign (Fig. 2) ($P > .05$). The "fascia tail sign" was more frequently observed in nodular fasciitis (Figs. 2A and 3D) than in other soft tissue lesions (observed in fibroma and neurinoma, respectively) ($P < .001$). Nodular fasciitis was slightly more likely to presented with the "inverted target sign" (Fig. 3) than in other soft tissue lesions (observed in pleomorphic undifferentiated sarcoma and fibrosarcoma, respectively) ($P > .05$). The "cloud sign" only appeared in nodular fasciitis ($P < .05$).

3.4. New classification system

According to the new classification system, 25.9% (n = 7) of the lesions belonged to the subcutaneous type, 25.9% (n = 7) to the fascial type, 29.6% (n = 8) to the intramuscular type, and 18.5% (n = 5) to the unclassified type. Among the unclassified type of lesions, 2 lesions were located in the parotid gland, 1 in the epidermis, 1 in the knee joint (Fig. 4) and 1 in the masticatory muscle space.

4. Discussion

In our study, the average size of nodular fasciitis lesions was 1.87 cm, approximately half of these lesions were located in the upper extremities, and numerous lesions presented with rim or obvious homogenous enhancement. The most compelling result was that our study identified four special signs that will help us differentiate nodular fasciitis from other soft lesions. For example, the "fascia tail sign" was more frequently observed in nodular fasciitis lesions than in other soft tissue lesions, while the "cloud sign" only appeared in nodular fasciitis lesions. Moreover, the redefinition of the system for classifying nodular fasciitis is explained in detail, and the subcutaneous type accounted for 25.9% of cases, the fascial type accounted for

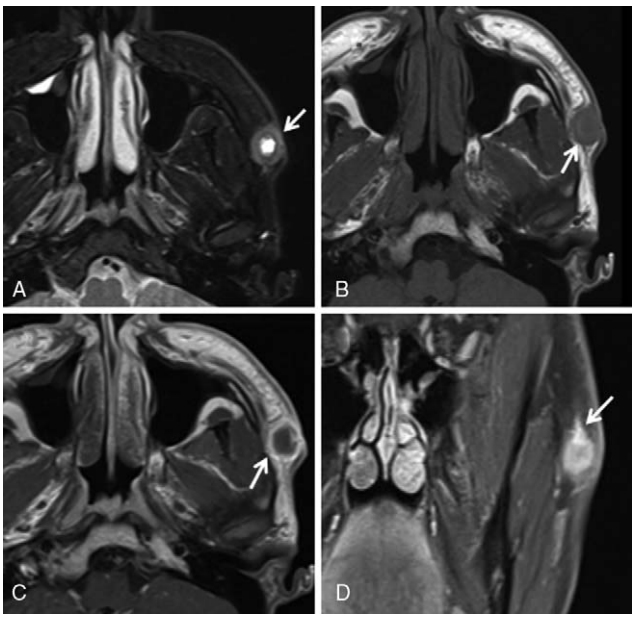

Figure 3. A 20-year-old male diagnosed with nodular fasciitis (subcutaneous type) on the left side of his face. (A) Fat-suppressed T2WI shows a mixed-signal nodule in the subcutaneous tissue with a high signal at the center of the lesion (white arrow), which is the inverted target sign. (B) T1WI shows an isointense lesion with a mildly elevated signal (white arrow). (C) Contrast-enhanced T1WI without fat suppression presents a lesion with rim enhancement (white arrow). (D) Coronal contrast-enhanced T1WI with fat suppression shows rim enhancement and a fascial tail sign adjacent to it (white arrow).

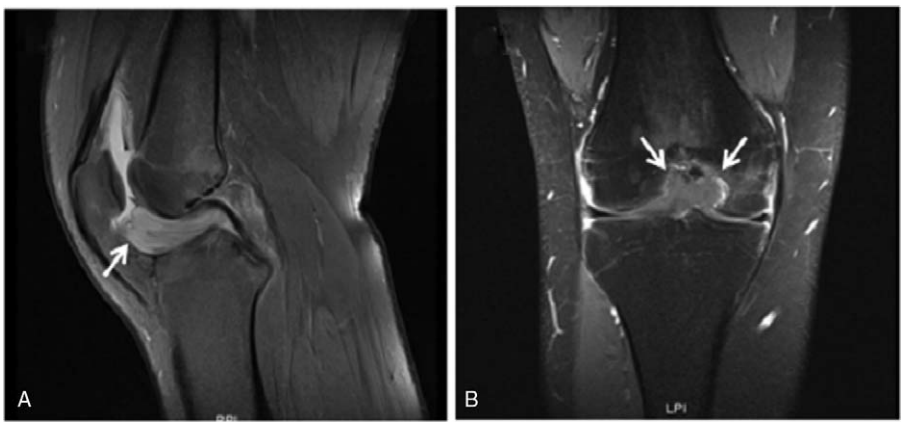

Figure 4. A 20-year-old male was diagnosed with local recurrence of nodular fasciitis (unclassified type) in his right knee joint after the first surgery 6 months prior. (A) Sagittal fat-suppressed T2WI shows high-signal soft tissue in the knee articular cavity (white arrow) with mild oedema. (B) Coronal contrast-enhanced T1WI with fat suppression shows that the lesion seems to lack enhancement, and bone destruction is seen in the adjacent femoral shaft (white arrow).

25.9%, the intramuscular type accounted for 29.6%, and the unclassified type accounted for 18.5%.

The "fascia tail sign" was the most common sign of nodular fasciitis identified in our study, which presented as a broad fascial base with a linear extension of the nearby fascia. Hu et al analyzed 6 patients with nodular fasciitis and found that 5 of them presented the a "fascia tail sign"; moreover, the "fascia tail sign" was a useful clue to differentiate nodular fasciitis from hemangioma or other superficial tumors.[5] However, 2 important malignancies, namely, undifferentiated pleomorphic sarcoma and myxofibrosarcoma, often manifest the "fascia tail sign," which may also be related to a shorter local recurrence-free survival caused by a diffusely spreading growth pattern along fascial planes.[11–13] Nevertheless, we did not observe any "fascia tail sign" among patients with these lesions in our study, which may be due to the small number of patients with these lesions, since the occurrence rate ranges from 6.8% to 53%.[5,13] Undifferentiated pleomorphic sarcoma and myxofibrosarcoma also display malignant features other than the "fascia tail sign," such as diffuse thick fascial enhancement and peritumor oedema.[11] Nodular fasciitis may present as a rapidly enlarging lesion with or without clinical symptoms, and has been detected in the breast.[10,14–16] However, these lesions are rarely present with peritumor oedema, as shown in our study and the study by Leung et al.[7] Nevertheless, Coyle et al reported that approximately 69% (20/29) of the lesions had oedema[8]; we suspected that this rate of oedema might be an overestimation because the infiltration of the peritumor fascia might be mistaken for oedema in some cases.

Nodular fasciitis has been divided into myxoid, cellular and fibrous subtypes, based on the main histological composition.[4,17] The myxoid subtype mainly occurs in newer lesions, while a fibrous composition occurs in older lesions. However, these three components may coexist,[4,17,18] resulting in various MR imaging signals.[19] For example, the coexistence of remarkable cellularity and abundant collagen, cytoplasm, and vascularity may lead to a strong signal on T2WI, while the presence of a fibrous histology may reduce the signal.[18,20] Moreover, the presence of higher-intensity areas in the center of the lesion in T2WI, known as the "inverted target sign," may be conducive to the diagnosis. These areas are probably secondary to internal cystic changes or necrosis caused by the myxoid component or extracellular matrix,[4,8] which may occur in malignancies, as shown in our study. The "inverted target sign" was slightly more common and suggest a diagnosis of nodular fasciitis, along with the relationship to the fascia, history of trauma, and short course of the disease.[8]

Nodular fasciitis typically presents with a small size, an ovoid shape and a well-defined margin, as described in our study. We observed 2 patients with poorly demarcated margins within the muscle. The lesions grew along the fascia between the intermuscular septa, forming the "cloud sign." However, if a lesion grows along the immediately surrounding fascia, it may resemble the "solar halo sign." These 2 particular signs are caused by a diffusely spreading growth pattern along the fascial bases of nodular fasciitis. Therefore, the relationship between the lesion and the adjacent fascia may be helpful in diagnosing a nodular fasciitis lesion, particularly the fascial type of lesion. However, a conclusive diagnosis is unable to be determined based on either sign, because imaging features will never replace a tissue analysis; they merely provide a clue to the diagnosis.

According to the new classification system, the intramuscular type was the most common type, followed by the subcutaneous, fascial, and unclassified types, in contrast to the original classification system. In studies using the original system, the subcutaneous type was 3 to 10 times more frequently detected than the other 2 types.[4] The reason for this difference may be that some fascial types were mistaken for the subcutaneous type because only the location and not the relationship between the lesion and adjacent fascia was considered. Using our new system, which highly generalized the characteristics of nodular fasciitis and its relationship with adjacent fascia, we are able to determine the correct diagnosis before surgery to decrease unnecessary surgery, reduce confusion, and improve our understanding of nodular fasciitis.

In general, compared with skeletal muscle, most nodular fasciitis lesions exhibited homogenous and isointense signals on T1WI and hyperintensity on T2WI.[4,5,7,8] However, fibroma (including desmoid fibroma) may be present as a hypointense signal on T2WI due to dense conglomerations of collagen bundles, which distinguish this lesion from nodular fasciitis.[6] Notably, mimic subcutaneous sarcoidosis presents as a mass-like

lesion and should be differentiated from nodular fasciitis. Sarcoidosis rarely involves the fascia and often has poorly defined margins, while nodular fasciitis is often related to the fascia and has well-defined margins.[21] Regarding contrast enhancement, early enhancement may be affected by high levels of cellularity and capillary density.[4] In our study, near half of the lesions exhibited rim enhancement, which may be related to the numerous capillaries at the periphery and few capillaries in the center or may be due to cystic or necrotic changes. In addition, lesions exhibiting obvious homogenous enhancement may be composed of cellular tissue, while lesions with no or slight enhancement may be due to myxoid changes.[14]

Several limitations should be emphasized. First, this investigation was a retrospective study conducted at a single center and may therefore have selection bias. Second, the number of patients was relatively small, and not all patients underwent contrast-enhanced MRI. Additionally, the imaging sequences were insufficient: diffusion-weighted imaging and other imaging modalities, such as computed tomography, X-rays and ultrasound, were not included in this study. Diffusion-weighted imaging may be helpful in differentiating muscle metastases from sarcomas or distinguishing malignant masses from benign soft tissue tumors, as previously reported[22,23]; thus, further evaluations of nodular fasciitis are needed. Moreover, a one-to-one correspondence between imaging and pathological specimens was not available.

5. Conclusions

Nodular fasciitis is characterized by some specific MR imaging features, particularly the four special imaging signs. The "fascia tail sign" and "cloud sign" might help differentiate nodular fasciitis from other soft tissue lesions. The new classification system may improve our understanding of nodular fasciitis.

Acknowledgments

The authors thank doctor Yeerfan for his encouragement and constructive suggestions, which helped a lot.

Author contributions

Conceptualization: Jin Zhao, Hai-Yan Chen, Yin-Yuan Zheng, Ri-Sheng Yu.
Data curation: Shi-Yong Wu, Jin Zhao, Hai-Yan Chen.
Formal analysis: Shi-Yong Wu, Yin-Yuan Zheng.
Investigation: Hai-Yan Chen, Miao-Miao Hu, Ji-Kang Min.
Methodology: Hai-Yan Chen, Miao-Miao Hu, Ji-Kang Min.
Project administration: Ji-Kang Min.
Resources: Miao-Miao Hu, Yin-Yuan Zheng, Ji-Kang Min, Ri-Sheng Yu.
Software: Miao-Miao Hu.
Supervision: Shi-Yong Wu, Jin Zhao, Ri-Sheng Yu.
Visualization: Ri-Sheng Yu.
Writing – original draft: Shi-Yong Wu, Hai-Yan Chen.
Writing – review & editing: Jin Zhao, Hai-Yan Chen.

References

[1] Erber R, Agaimy A. Misses and near misses in diagnosing nodular fasciitis and morphologically related reactive myofibroblastic proliferations: experience of a referral center with emphasis on frequency of USP6 gene rearrangements. Virchows Arch 2018;473:351–60.
[2] Allison DB, Wakely PEJr, Siddiqui MT, et al. Nodular fasciitis: a frequent diagnostic pitfall on fine-needle aspiration. Cancer Cytopathol 2017; 125:20–9.
[3] Fletcher CDM, Bridge JA, Hogendoorn PCW, et al. WHO Classification of tumours of soft tissue and bone. Pathology and genetics of tumours of soft tissue and bone. 4th edLyon, France: IARC Press; 2013.
[4] Wang XL, De Schepper AM, Vanhoenacker F, et al. Nodular fasciitis: correlation of MRI findings and histopathology. Skeletal Radiol 2002; 31:155–61.
[5] Hu PA, Zhou ZR. Imaging findings of radiologically misdiagnosed nodular fasciitis. Acta Radiol 2018;60:663–9.
[6] Dinauer PA, Brixey CJ, Moncur JT, et al. Pathologic and MR imaging features of benign fibrous soft-tissue tumors in adults. RadioGraphics 2007;27:173–87.
[7] Leung LY, Shu SJ, Chan AC, et al. Nodular fasciitis: MRI appearance and literature review. Skeletal Radiol 2002;31:9–13.
[8] Coyle J, White LM, Dickson B, et al. MRI characteristics of nodular fasciitis of the musculoskeletal system. Skeletal Radiol 2013;42: 975–82.
[9] Morgen EK, Carter P, Weinreb I, et al. Immunohistochemistry in nodular fasciitis of the head and neck. Pathology 2013;45: 432–3.
[10] Hseu A, Watters K, Perez-Atayde A, et al. Pediatric nodular fasciitis in the head and neck: evaluation and management. JAMA Otolaryngol Head Neck Surg 2015;141:54–9.
[11] Jin YH, Hwan HS, Yusuhn K, et al. MR imaging of myxofibrosarcoma and undifferentiated sarcoma with emphasis on tail sign; diagnostic and prognostic value. Eur Radiol 2014;24:1749–57.
[12] Kaya M, Wada T, Nagoya S, et al. MRI and histological evaluation of the infiltrative growth pattern of myxofibrosarcoma. Skeletal Radiol 2008; 37:1085–90.
[13] Lefkowitz RA, Landa J, Hwang S, et al. Myxofibrosarcoma: prevalence and diagnostic value of the "tail sign" on magnetic resonance imaging. Skeletal Radiol 2013;42:809–18.
[14] Lu L, Lao IW, Liu X, et al. Nodular fasciitis: a retrospective study of 272 cases from China with clinicopathologic and radiologic correlation. Ann Diagn Pathol 2015;19:180–5.
[15] Shimizu TK, Gibbs P, Orrison S, et al. Nodular fasciitis of the breast. Breast J 2020;26:1054–5.
[16] Maloney N, LeBlanc RE, Sriharan A, et al. Superficial nodular fasciitis with atypical presentations: report of 3 cases and review of recent molecular genetics. Am J Dermatopathol 2019;41:931–6.
[17] Gan S, Xie D, Dai H, et al. Proliferative myositis and nodular fasciitis: a retrospective study with clinicopathologic and radiologic correlation. Int J Clin Exp Pathol 2019;12:4319–28.
[18] Rankin G, Kuschner S, Gellman H. Nodular fasciitis: a rapidly growing tumor of the hand. J Hand Surg Am 1991;16:791–5.
[19] Khuu A, Yablon CM, Jacobson JA, et al. Nodular fasciitis: characteristic imaging features on sonography and magnetic resonance imaging. Journal of ultrasound in medicine: official journal of the American Institute of Ultrasound in Medicine 2014;33:565–73.
[20] Liu P, Thorner P. MRI of fibromatosis: with pathologic correlation. Pediatr Radiol 1992;22:587–9.
[21] Ruangchaijatuporn T, Chang EY, Chung CB. Solitary subcutaneous sarcoidosis with massive chronic prepatellar bursal involvement. Skeletal Radiol 2016;45:1741–5.
[22] Razek A, Nada N, Ghaniem M, et al. Assessment of soft tissue tumours of the extremities with diffusion echoplanar MR imaging. La Radiologia medica 2012;117:96–101.
[23] Surov A, Nagata S, Razek AA, et al. Comparison of ADC values in different malignancies of the skeletal musculature: a multicentric analysis. Skeletal Radiol 2015;44:995–1000.