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Association of Magnetic Resonance Imaging Features with Angioleiomyoma Histologic Subtype

Yasuyuki Kitagawa[1], Yoshihiro Sudo[2], Ryu Tsunoda[2], Mitsuhiko Nanno[2], Satoru Arai[3] and Shinro Takai[1]

[1]Department of Orthopaedic Surgery, Nippon Medical School, Tokyo, Japan
[2]Department of Orthopaedic Surgery, Nippon Medical School Tama Nagayama Hospital, Tokyo, Japan
[3]Department of Pathology, Nippon Medical School Tama Nagayama Hospital, Tokyo, Japan

Background: Angioleiomyomas typically present as small, painful, soft-tissue tumors less than 2 cm in diameter. The features of angioleiomyomas on magnetic resonance (MR) imaging are not well understood, and the association of MR findings with histologic subtype is unclear. In the present study, the MR features of angioleiomyomas of average size were compared in relation to histologic subtype.

Methods: This retrospective review of medical records analyzed MR imaging data and histologic specimens from 18 consecutive patients with angioleiomyomas that were resected at our hospital during the period from January 2006 through December 2013.

Results: On T1-weighted images, lesions exhibited homogeneous areas that were isointense with skeletal muscle. However, T2-weighted images of solid and venous angioleiomyomas showed heterogeneous areas that were isointense or slightly hyperintense, while cavernous angioleiomyomas exhibited hyperintensity. Most lesions had a hypointense rim, and two thirds had adjacent vessels.

Conclusions: Our results suggest that MR findings for angioleiomyoma vary in relation to histologic subtype. T2-weighted images of solid and venous angioleiomyomas yielded specific MR findings that allowed for differentiation from other soft-tissue tumors, such as soft-tissue sarcomas. Most of these tumors exhibited isointense to slightly hyperintense regions, as compared with skeletal muscle, while findings for cavernous angioleiomyomas were nonspecific. Thus, clinical findings and MR imaging were almost sufficient for preoperative diagnosis of solid and venous angioleiomyomas.

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Key words: angioleiomyoma, magnetic resonance imaging, histologic subtype, signal intensities

Introduction

Angioleiomyomas are relatively rare, frequently painful, soft tissue tumors that most often occur in the lower extremities of women; many angioleiomyomas are less than 2 cm in diameter[1]. Angioleiomyomas were previously classified as a smooth muscle tumor but were reclassified as a pericytic (perivascular) tumor in the 2013 classification of the World Health Organization. Histologically, angioleiomyomas are composed of smooth muscle cells proliferating around blood vessels and are classified as solid, venous, and cavernous on the basis of differences in the growth modes of blood vessels and smooth muscle cells[1,2]. The prevalence of pain, by tumor type, is 70%, 37%, and 30%, respectively[1].

Angioleiomyomas are difficult to diagnose preoperatively and may not be recognized as the cause of pain for some time, because pain severity is disproportionate to tumor size[3]. Clinical findings are usually insufficient for differentiating angioleiomyomas from other painful soft tissue tumors[4]. Some studies of magnetic resonance (MR) imaging describe MR findings for angioleiomyoma as nonspecific, namely, homogeneous isointense signals on

Correspondence to Yasuyuki Kitagawa, MD, Department of Orthopaedic Surgery, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: kitayasu@nms.ac.jp
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T1-weighted images and heterogeneous iso- to hyperintense signals on T2-weighted images. Several other features of angioleiomyomas on MR images have been reported; however, only a few lesions were assessed in those studies, and most of the lesions were larger than average[5–8]. Moreover, only a few reports have focused on MR imaging features in relation to histologic subtype.

In the present study, MR images of angioleiomyomas of average size[1] were compared in relation to histologic subtype.

Materials and Methods

This retrospective study was approved by our institutional review board (No. 608) and was conducted in accordance with the principles of the Declaration of Helsinki. This retrospective review of consecutive patients with angioleiomyomas analyzed medical records, MR imaging data, and histologic specimens in the orthopedics department of a university hospital where one of the authors practices.

Patients

Twenty-four angioleiomyomas of 24 patients were resected at a university hospital during the period from January 2006 through December 2013. Six lesions were excluded: 2 because the patients had not undergone preoperative MR imaging, 2 that could not be compared with skeletal muscle on MR images because no skeletal muscle was present on the images, and 2 for which preoperative MR images were unavailable. Ultimately, lesions from 18 patients were analyzed.

MR Imaging

All lesions were examined, at various hospitals, by MR imaging on a 1.5-T unit. Field of view varied from 16 to 37 cm, slice thicknesses from 2 to 5 mm, and slice gap from 0.3 to 5.5 cm. Matrices of 179-512 × 256-528 were used. Axial and either sagittal or coronal images were obtained for 11 lesions, coronal and sagittal images for 3 lesions, and all 3 image types for 4 lesions. Both T1-weighted spin-echo imaging [pulse sequences: 398-895/9-20 (TR/TE)] and T2-weighted spin-echo or fast spin-echo imaging [pulse sequences: 2,530-4,800/60-105 (TR/TE)] were performed for all lesions. A fat suppression technique was used for all lesions, including a short T1 inversion recovery technique for 8 lesions and a spectral presaturation with inversion recovery technique for 4 lesions.

MR Image Analysis

One of the authors (Y.K.) analyzed the MR imaging features, namely, signal intensity, heterogeneity, enhancement, rim hypointensity, and adjacent vessels. The signal intensities of the lesions were compared with those of skeletal muscle. Enhancement effects were assessed by comparing post-contrast and pre-contrast images. The findings for all MR images were analyzed and compared with histologic findings.

Histologic Analysis

Histologic slides were available for all lesions. The histologic subtype of the lesions was classified as solid, venous, and cavernous[2,9]. When heterogeneity was present on MR images, the main tissue structure that caused the heterogeneity was further examined.

Results

The clinical features of the patients are shown in **Table 1**. The patients comprised 5 men and 13 women (median age, 38 years; range, 31-70 years). Fourteen lesions were present in the lower extremities and 4 were in the upper extremities. The median long diameter of the tumors was 1.2 cm (range, 0.3-2.4 cm). Almost all patients (n = 17) reported pain, and the median duration of preoperative pain was 24 months (range, 1-180 months).

MR images and histologic findings are shown in **Table 2**. The lesions were oval in 13 patients and round in 5 patients. On T1-weighted images, lesions had homogeneous areas that were isointense with skeletal muscle (**Fig. 1〜3**). However, T2-weighted images showed heterogeneous areas that were isointense, slightly hyperintense or hyperintense. Most lesions had a hypointense rim, and two thirds had adjacent vessels. Areas of heterogeneity on MR images corresponded histologically to vascularization, fibrosis, thrombus, or calcification. Analysis of histologic subtype revealed 11 solid, 2 venous, and 5 cavernous tumors (**Fig. 1〜3**). On T2-weighted images, solid (**Fig. 1**) and venous (**Fig. 2**) tumors were heterogeneous and had isointense or slightly hyperintense areas, while all cavernous (**Fig. 3**) tumors exhibited hyperintensity. Contrast-enhanced MRI was performed for 2 solid, 2 venous, and 2 cavernous tumors. All but 1 lesion showed contrast enhancement in almost the entire area; 1 lesion showed contrast effects in only the peripheral area.

Histologic examination revealed calcification in 1 lesion, which was also detected by plain radiography (Patient 11). No lesion exhibited intratumoral bleeding on histologic examination. Histologic subtype was not associated with the presence of pain.

Discussion

The most important finding of this study is that all but 1

Table 1 Clinical characteristics of patients

Pt	Age	Sex	Location	Lesion depth	Long diameter (cm)	Pain	Tenderness	Duration of symptoms (months)	MR diagnosis (suggested)
1	36	M	Heel	Subc.	1.2	+	+	36	Fibroma
2	45	F	Forearm	Subc.	0.3	+	+	48	—
3	65	F	Ankle	Subc.	0.8	-	+	7	—
4	33	F	Forearm	Subc.	1.5	+	+	6	Fibrous tumor
5	70	F	Toe	Subc.	0.5	-	+	12	—
6	63	F	Elbow	Subc.	0.6	+	+	12	Fibroma
7	32	F	Foot	Subc.	1.2	+	+	180	Fibrous tumor
8	33	M	Sole	Subc.	1.4	-	-	—	Hemangioma/Neurogenic tumor
9	44	F	Foot	Subc.	0.9	+	+	24	Fibrous tumor
10	37	F	Knee	Subc.	0.4	+	+	13	Epidermal cyst
11	60	F	Foot	Subf.	1.7	-	+	120	Giant cell tumor of tendon sheath/ Fibrous tumor
12	68	F	Thigh	Subc.	1.5	+	+	30	Neurogenic tumor
13	47	M	Ankle	Subf.	1.1	+	+	24	—
14	31	F	Foot	Subc.	0.7	+	-	30	Hemangioma
15	63	F	Thigh	Subc.	2.0	-	+	180	—
16	38	F	Leg	Subc.	0.6	+	+	12	—
17	37	M	Knee	Subc.	1.8	-	+	24	—
18	38	M	Hand	Intram.	2.4	+	+	1	Neurogenic tumor

Pt, patient; MR, magnetic resonance; subc., subcutaneous; subf., subfascial; intram, intramuscular

Table 2 MRI and histologic findings

Pt	Shape	MRI findings							Histologic findings	
		T1-weighted image		T2-weighted image		Enhancement	H rim	Adjacent vessel	Tissue for heterogeneity	Subtype
		SI	Heterogeneity	SI	Heterogeneity					
1	Oval	SH	+ (Lower SIA)	SH	+ (Lower SIA)	ND	+	-	Vessels	Solid
2	Oval	I	-	SH	+ (Lower SIA)	ND	+	+	Vessels	Solid
3	Oval	I	+ (Lower SIA)	SH	-	ND	-	+		Solid
4	Oval	I	-	I	+ (Hyper SIA)	ND	+	+	Vessels	Solid
5	Round	I	-	SH	+ (Lower SIA)	ND	+	-	Fibrosis	Solid
6	Round	I	-	I	-	+ (diffuse)	+	+		Solid
7	Oval	I	+ (Lower SIA)	SH	+ (Hyper SIA)	ND	+	+	Vessels	Solid
8	Oval	SH	-	SH	+ (Hyper SIA)	ND	+	+	Vessels	Solid
9	Oval	I	-	SH	+ (Lower SIA)	ND	+	-	Vessels and fibrosis	Solid
10	Round	SH	-	SH	-	ND	+	+		Solid
11	Round	I	+ (lower SIA)	SH	+ (Lower SIA)	+ (peripheral)	-	+	Calcification and fibrosis	Solid
12	Round	I	-	SH	+ (Lower SIA)	+ (diffuse)	+	+	Fibrosis	Venous
13	Oval	SH	-	SH	+ (Lower SIA)	+ (diffuse)	+	+	Fibrosis	Venous
14	Oval	I	-	H	-	+ (diffuse)	+	-		Cavernous
15	Oval	I	+ (Lower SIA)	H	+ (Lower SIA)	ND	+	-	Fibrosis	Cavernous
16	Oval	I	-	H	+ (Lower SIA)	ND	+	+	Fibrosis	Cavernous
17	Oval	I	-	H	+ (Lower SIA)	ND	+	+	Fibrosis	Cavernous
18	Oval	I	-	H	+ (Lower SIA)	+ (C & P)	+	-	Thrombus	Cavernous

Pt, patient; H rim, hypointense rim; SI, signal intensity; SH, slightly high; SIA, signal intensity area; I, iso; H, high; C & P, central and peripheral; ND, not done.

angioleiomyoma of average size had specific MR imaging features, ie, isointense to slightly hyperintense signals on T2-weighted images. The exception was a cavernous angioleiomyoma, which has a reported prevalence of 11%, as compared with a prevalence of 66% for solid tumors and 23% for venous tumors[1]. Studies of the MR imaging features of angioleiomyomas consistently report nonspecific signal intensities; however, some unique fea-

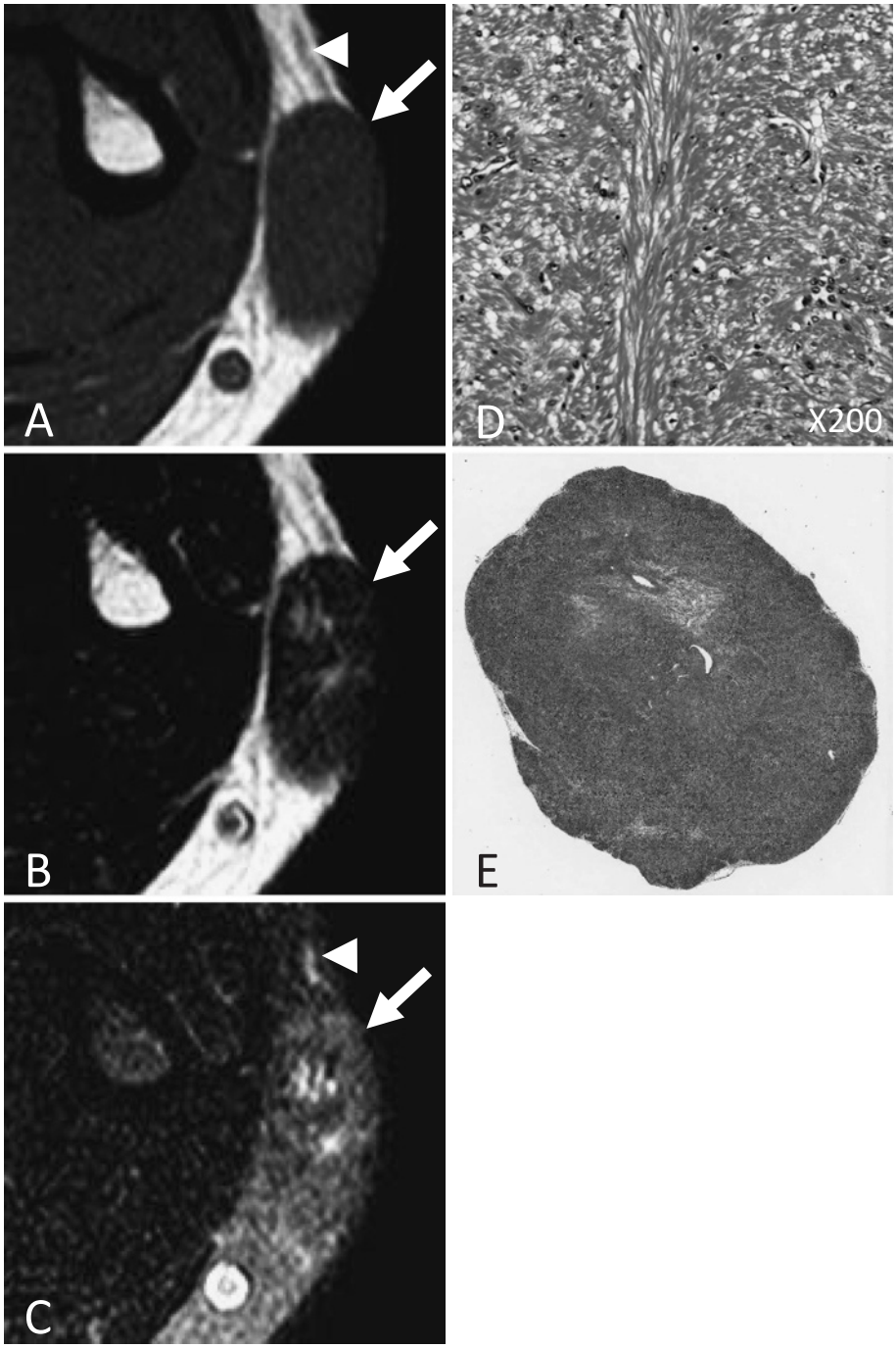

Fig. 1 Magnetic resonance and histologic findings for a solid angioleiomyoma.
A: Lesion showing isointensity, as compared with skeletal muscle, on a T1-weighted image (arrow). Lesion with an adjacent vessel (arrowhead).
B: Lesion showing isointensity, as compared with skeletal muscle, and heterogeneity on a T2-weighted image (arrow).
C: Lesion showing heterogeneous hyperintensity on a T2-weighted image with fat suppression (arrow). Lesion with an adjacent vessel (arrowhead).
D: Solid tumor containing densely packed smooth muscle cells with slit-like vascular channels (HE, ×200).
E: Macroscopic specimen stained with HE.

tures have been identified, namely, mixed hyperintense and isointense areas, as compared with skeletal muscle, on T2-weighted images, a hypointense rim[7], multiple hyperintense linear or branching areas[6], curvilinear structures of low signal intensity on T1-weighted images (corresponding to vascular structures)[8], and adjacent tortuous

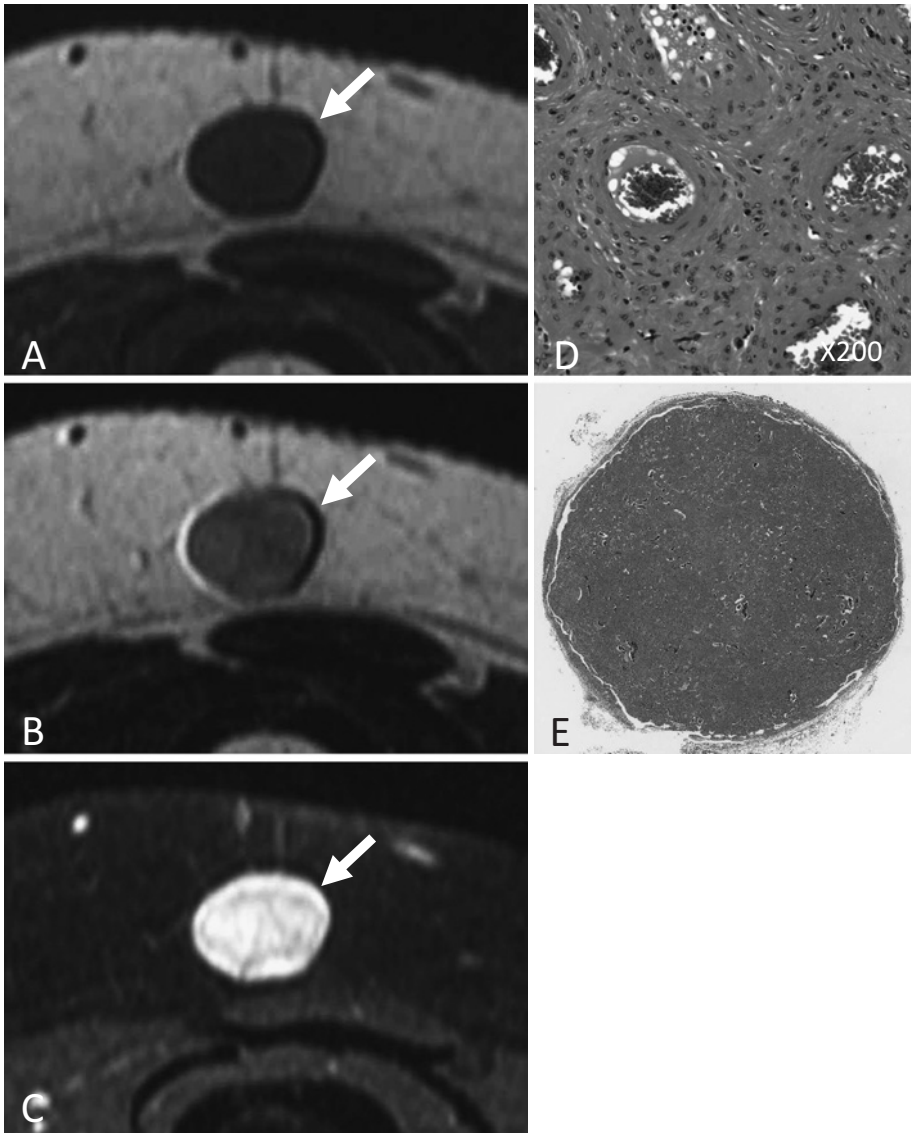

Fig. 2 Magnetic resonance and histologic findings of a venous angioleiomyoma.
A: Lesion showing isointensity, as compared with skeletal muscle, on a T1-weighted image (arrow).
B: Lesion showing slight hyperintensity, as compared with skeletal muscle, and heterogeneity on a T2-weighted image (arrow).
C: Lesion showing diffuse enhancement after gadolinium administration on a T1-weighted image with fat suppression (arrow).
D: Venous tumor showing thick muscle-coated vascular elements and smooth muscle (HE, ×200).
E: Macroscopic specimen stained with HE.

vascular structures[5]. These studies mostly examined larger and deeper lesions. The present lesions measured 0.3-2.4 cm (median 1.2 cm), as compared with 1.5-2.6 cm (median, 2.1 cm) and 2.2-8.5 cm (median not reported) in previous reports[5,6]. MR findings such as T1 and T2 signal intensity, contrast enhancement, and heterogeneity of angioleiomyomas in the present study were consistent with those of previous reports. The present results suggest that MR findings of angioleiomyoma vary in relation to histologic subtype.

In the present study, contrast enhancement was observed in all 6 lesions examined, which was consistent with previous findings. All lesions except 1 solid lesion showed contrast enhancement in almost the entire area. In previous reports, the pattern of contrast enhancement varied, and no association with tissue subtype has been reported.

Pain is an important symptom in diagnosing angioleio-

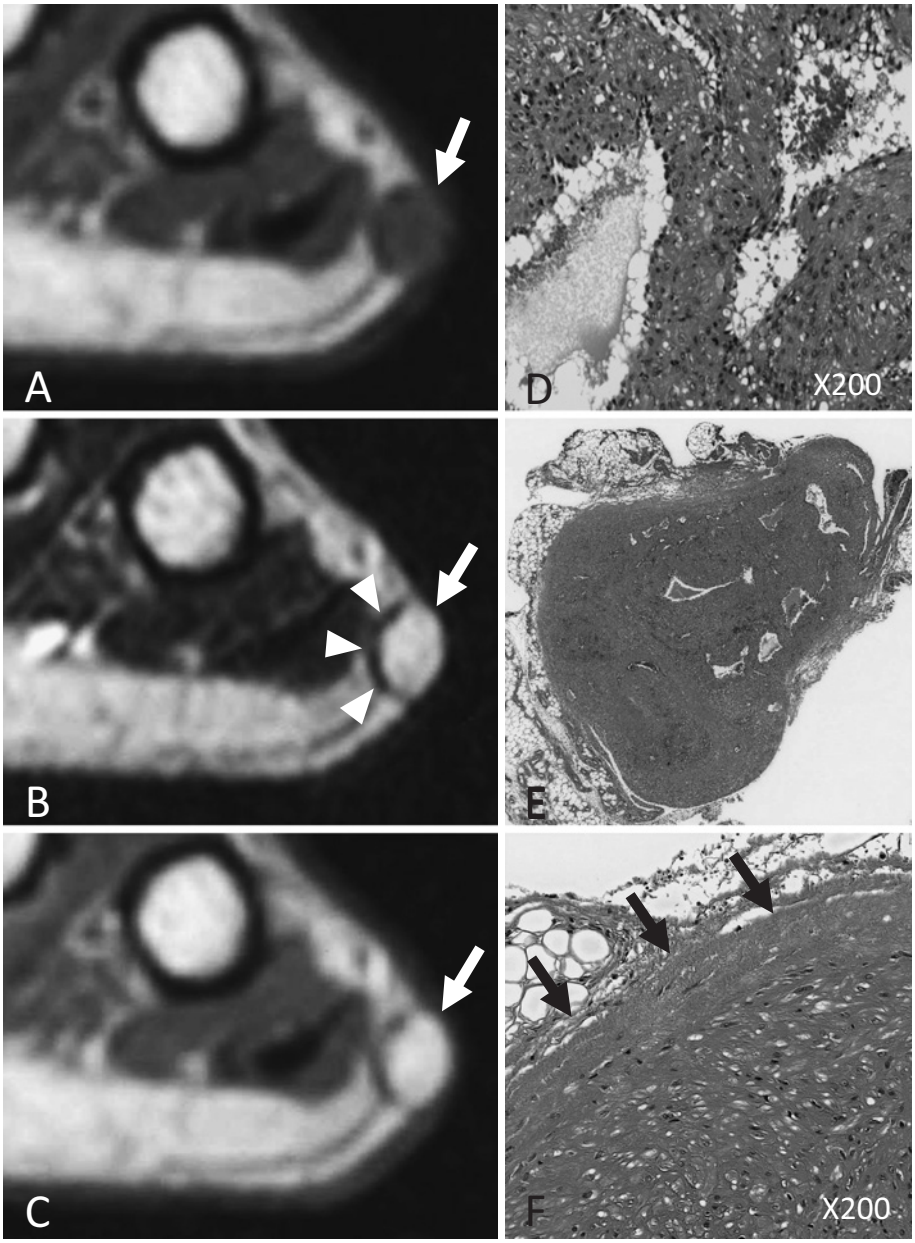

Fig. 3 Magnetic resonance and histologic findings for a cavernous angioleiomyoma.
A: Lesion showing isointensity, as compared with skeletal muscle, on a T1-weighted image (arrow).
B: Lesion showing hyperintensity, as compared with skeletal muscle, on a T2-weighted image (arrow) and a peripheral hypointense rim (arrowheads).
C: Lesion showing diffuse enhancement after gadolinium administration on a T1-weighted image (arrow).
D: Cavernous tumor exhibiting dilated vascular channels with thin walls (HE, ×200).
E. Macroscopic specimen stained with HE.
F: Photomicrograph showing a fibrous capsule corresponding to the peripheral rim shown on MRI (arrows) (HE, ×200).

myomas. In the present study, 17 of the 18 patients reported pain or tenderness. In a study of 562 angioleiomyomas[1], 58% of patients experienced pain. The incidence of pain, by histologic subtype, was 70%, 30%, and 37% for solid, cavernous, and venous tumors, respectively[1]. Pain caused by angioleiomyomas is considered to be mediated by nerve fibers in the tumor parenchyma[1,10].

Painful, small, soft tissue tumors that must be clinically differentiated from angioleiomyomas include angiolipomas, schwannomas, neuromas, glomus tumors, eccrine spiradenomas, and synovial sarcomas. Although these tumors exhibit specific clinical features, imaging is impor-

tant for diagnosis in atypical cases. The principal MR imaging feature of angiolipoma is the presence of a fatty tumor[11], while 90% of schwannomas exhibit a target sign[12]. Neuromas, glomus tumors, eccrine spiradenomas, and synovial sarcomas show nonspecific hypointense signals on T1-weighted images and hyperintense signals on T2-weighted images[13–15].

The proportion of angioleiomyomas with calcification is only about 1.7%[2]. In addition, calcification is present in many benign and malignant tumors and thus is not evidence for a diagnosis of angioleiomyoma. In the present study, calcification was present in 1 lesion.

This study was retrospective and therefore has limitations. The MR imaging procedure was different for each lesion. Image analysis was done by nonblinded examiners who were aware of the angioleiomyoma diagnosis. Moreover, the histologic specimens used for histologic comparison did not always have planes identical to those of the MR images.

In conclusion, our results suggest that MR findings for angioleiomyoma vary by histologic subtype. T2-weighted images of solid and venous angioleiomyomas yielded specific MR findings that allowed those tumors to be differentiated from other soft tissue tumors. MR images usually showed isointense to slightly hyperintense signals, as compared with skeletal muscle, while cavernous tumors exhibited nonspecific findings. Thus, it might be possible to preoperatively diagnose solid and venous angioleiomyomas by using clinical findings and MR images.

Conflict of Interest: The authors declare no conflicts of interest. The study received no external funding.

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