Association of Magnetic Resonance Imaging Features with Angioleiomyoma Histologic Subtype

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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 diameter1. 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 cells2. The prevalence of pain, by tumor type, is 70%, 37%, and 30%, respectively3.

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 size4. Clinical findings are usually insufficient for differentiating angioleiomyomas from other painful soft tissue tumors4. Some studies of magnetic resonance (MR) imaging describe MR findings for angioleiomyoma as nonspecific, namely, homogeneous isointense signals on
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. 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 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. 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). 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
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 been reported to have the highest MR prevalence of cavernous tumors, with a reported prevalence of 41% to 11%, as compared with a prevalence of 66% for solid tumors and 23% for venous tumors. Studies of the MR imaging features of angioleiomyomas consistently report nonspecific signal intensities; however, some unique features of angioleiomyomas consistently report isointense to slightly hyperintense signals on T2-weighted imaging features, which is consistent with the report of specific MR imaging features of angioleiomyomas consistently report isointense to slightly hyperintense signals on T2-weighted images. The exception was a cavernous angioleiomyoma, which has been reported to have the highest MR prevalence of cavernous tumors, with a reported prevalence of cavernous tumors, with a reported prevalence of 41% to 11%, as compared with a prevalence of 66% for solid tumors and 23% for venous tumors. Studies of the MR imaging features of angioleiomyomas consistently report nonspecific signal intensities; however, some unique fea-
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.

Fig. 1

tures have been identified, namely, mixed hyperintense and isointense areas, as compared with skeletal muscle, on T2-weighted images, a hypointense rim, multiple hyperintense linear or branching areas, curvilinear structures of low signal intensity on T1-weighted images (corresponding to vascular structures), and adjacent tortuous
vascular structures. 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. 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 angioleiomyoma.
myomas. In the present study, 17 of the 18 patients reported pain or tenderness. In a study of 562 angioleiomyomas, 58% of patients experienced pain. The incidence of pain, by histologic subtype, was 70%, 30%, and 37% for solid, cavernous, and venous tumors, respectively. Pain caused by angioleiomyomas is considered to be mediated by nerve fibers in the tumor parenchyma.

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\(^1\), while 90% of schwannomas exhibit a target sign\(^2\). Neuromas, glomus tumors, eccrine spiradenomas, and synovial sarcomas show nonspecific hypointense signals on T1-weighted images and hyperintense signals on T2-weighted images\(^3\-\(^15\).\)

The proportion of angioleiomyomas with calcification is only about 1.7\%.\(^1\) 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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