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ARTICLE

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MRI findings in intramuscular lipomas

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Abstract *Objective*. To investigate the spectrum of magnetic resonance (MR) findings of intramuscular lipoma.
Design and patients. A retrospective review of 17 consecutive cases of intramuscular lipoma examined with MR imaging was undertaken. Features assessed included the size and margin of the mass; the homogeneity of the contents, including the presence or absence of intermingled muscle fibers; whether the mass was uninodular or multinodular; and the presence of linear structures between and within the tumor nodules. Three well-differentiated liposarcomas and one dedifferentiated liposarcoma associated with lipoma-like components were also studied to allow a comparison of the benign and malignant lesions.
Results. The diameter of the intramuscular lipomas varied from less than 3 cm to more than 10 cm. Ten of the intramuscular lipomas were homogeneous but the remaining seven were inhomogeneous with intermingled muscle fibers within the mass. The intramuscular lipomas were well defined in 12 cases, and infiltrative in five. In one case the margin of the lesion showed prominent infiltration of the surrounding muscle tissue. Of the 17 cases of intramuscular lipoma, 15 were composed of a single nodule, whereas three of four cases of liposarcoma were composed of multinodular masses.
Conclusion. The MR findings of intramuscular lipoma varied from a small, single and homogeneous mass identical to ordinary (superficial) lipoma, to a large, inhomogeneous lesion with an infiltrative margin. The presence of infiltrative margins and intermingled muscle fibers in intramuscular lipoma indicates a benign lesion rather than malignancy. In addition, uninodularity of the mass is helpful in differentiating intramuscular lipoma from well-differentiated liposarcoma.

Key words Intramuscular lipoma · Liposarcoma · Malignant soft tissue tumors · MRI

Introduction

Magnetic resonance (MR) imaging is useful in distinguishing fat-containing tumors from other types of soft tissue tumors. Many studies have discussed the MR findings of liposarcomas and lipomas at various sites [1–11]. However, to the best of our knowledge the appearances of intramuscular lipoma have not been reported independently or extensively, being documented only in comparison with the findings of liposarcoma or as individual case reports [2, 3, 8]. The variety of MR findings of intramuscular lipoma have also not been elucidated fully. We therefore studied the spectrum of MR findings of a series of intramuscular lipomas, and examined whether or not these findings contribute to the differentiation between benign and malignant lesions.

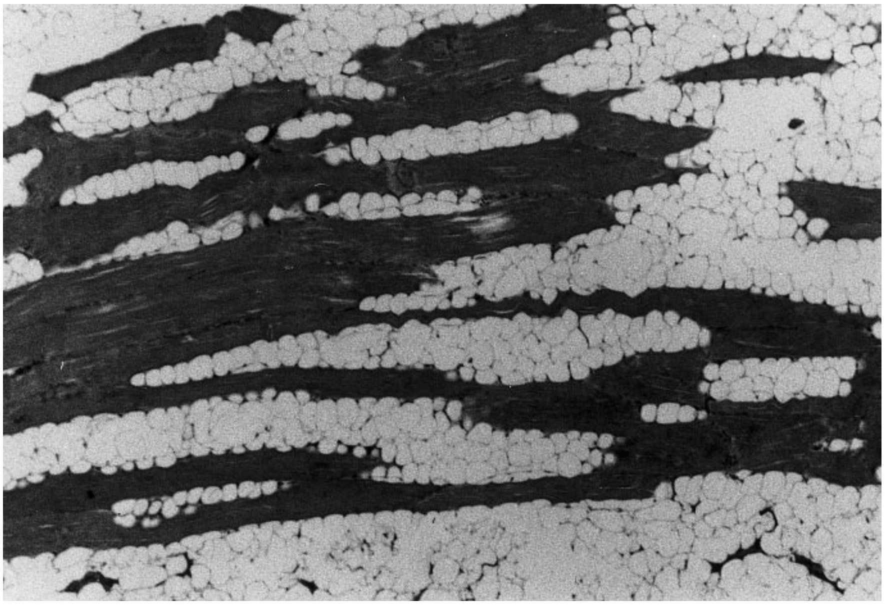


Fig. 1 Histological appearance of the infiltrative type of intramuscular lipoma. Longitudinal section showing the striated appearance of the muscle fibers caused by the proliferation of fat cells (hematoxylin & eosin)

Materials and methods

From 1989 to 1997, 17 intramuscular lipomas that had been studied preoperatively with MR imaging were excised in our institution. There were 5 male and 12 female patients with an age range of 15–71 years (mean age 48 years). The sites of the tumor included the lower extremities in 10 cases, upper extremities in three cases and neck/trunk in four cases. Histological confirmation of intramuscular lipoma was available in all cases, and the tumors classified into the well-circumscribed type in five cases and the infiltrative type (Fig. 1) in 12 cases according to the classification of Fletcher and Martin-Bates [12].

Three cases of well-differentiated liposarcoma (atypical lipoma) and one case of dedifferentiated liposarcoma with lipoma-like portions were also examined to identify whether these MR findings were specific to intramuscular lipoma. Two men and one woman had well-differentiated liposarcomas situated in the thigh (n=2) and upper arm (n=1); their age range was 36–82 years (mean age 61 years). The dedifferentiated liposarcoma was resected from the thigh of a 77-year-old man.

MR images were obtained with several systems: seven, including two cases of liposarcoma, were imaged with a 1.5-T system, and 14 cases, including two cases of liposarcoma, with a 0.5-T system, depending on the institution where MR imaging was performed. The imaging protocols varied, but usually scanning sequences included T1-weighted spin-echo (TR 450–600/TE 9–25) and T2-weighted (TR 2000–5542/TE 80–120) pulse sequences in at least two planes. Section thickness varied from 4 to 10 mm. Fat-suppressed images were obtained in 10 of 17 cases of intramuscular lipoma and in all four cases of liposarcoma. Enhancement with gadolinium-DTPA was performed in seven of 17 cases of intramuscular lipoma and three of four cases of liposarcoma to determine the vascularity of the tumor. Fat-suppressed T1-weighted images after injection of contrast medium were obtained in five of 17 cases of intramuscular lipoma and three of four cases of liposarcoma.

MR findings were recorded by two of the authors (K.M., M.I.) independently. In the case of differences between the two readers, secondary consensus was adopted. The characteristic MR signal intensity of the tumor was evaluated on both T1- and T2-weighted images as isointense with skeletal muscle in the normal portion and isointense with subcutaneous fat. The following findings were especially noted:

1. *Mass size and shape*. The lesions varied from ovoid to irregularly polygonal. The mass size was measured on the MR images using an average of at least two measurements, and diameter graded as follows: less than 3 cm, 3–5 cm, 5–10 cm, 10–15 cm, and greater than 15 cm.
2. *Homogeneity of the lesion*. Intermingled muscle fibers are frequently observed in intramuscular lipoma. The lesion was described as homogeneous when it was composed of pure fatty mass except for linear structures, while it was described as inhomogeneous when the mass was composed of intermingled massive muscle fibers or other types of tumor tissue. Intermingled muscle fibers were identified when the tissue within the mass showed a signal intensity equal to normal muscle on both T1- and T2-weighted images.
3. *Tumor margin*. The margin was described as well defined when the entire lesion was sharply demarcated. An infiltrative margin was recorded when the neoplastic fatty tissue infiltrated the surrounding muscle tissue at any point.
4. *Single mass or multinodular mass*. A lesion with no daughter nodules was defined as a single mass independent of its size and shape. A mass associated with fatty tissue infiltrating the surrounding muscle was also considered single due to a lack of daughter tumor formation. The term multinodular mass was used to refer to tumors composed of many daughter nodules or lobules. A lesion that had a number of interrelated tumor masses was also defined as multinodular.
5. *Presence or absence of linear structures between and within the nodule*. The linear structures were described as thick (more than 2 mm) or thin (less than 2 mm). They were also divided into two categories based on their relationship with the tumor nodule: septum-like structures separating the tumor nodules and linear structures within the nodules. Identified intermingled muscle fibers as defined in (2) were excluded from the definition of linear structures.

Results

The results are summarized in Table 1. The average diameter of the intramuscular lipomas was less than 3 cm in six

Table 1 MR findings in intramuscular lipoma and well-differentiated liposarcoma

Case No.	Size (cm)	Homogeneity of contents	Margin of the lesion	Linear structures within the nodules	Single or multinodular mass
Intramuscular lipomas					
1	<3	Intermingled	Infiltrating	–	Single
2	<3	Intermingled	Infiltrating	–	Single
3	10–15	Homogeneous	Infiltrating	Thick+	Binodular
4	<3	Homogeneous	Infiltrating	Thick+	Single
5	5–10	Intermingled	Infiltrating	–	Single
6	5–10	Homogeneous	Well-defined	–	Single
7	10–15	Homogeneous	Well-defined	Thick+, thin+	Single
8	<3	Homogeneous	Well-defined	–	Single
9	5–10	Intermingled	Infiltrating	–	Single
10	3–5	Homogeneous	Well-defined	–	Single
11	3–5	Homogeneous	Well-defined	–	Single
12	10–15	Homogeneous	Well-defined	Thick+, thin+	Single
13	3–5	Intermingled	Infiltrating	–	Single
14	5–10	Homogeneous	Well-defined	Thin+	Single
15	<3	Homogeneous	Well-defined	Thin+	Single
16	10–15	Homogeneous	Well-defined	Thick+, thin+	Binodular
17	<3	Homogeneous	Well-defined	–	Single
Liposarcomas					
18	14.6	Hmogeneous	Well-defined	Thick ++, thin +	Multinodular
19	5.4	Homogeneous	Well-defined	Thin +	Single
20	17.4	Inhomogeneous (other than muscle)	Well-defined	Thick +, thin +	Multinodular
21[a]	5.0	Inhomogeneous (other than muscle)	Infiltrating	–	Multinodular

Thick septum-like structures between the tumor nodules were identified in both intramuscular lipoma (case 3) and liposarcoma (cases 18, 20)

[a] Dedifferentiated liposarcoma

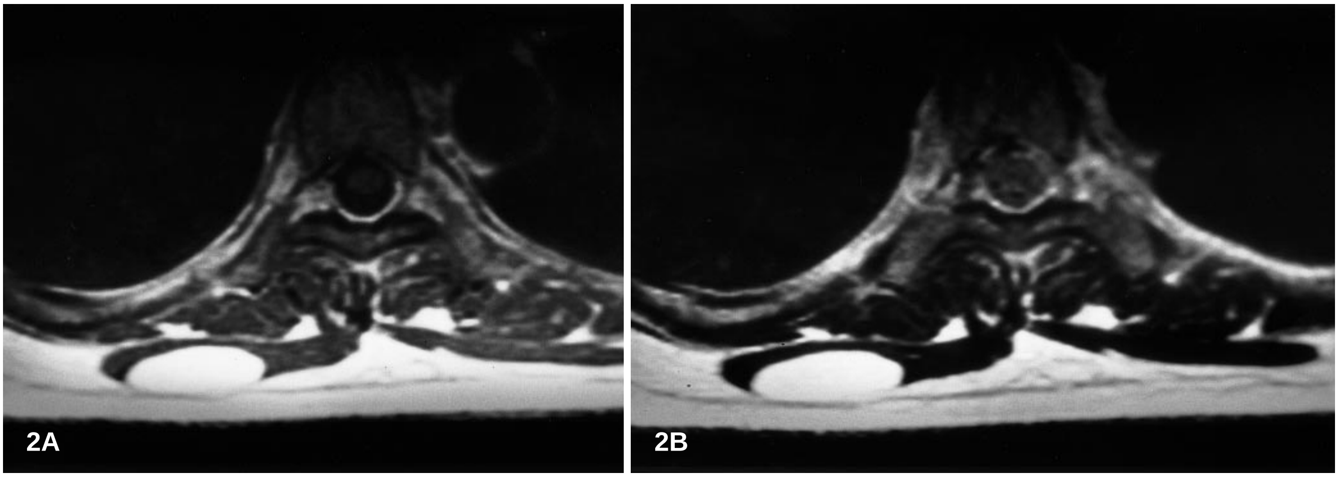
cases (35%), 3–5 cm in three, 5–10 cm in four, and 10–15 cm in four (23.5%). The average diameter of the liposarcomas was 5.0, 5.4, 14.6 and 17.4 cm, respectively.

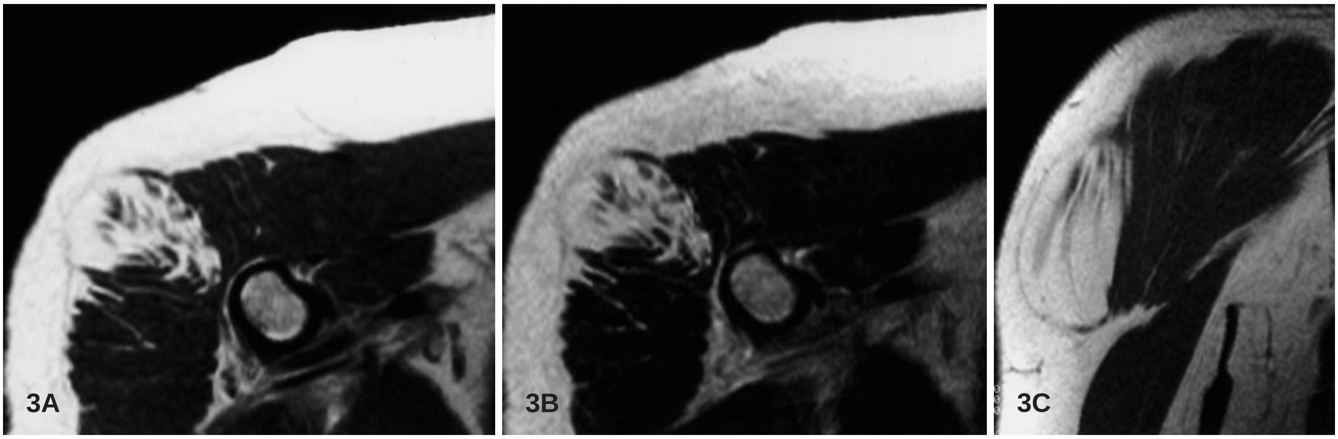
The fatty tissue in the intramuscular lipomas demonstrated high signal intensity on both T1- and T2-weighted images. Twelve cases of intramuscular lipoma were composed of homogeneously pure fatty tissue (Fig. 2), while five had intermingled fat and muscle fibers that were isointense with normal muscle on both T1- and T2-weighted images (Fig. 3). The MR findings of intermingled fat and muscle fibers do not correspond completely to the infiltrative type determined by histological findings. Two of three cases of well-differentiated liposarcoma were homogeneously composed of pure fatty tissue, whereas a small nodule that showed slightly low signal intensity on T1-weighted images and high signal intensity on T2-weighted images was present in one case (Fig. 4). Histological examination of the nodule also showed the feature of well-differentiated liposarcoma. The dedifferentiated liposarcoma was composed of both fatty tissue and another type of tumor tissue other than muscle fibers. The latter showed mixed high signal intensity and signal isointense with muscle on T1-weighted images, and high signal intensity on T2-weighted images. It was unevenly well enhanced after injection of gadolinium-DTPA. This enhanced portion corresponded to the dedifferentiated foci on histological examination.

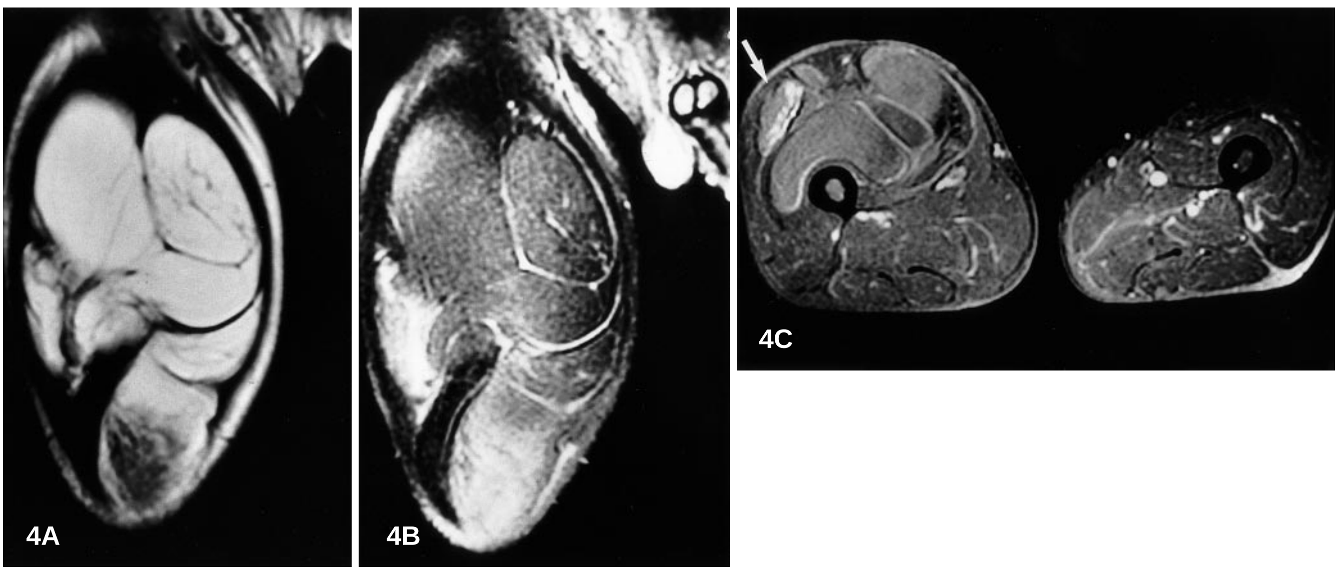
An infiltrative margin was observed in seven of 17 cases of intramuscular lipoma. These seven cases included the five lesions that were composed of intermingled fat and muscle fibers. The infiltrative margin was particularly prominent in the surrounding muscle tissue in one case (Fig. 5). Two lesions were composed of homogeneous fatty tissue with infiltrative margins. Well-defined margins were observed in 10 cases of intramuscular lipoma and in all three cases of well-differentiated liposarcoma. In the dedifferentiated liposarcoma the lipoma-like component had a well-defined margin, whereas the dedifferentiated portion showed an infiltrative margin.

There were only two cases of binodular intramuscular lipoma (Fig. 6), while the remaining 15 cases were uninodular. Three of four cases of liposarcoma, including the dedifferentiated liposarcoma, were multinodular masses, and the shape of these nodules was almost ovoid. Only one well-differentiated liposarcoma was uninodular.

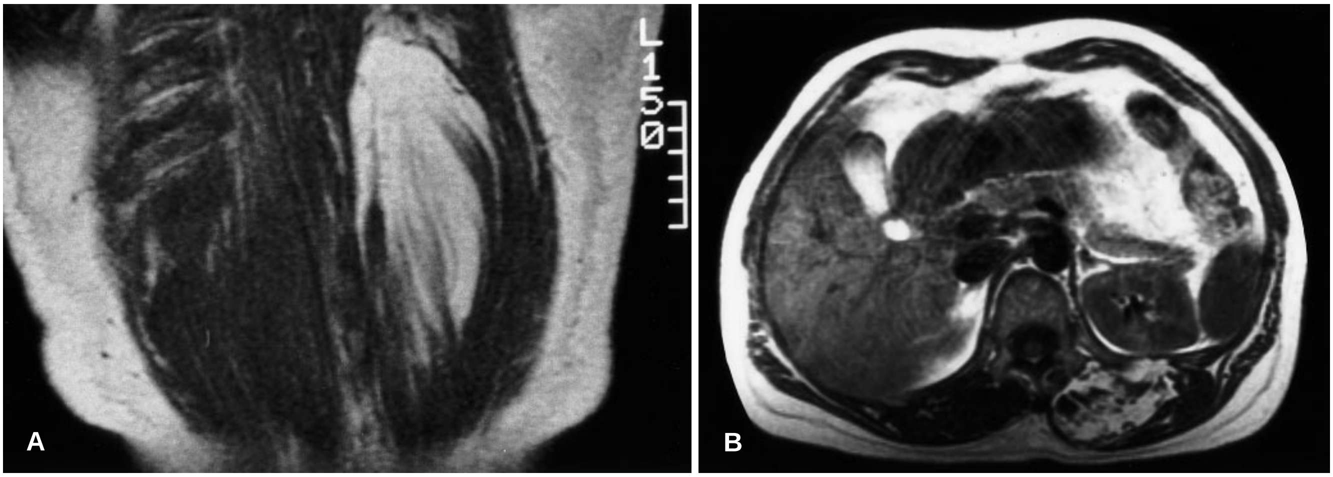
Both thin and thick linear structures were occasionally observed in both intramuscular lipomas and liposarcomas. In the intramuscular lipomas, a thick septum-like structure was identified in one of 17 cases. It was present between the main mass and a daughter tumor, and separated them. Thick linear structures within the nodule were recognized in five intramuscular lipomas (Figs. 6, 7), four of which were over 10 cm in diameter. These thick linear structures had a low signal intensity on both T1- and







T2-weighted images. They were enhanced in two cases and not enhanced in another case following injection of contrast medium on fat-suppressed T1-weighted images, which were performed in three of five cases. In liposarcoma, thick linear structures were identified not only within the nodules but also between the nodules in two of four cases. These two lesions were composed of a number of interrelated tumor masses defined as multinodular. In contrast, thin linear structures were identified within the nodules of both intramuscular lipoma and liposarcoma.



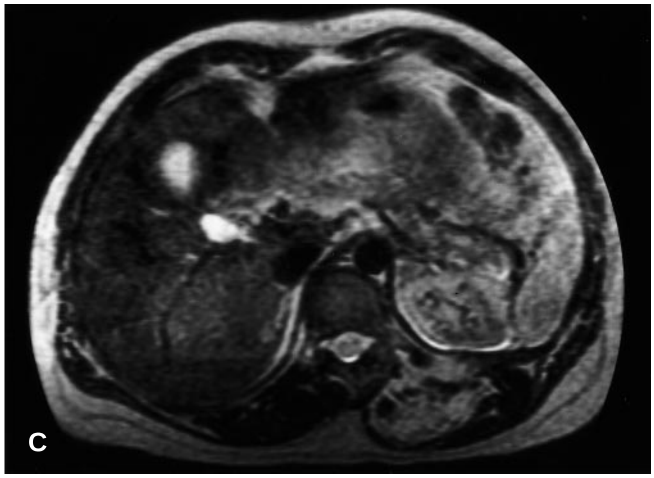


Fig. 5A–C Intramuscular lipoma (case 9). **A** Coronal T1-weighted (TR/TE, 500/20) MR image of the trunk showing a prominent infiltrative margin in the surrounding muscle tissue. **B,C** Axial T1-weighted (TR/TE, 500/20) and T2-weighted (TR/TE, 2000/20) MR images of the trunk also showing a mass composed of intermingled fat and muscle fibers

◄ **Fig. 2A, B** Intramuscular lipoma (case 8). **A** Axial T1-weighted (TR/TE, 570/14) MR image of the trunk showing a single, small and homogeneous mass. The margin is well defined. **B** T2-weighted (TR/TE, 4000/80) axial image

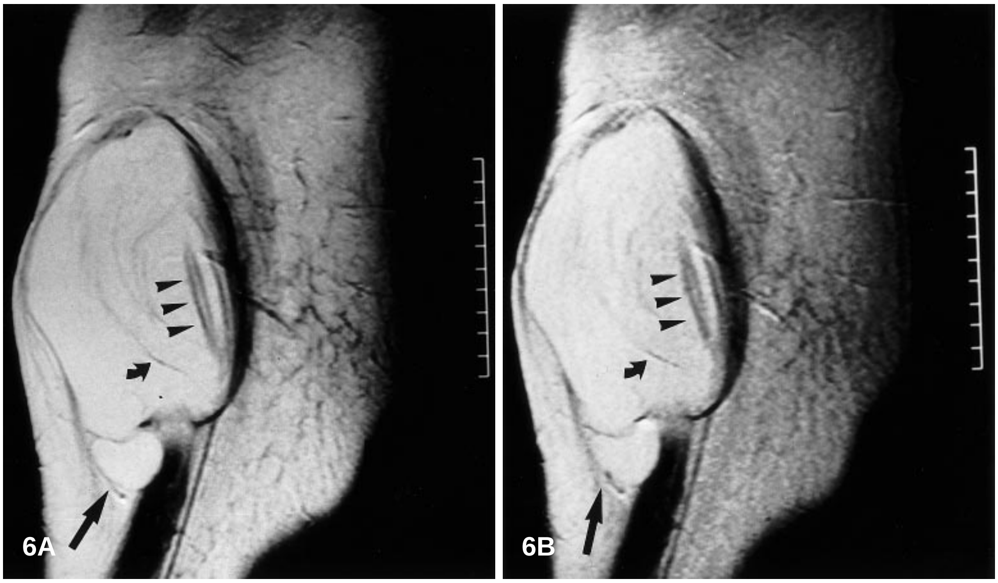
Fig. 3A–C Intramuscular lipoma (case 5). **A** Axial T1-weighted (TR/TE, 500/20) MR image of the shoulder showing intermingled fat and muscle fibers in the lesion. **B** Axial T2-weighted (TR/TE, 4000/80) MR image showing that the intermingled muscle fibers are isointense with normal muscle tissue. The margin of the lesion is also infiltrative. **C** Coronal T1-weighted (TR/TE, 500/20) MR image of the shoulder showing muscle fibers in the lesion with an infiltrative margin

Fig. 4A–C Well-differentiated liposarcoma (case 20). **A,B** Coronal T1-weighted (TR/TE, 500/9) and fat-suppressed T2-weighted (TR/TE, 4000/100) MR images of the thigh showing multiple tumor nodules. The nodules are composed of a pure fatty mass except for the inferior nodule with well-defined margins all around the lesion. The inferior nodule shows a slightly low signal intensity on the T1-weighted image and a slightly high signal intensity on the T2-weighted image. **C** Fat-suppressed T1-weighted axial image (TR/TE, 450/9) following administration of gadolinium-DTPA showing enhancement of the inferior nodule (*arrow*) and septum-like structures. Most thick linear structures are observed between the nodules

Fat-suppressed T1-weighted images showed that all five cases of intramuscular lipoma demonstrated no enhancement of the tumor following intravenous contrast. One case of well-differentiated liposarcoma showed faint to no enhancement. A small nodule in one case demonstrated slight enhancement (Fig. 4C). Only the dedifferentiated portion of the dedifferentiated liposarcoma showed marked enhancement.

Discussion

Lipoma is one of the commonest types of soft tissue tumor and may be divided into cutaneous or superficial lipoma and deep-seated or subfascial lipoma [13]. Intramuscular lipoma is a deep-seated lipoma that arises in muscle, and is benign and relatively rare. It has also been reported as infiltrating lipoma due to its infiltrative nature on histological examination [12, 13]. Enzinger and Weiss [13] showed that in cross-section there is gradual replace-



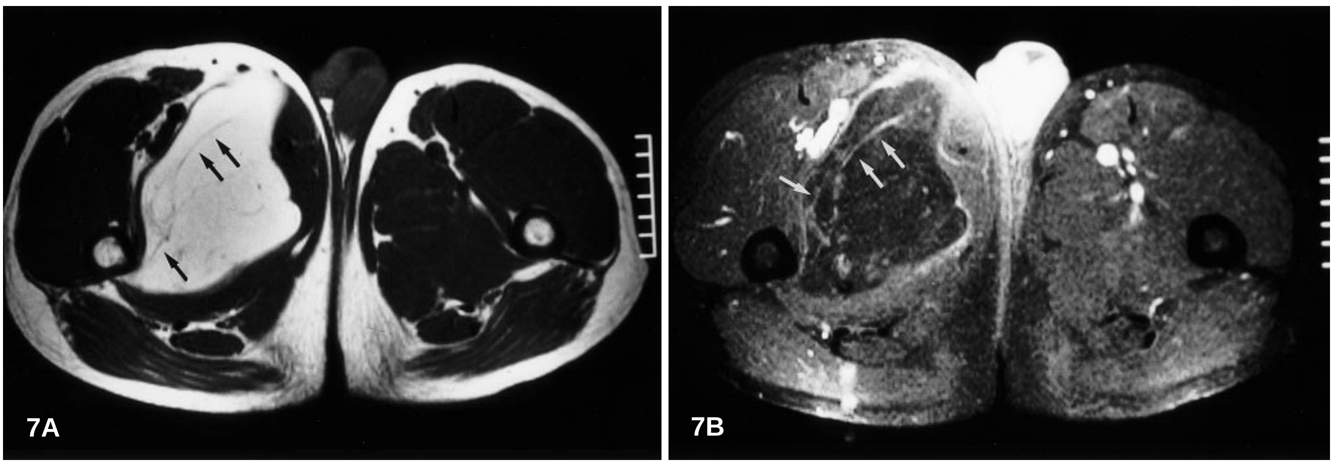


Fig. 6A, B Intramuscular lipoma involving the sartorius muscle (case 3). Sagittal T1-weighted (TR/TE, 400/15) and T2-weighted (TR/TE, 4000/112) MR images of the pelvis showing a large homogeneous mass with a small daughter nodule (*straight arrow*) in spite of its size. A thickened septum-like structure was present between the main mass and daughter tumor. Thick (*arrowheads*) and thin linear structures (*curved arrow*) within the nodules are also observed in the mass. There was no enhancement of these structures following administration of gadolinium-DTPA

Fig. 7A, B Intramuscular lipoma (case 12). **A** Axial T1-weighted (TR/TE, 470/18) MR image of the thigh showing a single large mass, homogeneous except for a thick linear structure (*black arrows*) within it. The margin is well defined. **B** Fat-suppressed T1-weighted (TR/TE, 500/18) axial image following administration of gadolinium-DTPA shows that the linear structure is enhanced (*white arrows*)

ment of the muscle tissue by proliferation of fat and lipocytes between muscle fibers. Fletcher and Martin-Bates [12] divided intramuscular lipoma histologically into two types: a well-circumscribed type and an infiltrative type. In the former, fatty tissue was clearly delineated from the surrounding muscle, whereas in the latter there was replacement of the muscle tissue in a bland fashion by lipocytes, while longitudinal sections demonstrated a striated appearance of muscle fibers caused by the proliferation of fat cells [12].

The MR findings of fat-containing soft-tissue tumors have been well documented [1–11]. The MR features of liposarcoma vary depending on the histological subtype [1, 5, 6, 10, 11]. On MR images, myxoid liposarcoma revealed a relatively homogeneous internal structure, isointense with muscle on T1-weighted images and of homogeneously high signal intesity with linear septa dividing the lobules on T2-weighted images [10]. In the absence of fat, the imaging characteristics were not specific [11]. High-grade liposarcoma such as the round cell and pleomorphic types is sometimes difficult to differentiate from other types of malignant tumors as there may be no lipomatous component [6, 10]. The differential diagnosis between intramuscular lipoma, atypical lipoma and well-differentiated liposarcoma is also sometimes difficult not only on MR imaging but also on histological examination [2, 7, 9, 14]. Therefore, it is important to identify the MR features of intramuscular lipoma for appropriate preoperative differential diagnosis. To the best of our knowledge no previous study has examined the histological subdivisions of intramuscular lipoma.

Clinically, size is an important factor in predicting the clinical behavior of the neoplasms. In general, the larger the mass, the greater the probability of malignancy. Berquist et al. [15] did not find any malignant tumors less than 3 cm in diameter in a study of 95 benign and malignant soft tissue masses. In the present study all six cases less than 3 cm were benign. Four cases of intramuscular lipoma were larger than 10 cm in diameter, and liposarcoma tends to be larger than its benign counterpart, although two cases of liposarcoma were medium-sized lesions in the present study. Intramuscular lipomas are likely to be benign if they are less than 3 cm in diameter regardless of an irregular margin and inhomogeneity, whereas large tumors greater than 10 cm may not all be malignant, especially in intramuscular lipoma.

Berquist et al. [15] also suggested that benign lesions tended to show a homogeneous signal intensity, while malignant lesions were inhomogeneous. However, Kransdorf et al. [16] and Crim et al. [17] reported that MR imaging was incapable of distinguishing reliably between benign and malignant soft tissue tumors. Kransdorf et al. [4] suggested that on CT and MR images intramuscular lipoma was a predominantly fatty mass with imaging characteristics similar to those of an ordinary lipoma in spite of its histologically infiltrating margin. The same authors, however, reported that some intramuscular lipomas were inhomogeneous on MR imaging due to interspersed regions of decreased signal on T1-and T2-weighted images, and that the regions were believed to represent either muscle or fibrous tissue within the lipoma [16]. We speculate that this discrepancy is due to the wide variety of MR findings of intramuscular lipoma. Gelineck et al. [7] also found that deep-seated lipomas often contained skeletal muscle fibers, but did not include the MR images. The intermingled muscle fibers in intramuscular lipoma in the present study showed a inhomogeneous MR appearance that reflects the gradual replacement of the muscle tissue by fat. Although tumor tissue other than muscle fibers exist in myxoid, pleomorphic and dedifferentiated liposarcomas, the tumor tissue can easily be distinguished from muscle fibers as the latter maintain their original structure and are usually isointense with normal muscle on both T1- and T2-weighted images, while the former has a low signal intensity on T1-weighted images and increased signal intensity on T2-weighted images.

Previous reports have suggested that intramuscular lipomas are well defined [2, 4]. However, seven (41%) of the cases in our series had infiltrative margins, corresponding to the infiltrative type of intramuscular lipoma described by Fletcher and Martin-Bates [12]. The presence of infiltrative margins in intramuscular lipoma has been described before [3, 8], but is not well known. Conversely, Arkun et al. [10] previously reported that liposarcomas of different histological types had well-defined margins. The three well-differentiated liposarcomas in our series had well-defined margins. However, the dedifferentiated portion of the dedifferentiated liposarcoma had an infiltrative margin. We speculate that well-differentiated liposarcoma tends to grow expansively rather than infiltratively.

Fifteen of the intramuscular lipomas in this series appeared as a single mass and other two were binodular, whereas three of the four liposarcomas were multinodular. Multinodularity [10] and thick, irregular septa [6] have previously been shown to be common in liposarcomas and may help to distinguish between benign and malignant tumors. We considered that the former was more important than the latter in the differential diagnosis.

Previous authors have described the presence of thick linear or nodular septum-like structures in well-differentiated liposarcoma [6, 9]. These septa were reported to contain muscle fibers [9]. As mentioned-above, massive muscle fibers within the nodules of intramuscular lipoma were present. Therefore, we divided these thick linear structures into two categories based on the relationship with the tumor nodule: septum-like structures present between and separating tumor nodules, and linear structures within the nodules. Hosono et al. [9] reported that identification of these septa helped to differentiate well-differentiated liposarcoma from lipoma in a series containing liposarcomas, superficial lipomas and deep-seated lipomas. They speculated that muscle fibers were trapped as malignant tumors infiltrated muscle bundles. This may be true for well-differentiated liposarcoma but not for intramuscular lipoma, which infiltrated muscle bundles and contained massive muscle fibers in the tumor nodule in the present study. This fact was also confirmed by the macroscopic appearance at surgery. The MR findings of deep-seated liposarcoma should not be compared with those of superficial lipoma containing no muscle fibers. Thick linear structures within the nodules, which were recognized not only in well-differentiated liposarcoma but also in intramuscular lipoma, may not be pathognomonic. We speculate that the septum-like structures reported previously in well-differentiated liposarcoma may correspond to the thick fibrous elements which contained feeding vessels. The important finding is not the presence of linear structures but the presence of daughter nodules in lipomatous tumors. In comparison, thin linear structures were found in both intramuscular lipomas and liposarcomas. They corresponded to the fibrous septa in the tumor mass [7, 9], and were not pathognomonic.

The MR findings of intramuscular lipoma varied from a small, single and homogeneous mass identical to ordinary (superficial) lipoma to a large, inhomogeneous lesion with an infiltrative margin. MR findings such as intermingled muscle fibers and infiltrative margins demonstrate the infiltrative nature of intramuscular lipomas. In conclusion, the infiltrative nature, which is a general characteristic of malignant tumors, in the case of intramuscular lipomas indicates not malignancy but benignity. In addition, uninodularity of the mass is helpful in differentiating intramuscular lipoma from well-differentiated liposarcoma.

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