MR imaging of fat-containing tumours: the distinction between lipoma and liposarcoma

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ABSTRACT

Introduction: This study aimed to retrospectively review the magnetic resonance (MR) imaging features of the lipomatous tumour in order to differentiate between lipoma and liposarcoma.

Methods: The MR images of 38 patients (24 female and 14 male with a mean age 48 years) in a consecutive five-year period, who had histologically verified lipoma (n is 29) and liposarcoma (n is 9), were retrospectively reviewed. The images were assessed for the number, site, size and margin of the lesions, as well as the signal intensity (homogenous, bright signal on T1-weighted [T1W] image, bright signal suppressed on T1W with fat-suppression image, bright signal on T2-weighted with fat-suppression image), the internal architecture (thin/thick septum, cystic change), the effect on the surrounding tissue (oedema, neurovascular involvement) and the enhancement pattern.

Results: A partially ill-defined margin, neurovascular involvement, enhancing thick/nodular septum and a partially bright signal intensity on T1W images were statistically significant MR imaging features that favoured a diagnosis of liposarcoma (p-value is less than 0.0001). Male gender, an internal cystic change and surrounding soft tissue oedema increased the risk of liposarcoma approximately 2.8, 3.5 and 3.5 times, respectively, compared with the reference group (lipoma), but this was not a statistically significant finding. Thick/nodular septum was significantly associated with liposarcoma compared with lipoma (odds ratio 69.3, 95 percent confidence interval 5.2–3184.8, p-value is less than 0.0001).

Conclusion: Statistically significant MR imaging features that favour a diagnosis of liposarcoma included a partially ill-defined margin, neurovascular involvement, enhancing thick/nodular septum, and a partially bright signal intensity on T1W images. The most statistically significant predictor of liposarcoma was thick/nodular septum.

Keywords: lipoma, liposarcoma, magnetic resonance imaging, soft tissue neoplasm

Singapore Med J 2010; 51(5): 418-423

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INTRODUCTION

Lipoma is the most common type of soft tissue tumour. It is a benign lesion that is composed of mature adipose tissue (adipocyte) that is unavailable for systemic metabolism.[1-3] It is categorised into superficial (subcutaneous) and deep-seated lesions; the former is more frequently found. It is usually a solitary lesion, but multiple tumours can also be encountered.[1,4] The pathogenesis of lipoma is unknown, although it has been thought to represent a true mesenchymal neoplasm. Liposarcoma is the second most common type of soft tissue sarcoma in adults, after malignant fibrous histiocytoma, with an incidence of 16%–18% of all malignant soft tissue tumours.[3,5,6] The name liposarcoma does not imply that the tumour is derived from fat, but merely that the bulk of the tumour has differentiated into tissue with a microscopic appearance that is similar to that of adult adipose tissue.[1]

Ultrasonography has been largely used in the diagnosis of lipoma, and the ultrasonographic features of lipoma have been previously described.[7] The advantages of ultrasonography include its wide availability, low cost and its ability to perform a dynamic and colour Doppler scan at the time of the investigation. Its limitations in evaluating lipoma arise when the mass is large or exhibits inhomogeneous echogenic patterns that are not typical of lipoma, thus making it difficult to differentiate from liposarcoma. Magnetic resonance (MR) imaging is therefore utilised in such circumstances.

In MR imaging, the signal intensity (SI) of

Table I. The results and statistical analyses of multiple variables in differentiating between lipomas and liposarcomas.

Variable	No. (%)		p-value
	Lipoma (n = 29)	Liposarcoma (n = 9)	
Gender			
Male	9 (31.0)	5 (55.6)	0.245[a]
Female	20 (69.0)	4 (44.4)	
Mean age ± SD (years)	52.7 ± 14.4	44.8 ± 12.9	0.1501[b]
Site			
Subcutaneous fat	10 (34.5)	0	0.001[a]
Intramuscular	9 (31.0)	9 (100.0)	
Intermuscular	10 (34.5)	0	
Mean size ± SD (cm)			
AP diameter	5.2 ± 3.2	9.0 ± 3.6	0.0046[b]
Transverse diameter	5.0 ± 2.6	8.2 ± 4.5	0.0109[b]
Vertical diameter	9.7 ± 6.4	16.2 ± 9.0	0.0211[b]
Margin			
Well-defined	29 (100.0)	0	< 0.0001[a]
Partially ill-defined	0	9 (100.0)	
Ill-defined	0	0	
Homogeneity of SI			
Homogeneous	13 (44.8)	0	0.016[a]
Inhomogeneous	16 (55.2)	9 (100.0)	
Neurovascular involvement			
Present	0	3 (33.3)	< 0.0001[a]
Absent	27 (93.1)	3 (33.3)	
Only pressure effect	2 (6.9)	3 (33.3)	
Septum			
No or thin septum	26 (89.7)	1 (11.1)	< 0.0001[a]
Thick/nodular septum	3 (10.3)	8 (88.9)	
Bright SI in T1W images			
Entire lesion	28 (96.6)	0	< 0.0001[a]
Partial	1 (3.4)	9 (100.0)	
None	0	0	
T1W not done	0	0	
Bright SI suppressed in T1FS images			
Totally suppressed	26 (89.7)	4 (44.4)	0.002[a]
Partial	0	3 (33.3)	
Not suppressed	0	0	
T1FS not done	3 (10.3)	2 (22.2)	
Bright SI in T2FS images			
Entire lesion	0	1 (11.1)	0.005[a]
Partial	3 (10.3)	4 (44.4)	
None	16 (55.2)	0	
T2FS not done	10 (34.5)	4 (44.4)	
Internal cystic change			
Present	1 (3.4)	1 (11.1)	0.422[a]
None	28 (96.6)	8 (88.9)	
Surrounding soft tissue oedema			
Present	1 (3.4)	1 (11.1)	0.422[a]
None	28 (96.6)	8 (88.9)	
Enhancing pattern			
Not enhanced/enhanced thin septum	11 (37.9)	0	< 0.0001[a]
Thick/nodular enhancement	1 (3.4)	6 (66.7)	
Enhancement study not done	17 (58.6)	3 (33.3)	

[a]p-value from Fisher's exact test. [b]p-value from unpaired *t*-test.
SD: standard deviation; AP: anteroposterior; SI: signal intensity; T1W: T1-weighted; T1FS: T1-weighted with fat-suppression; T2FS: T2-weighted with fat-suppression

lipoma parallels the SI of subcutaneous fat on all pulse sequences,[8,9] without discernible enhancement after the administration of intravenous gadopentetate dimeglumine.[10] Most lipomas are well-circumscribed and small, with 80% measuring less than 5 cm.[3] However, some reports have found that about 1% of

Table II. Odds ratios for features related to liposarcoma in comparison to lipoma.

Variable	Odds ratio	95% confidence interval	p-value
Gender			
Male	2.8	0.6–17.2	0.1828
Female*			
Septum			
Thick/nodular	69.3	5.2–3184.8	< 0.0001
None/thin*			
Internal cystic change			
Present	3.5	0.0–284.3	0.3685
None*			
Surrounding soft tissue oedema			
Present	3.5	0.0–284.3	0.3685
None*			

* Reference group

lipomas were larger than 10 cm,[11] and in one study, about 60% of lipomatous soft tissue masses larger than 5 cm were identified as lipoma.[4]

MR imaging of liposarcoma reflects its degree of differentiation. The higher the differentiation of the tumour, the more the SI of the tumour approaches that of fat, and the more fat-like it appears. A well-differentiated liposarcoma produces an image of a predominantly fatty mass with irregularly thickened linear or nodular septa, which decreases SI on T1-weighted (T1W) images and increases SI on T2-weighted (T2W) images.[12] The myxoid, round and pleomorphic subtypes do not contain substantial amounts of fat. A dedifferentiated type is best defined as a bimorphic neoplasm in which a borderline or low-grade malignant neoplasm is juxtaposed with a high-grade sarcoma.[13] In addition, some reports have stated that liposarcoma may appear as a well-circumscribed, lobulated mass.[1,4]

It is important to suggest the diagnosis of liposarcoma rather than lipoma preoperatively because of the difference in prognosis, initial treatment and long-term care. We studied the MR images of fat-containing soft tissue tumours in the musculoskeletal system, in order to determine which findings would be used to differentiate lipoma from liposarcoma.

METHODS

All patients who attended the Ramathibodi Hospital within a consecutive five-year period and whose histologically proven lipoma and liposarcoma with MR imaging was available were included in this study. There were 24 female and 14 male patients, with a mean age of 48 years. The use of the material was approved by the Ethics Committee of our hospital for this retrospective review.

The MR imaging techniques (sequences) used consisted of a transaxial plane in T1W and T2W images, T1-weighted with fat-suppression (T1FS), coronal plane in T1W, T2W and/or T2-weighted with fat-suppression (T2FS) images, and sagittal planes in T1W images. A gadolinium-enhanced study was performed using T1FS in axial and one longitudinal (coronal or sagittal) plane. All sequences were performed at a 3.0 mm slice thickness and a 1.0 mm slice gap. The MR images were reviewed by two radiologists who were blinded to the histological result, and the data was recorded with a consensus agreement.

The following data was collected: the patients' gender, age and pathological diagnosis which were not provided to the radiologists who reviewed the cases; and the MR imaging data including the number of lesion(s), the site of the lesion (subcutaneous, intramuscular or intermuscular), the size of the lesion in anteroposterior, transverse and vertical diameters, the margin (well-defined, partially ill-defined or ill-defined), the homogeneity of SI (homogeneous or inhomogeneous), neurovascular involvement (involvement, no involvement or having only a pressure effect), septum (no septum, a thin septum or a thick/nodular type of septum), bright SI depicted on T1W images (in the entire lesion, in some parts of the lesion [partial], or not at all [no]), bright SI depicted on T1W images suppressed by using T1FS (totally suppressed, partially suppressed or not suppressed at all), whether there was any bright SI when using T2FS images (totally bright, partially bright or not bright at all), internal cystic change (change or no change), surrounding soft tissue oedema (oedema or no oedema), enhancing pattern after contrast administration (not enhanced, minimally enhanced thin septum or nodular-like enhancement).

Data analysis was carried out using the Stata program 10.0 (StataCorp, College Station, TX, USA). For continuous variables, the patients' age and the size of the lesion were described as the mean ± standard deviation, with a normal distribution of data. The categorical

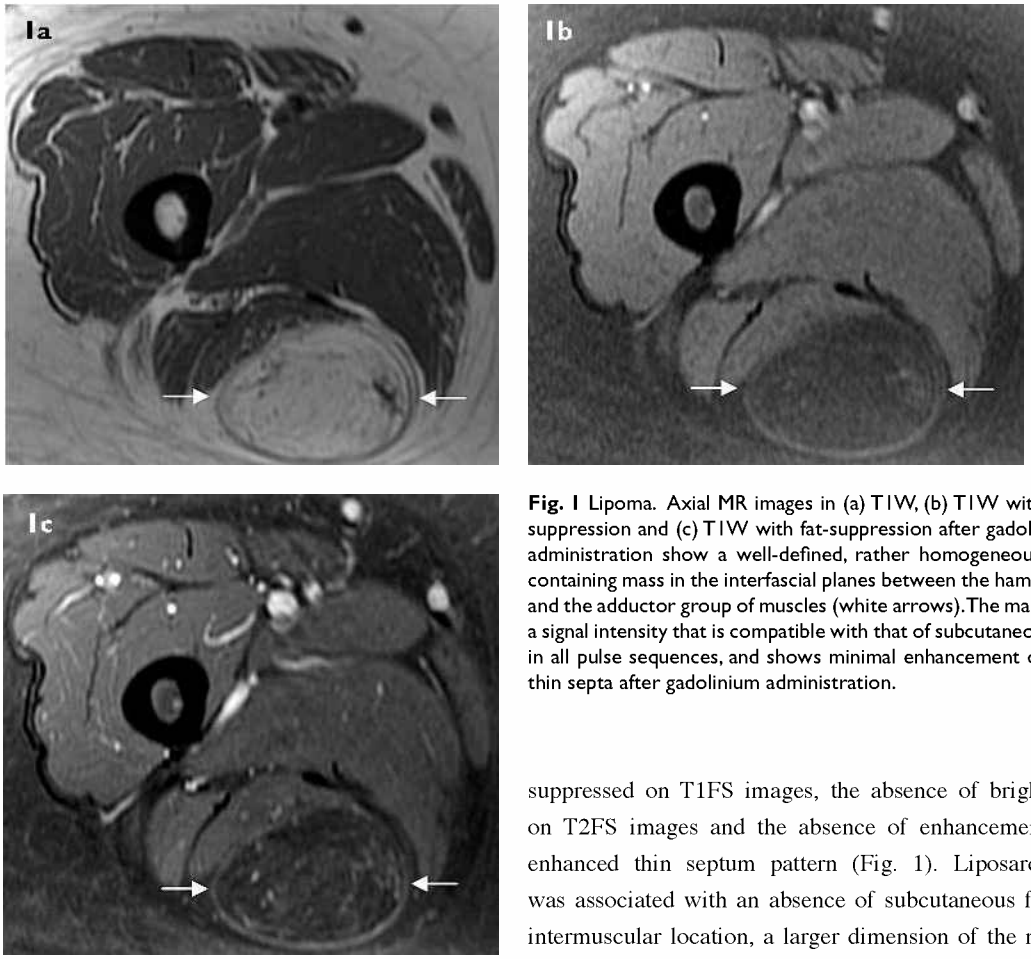

Fig. 1 Lipoma. Axial MR images in (a) T1W, (b) T1W with fat-suppression and (c) T1W with fat-suppression after gadolinium administration show a well-defined, rather homogeneous fat-containing mass in the interfascial planes between the hamstring and the adductor group of muscles (white arrows). The mass has a signal intensity that is compatible with that of subcutaneous fat in all pulse sequences, and shows minimal enhancement of the thin septa after gadolinium administration.

variables included gender, the site of the lesion, margin, homogeneity of SI, neurovascular involvement, septum, bright SI on T1W images, bright SI on T1W suppressed by T1FS images, bright SI on T2FS images, internal cystic change, surrounding soft tissue oedema and enhancing pattern after contrast administration. These were analysed so as to uncover any statistically significant differences between benign and malignant lesions. The comparisons between continuous variables were analysed using unpaired Student's *t*-test, and those among the categorical data were analysed using Fisher's exact test. A p-value of less than 0.05 was considered to be statistically significant.

RESULTS

Based on the pathological diagnosis, there were 29 lipomas and nine liposarcomas. All the cases were single lesions. Details of the results and statistical analyses are shown in Tables I and II. Table I shows that lipoma was associated with subcutaneous fat and intermuscular location, a well-defined margin, homogeneity of SI, the absence of neurovascular involvement, bright SI of the entire lesion on T1W images which was totally suppressed on T1FS images, the absence of bright SI on T2FS images and the absence of enhancement or enhanced thin septum pattern (Fig. 1). Liposarcoma was associated with an absence of subcutaneous fat or intermuscular location, a larger dimension of the mass, a partially ill-defined margin, inhomogeneity of SI, neurovascular involvement, partially bright SI on T1W images which was suppressed on T1FS images, bright SI on T2FS images and an enhanced thick/nodular septum (Fig. 2).

The odds ratios in Table II show the independent factors that were related to liposarcoma. Male gender, the presentation of internal cystic changes and the presentation of surrounding soft tissue oedema increased the risk of having liposarcoma by approximately 2.8, 3.5 and 3.5 times, respectively, when compared with the reference group. However, these relationships were not statistically significant. Thick/nodular septum was significantly associated with liposarcoma when compared with lipoma (OR 69.3, 95% confidence interval [CI] 5.2–3184.8, $p < 0.0001$).

DISCUSSION

For fat-containing soft tissue tumours, namely lipoma and liposarcoma, many imaging features have been studied in an attempt to differentiate between these two entities.[3-5,14-22] The features of entire fatty masses on T1W images that are completely suppressed on T1FS images, as well as the containment of no septa or a thin septa, have been described as features of lipoma.[3,14-16]

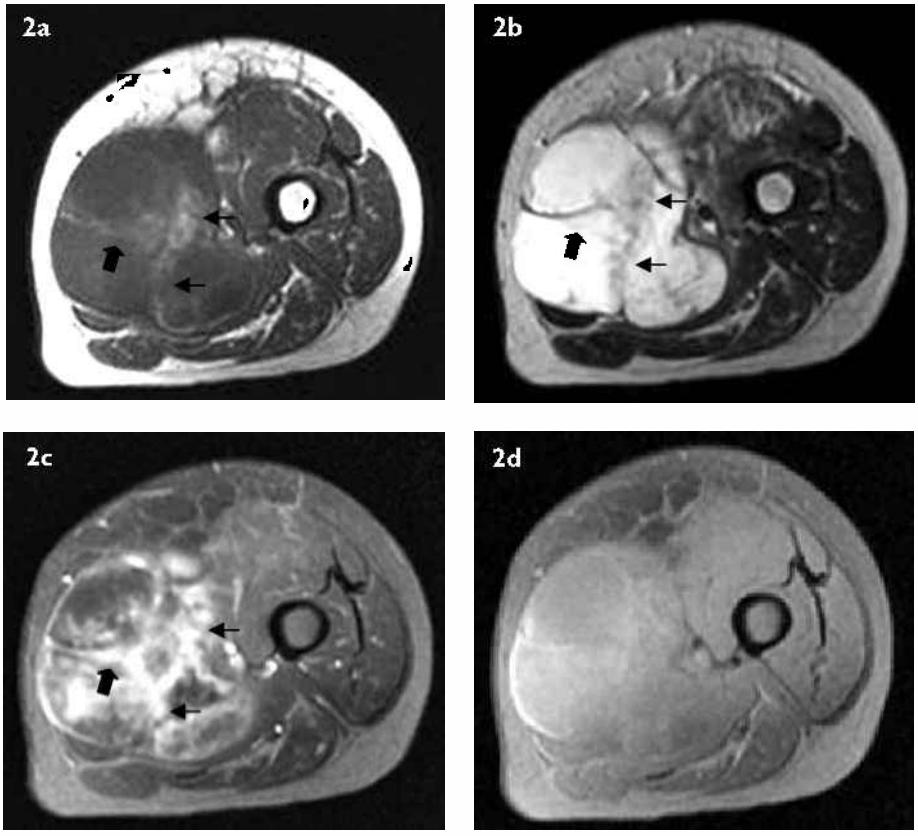

Fig. 2 Liposarcoma. Axial MR images in (a) T1W, (b) T2W and (c) T1W with fat-suppression after gadolinium administration show a rather well-defined inhomogeneous signal intensity mass involving the adductor muscles. The mass contains thick (thick arrow) and nodular (thin arrows) septa that are associated with fat infiltration, which subsequently show irregular enhancement after gadolinium administration. (d) Axial MR image in T1W with fat-suppression is shown here for comparison.

Our results corroborate these reports, with the addition of a well-defined margin and the absence of neurovascular involvement as the features of lipoma that are significantly different from liposarcoma statistically.

The presence of thick or nodular septa has been considered to be a feature that is more suggestive of liposarcoma than lipoma in many studies,[5,14-17,19,21] including ours. The reason septa in liposarcoma differ from those in lipoma is not entirely understood. Hosono et al reported that pathologically, the septa of liposarcoma contain muscle fibres whereas those of lipoma represent a fibrous capsule.[15] In contrast, Doyle et al stated that the only abnormality they found that was related to the thickened septa or nodules was the presence of broad bands of fibrous tissue.[16]

A larger dimension is one feature that is suggestive of the presence of liposarcoma rather than lipoma.[4,17-20] While some authors have used a size of 5 cm as a cut-off point,[4,18] others use the ratio of the largest dimension.[17,20] The average value of the largest dimension of liposarcoma has been reported to be more than 1.6 times,[20] or almost twice,[17] that of lipoma. The ratio of all average anteroposterior, transverse and vertical dimensions of liposarcoma to those of lipoma in our study were found to be 1.70, 1.64 and 1.67, respectively, a finding that corresponds to those of previous studies. Although male gender and an older age of patients have been described as significant risk factors for malignancy,[17,18] we did not find a similar result in our study.

A well-defined margin was found in 87% and 100% of liposarcomas in two studies.[5,21] One of these studies has also found that irregular margins were recognised in benign infiltrating lipoma.[21] Our study, however, had different results; all our lipomas had well-defined margins whereas all our liposarcomas had partially ill-defined margins.

There were some limitations to this study that should be noted. First, this study was retrospective and not all patients were studied in a uniform fashion. Some imaging sequences were not performed in some patients. Second, due to the high cost of MR imaging in our country, many patients with clinically suspected lipoma were diagnosed through ultrasonography and underwent surgery without further investigations being conducted. This resulted in

the small number of cases in our study and thus limits its statistical power.

In conclusion, our study supports the argument that statistically significant MR imaging features that favour a diagnosis of liposarcoma include a partially ill-defined margin, neurovascular involvement, enhancing thick/nodular septum, and a partially bright SI on T1W images. The most statistically significant predictor of liposarcoma is the presence of a thick/nodular septum.

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