Benign and Malignant Soft Tissue Mass: Magnetic Resonance Imaging Criteria for Discrimination

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Objective: *Determine MRI features to differentiate between benign and malignant lesions.*
Material and Method: *The Magnetic resonance imaging (MRI) taken in the 5-year period (2003-2007) of 85 patients with benign and malignant soft tissue masses were analyzed. The criteria for discrimination were based on size, origin, signal homogeneity on T1- and T2-weighted, perilesional edema or invasion, hemorrhage, necrosis, and bone and neurovascular involvements.*
Result: *There were 50 benign and 35 malignant lesions. Eighty-two lesions had histologic proof while three lesions had MRI characteristics of benign lipoma.*
Conclusion: *No single MRI feature was diagnostic for any soft tissue tumors in the present study. However, three individual MRI features were statistically significant for differentiation between benign and malignant soft tissue masses ($p < 0.05$).The features that favor malignancy were heterogeneous signal on T2-weighted, perilesional edema or invasion, and necrosis in the masses.*

Keywords: *Benign, Malignant, Soft tissue mass, MRI criteria*

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Soft tissue masses are classified into several categories, including those of neoplastic (benign and malignant), inflammatory, traumatic and vascular origins[1,2]. Published opinions regarding MRI in distinguishing between benign and malignant masses are divergent[3-5].

Some authors conclude that MRI is accurate for making this discrimination[4], but others believe that MRI appearance of soft tissue lesions are nonspecific[3,5]. The present study attempted to determine MRI features to differentiate between benign and malignant lesions.

Material and Method

The population study consisted of 85 patients who were seen with soft tissue masses at Rajavithi Hospital between July 2003 and July 2007 and MRI was made. Histopathology was available in 82 patients. In three patients, the diagnoses were from MRI characteristics of benign lipoma. All MRI images were done before biopsy of the soft tissue masses as prior biopsy will cause reactive changes in soft tissue such as hemorrhage and edema and may hamper interpretation of the MRI images and will cause interference with staging[6].

The MRI examinations were done on 1.5 tesla system. Pulse sequences used were spin echo T1-weighted (300/10[repetition (TR)/echo time (TE)]) and T2-weighted (2000/80[TR/TE]), gradient echo T2*-weighted (360/18/25[TR/TE/flip angle]), fat suppression short tau inversion recovery (STIR) (1600/40/150[TR/TE/inversion time (TI)]). Gadolinium injection had been used to enhance contrast on T1-weighted images, to better characterize the mass, to study surrounding edema or invasion and to find the optimal site for biopsy of the tumor[6,7]. Axial, sagittal and coronal planes were obtained in all cases. Criteria for evaluation in each MR examination were size, origin, margin, signal homogeneity on T1- and T2- weighted, perilesional edema or invasion, hemorrhage, necrosis, bone and neurovascular involvements.

Sizes were divided into two groups, size with greatest dimension less than 5 centimeters (cm) and more than 5 cm. Origins were classified as superficial (subcutaneous) or deep (intramuscular, fascia, tendon, joint, in or near nerve). Lesions that involved both

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superficial and deep areas were considered as deep. Both T1- and T2-weighted sequences were evaluated for tumor margination as well-defined or poorly defined. Signal homogeneity on T1- and T2-weighted was grouped as homogeneous and heterogeneous varieties. Perilesional edema was considered as present when high signal intensity could be seen extending from the margin of the lesion into the surrounding areas or muscles on T2-weighted images and invasion when there was enhancement at those areas after contrast injection on T1-weighted images. Hemorrhage was considered as present if there was high signal on T1-weighted images coupled with low or high signal on T2-weighted images, and the tissue was not isointense with fat on all sequences. A low signal hemosiderin rim was also considered ancillary evidence of prior hemorrhage. Necrosis was graded as absent or present. If irregular low signal area was present after contrast study, then necrosis was present. Bone involvement was graded as absent and present (remodeled or invaded) and was correlated with findings on plain radiographs. Neurovasculature involvement was graded as absent or present (abutment, displacement, encasement). The presence of a tumor mass within the confines of a joint space was required to document articular involvement. A joint effusion alone adjacent to a tumor mass was not considered evidence of articular involvement. The results were presented as frequency (%). The cut off criteria for the risk factors were described of the odds ratio and 95% confidence interval (95% CI) was calculated. A p-value of less than 0.05 was considered significant.

Results

Patient demographics and lesion location are shown in Table 1. There were 34 males and 51 females and the male to female ratio is 1:1.5. The mean age for benign tumor was 40 years old with standard deviation (SD) of 16.6 and for malignant tumor was 48 years old with SD of 18.2. Soft tissue tumors were found predominantly in lower extremities particularly in thigh or legs in this report.

Table 2 lists the pathology and MRI diagnosis of soft tissue masses in 85 patients. There were 50 benign lesions and 35 malignant lesions. The frequency of benign soft tissue lesions were hemangioma (10 patients), neural tumor (10 patients), and lipoma (8 patients).

The frequency of malignant lesions were liposarcoma (5 patients), malignant fibrous histiocystoma (MFH) (5 patients), synovial sarcoma (5 patients) and spindle cell sarcoma (5 patients). Table 3 lists the

Table 1. Patients' demographics and lesions localization

Demographics	Soft tissue tumor (n = 85) (%)	Benign (n = 50) (%)	Malignant (n = 35) (%)
Sex			
Male	34 (40.0)	19 (38.0)	15 (42.8)
Female	51 (60.0)	31 (62.0)	20 (57.1)
Age (year old)			
Mean	43 $\pm$ 17.7	40 $\pm$ 16.6	48 $\pm$ 18.2
Median	45	39	51
Range	7-79	7-73	13-79
Lesion location			
Upper extremities	22 (25.9)		
Forearm + arm		8 (16.0)	5 (14.3)
Hand + wrist		5 (10.0)	4 (11.4)
Lower extremities	39 (45.9)		
Thigh		9 (18.0)	13 (37.1)
Leg		10 (20.0)	3 (8.6)
Ankle + foot		3 (6.0)	1 (2.9)
Others	24 (28.2)		
Hip		6 (12.0)	4 (11.4)
Shoulder		7 (14.0)	3 (8.6)
Knee		1 (2.0)	2 (5.7)
Elbow		1 (2.0)	-

n = number

Table 2. Distribution of soft-tissue mass diagnosis

Diagnosis	No. of cases
Benign masses (n = 50)	
Hemangioma	10
Benign neural tumor	10
Lipoma*	8
Fibromatosis	6
Hematoma	4
Giant cell tumor of tendon sheath/ pigmented villonodular synovitis (PVNS)	4
Bursitis	2
Myxoma	1
Abscess	1
Giant cell tumor	1
Fibrous histiocytoma	1
Fibroma	1
Myositis ossificans	1
Malignant masses (n = 35)	
Liposarcoma	5
Malignant fibrous histiocytoma (MFH)**	5
Synovial sarcoma	5
Spindle cell sarcoma	5
Malignant high grade sarcoma	4
Malignant neural tumor	4
Metastasis	2
Leiomyosarcoma	1
Rhabdomyosarcoma	1
Clear cell sarcoma	1
Epitheloid carcinoma	1
Hemangiopericytoma	1

* 3 cases of lipoma were diagnosed by MRI characteristics
** has been replaced by the term undifferentiated pleomorphic sarcoma (WHO classification adopted in 2002)

individual MR imaging criteria and the frequency with which they occurred in benign and malignant lesions. Three criteria were found to be useful in differentiation between benign and malignant lesions and those criteria were heterogeneous signal in T2-weighted ($p < 0.05$), presence of perilesional edema or invasion and presence of necrosis in the mass ($p < 0.001$).

Discussion

In this current study, the statistically significant MRI features that favored malignancy were identified. These features were heterogeneous T2 signal ($p < 0.05$), perilesional edema or invasion, and necrosis ($p < 0.001$) (Fig. 1). Most soft tissue tumors exhibit prolonged T1 and T2 relaxation times appearing of relatively low signal intensity and high signal intensity

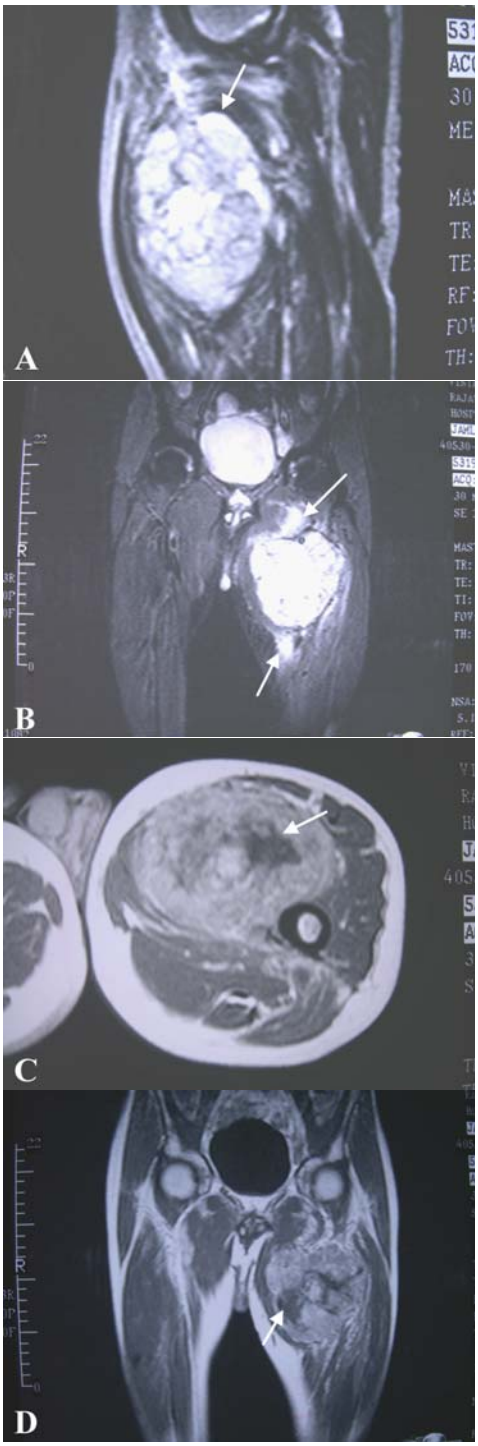

Fig. 1 Pleomorphic liposarcoma in a 49-year old man, presented with soft tissue mass at left thigh
The mass showed heterogeneous signal on sagittal T_2W (A), perilesional edema or invasion around the mass on coronal STIR (B) and tumor necrosis on axial and coronal T_1W post contrast (C, D)

Table 3. Individual MRI features of 85 soft tissue lesions

Criteria	Benign (n = 50)	Malignant (n = 35)	Odds ratio	95% CI*	p-value
Size			1.41	0.44-4.53	0.52
< 5 cm	13	7			
> 5cm	37	28			
Origin			0.54	0.18-1.58	0.22
Superficial	11	12			
Deep	39	23			
Margin			1.87	0.66-5.35	0.19
Well defined	38	22			
Poorly defined	12	13			
Signal homogeneity on T1-weighted			1.73	0.66-4.56	0.21
Homogeneous	31	17			
Heterogeneous	19	18			
Signal homogeneity on T2-weighted			2.96	0.95-10.25	0.03**
Homogeneous	19	6			
Heterogeneous	31	29			
Perilesion edema/invasion			16.47	4.55-72.35	0.0000002***
Absent	34	4			
Present	16	31			
Hemorrhage			2.74	0.88-8.70	0.05
Absent	42	23			
Present	8	12			
Necrosis			5.56	1.84-17.32	0.0004853***
Absent	42	17			
Present	8	18			
Bone involvement			2.54	0.72-9.23	0.10
Absent	44	26			
Present	6	9			
Neurovascular involvement			1.37	0.52-3.62	0.47
Absent	31	19			
Present	19	16			

* 95% confidence interval
** $p < 0.05$
*** $p < 0.001$

on T1 and T2 sequences respectively[8]. Attempts had been made to develop criteria to differentiate them utilizing MRI. Benign soft tissue masses are more common than malignant masses[9-11]. Kransdorf et al[7] mentioned in their report that, the larger the soft tissue mass and the greater T2 heterogeneity, the greater was the concern for malignancy. Malignancies, by virtue of their very nature and their potential for autonomous growth are generally larger and more likely to outgrow their vascular supply with subsequent infarction and necrosis. Peritumoral edema or invasion on T2-weighted spin echo MR images or fluid sensitive sequence (STIR) has also suggested as a reliable indicative of malignancy[7,11,12].

Today differentiation between benign and malignant soft tissue tumor is still controversial by MRI. In a study of 95 patients, Berquist et al[4] concluded that "the nature of the lesion (benign versus malignant) can be determined in the majority of the cases," with an overall accuracy of 90%. Kransdorf et al[5], in a study of 112 tumors, found that a specific diagnosis could be made on the basis of MRI findings in only 24%, concluding "MR was incapable of reliably distinguishing between benign and malignant soft tissue tumors". The author found statistically significant MRI criteria in 85 patients regarded to the nature of the soft tissue mass corresponding with the findings by Berquist et al[4].

In this current study, five cases of lipoma had been proved by biopsy (Fig. 2). The other three cases of lipoma were diagnosed by MRI characteristics, showing homogeneous signal intensity identical to that of fat in all pulse sequences. To date, this is the most reliable feature in establishing the diagnosis of lipoma at imaging. Thin fibrous septa of low signal intensity on T1- and T2-weighted images may traverse the lesion[13]. Many benign lesions (Fig. 3, 4) can often be correctly diagnosed with MRI,including lipoma,

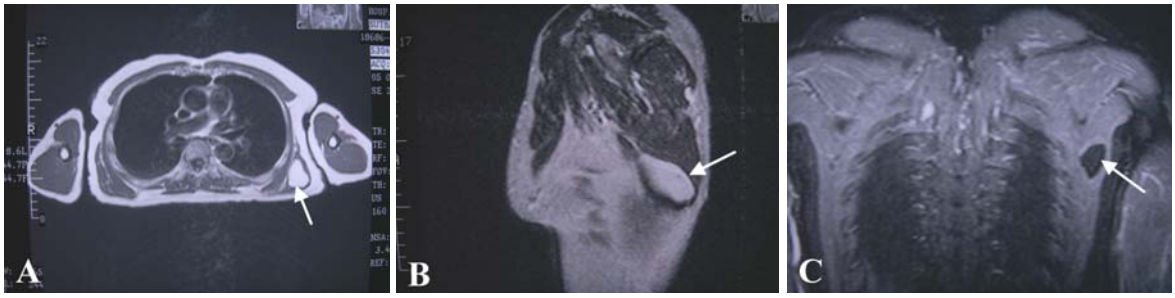

Fig. 2 Intramuscular lipoma in a 38 years old man
The tumor had well-defined high signal on axial T_1W (A) and sagittal T_2W (B)
Dark signal was shown on coronal STIR (C)

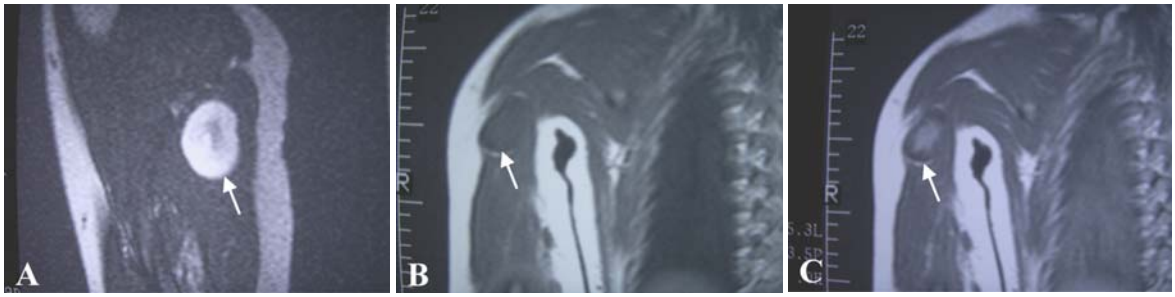

Fig. 3 Neurofibroma at right arm in a women (40 years old)
Sagittal T_2W (A) showed target sign with internal low signal and peripheral high signal
Coronal T_1W showed the mass before and after contrast injection (B, C) The mass has low signal in B
Enhancement appeared in C as solid at the center and rim at the periphery

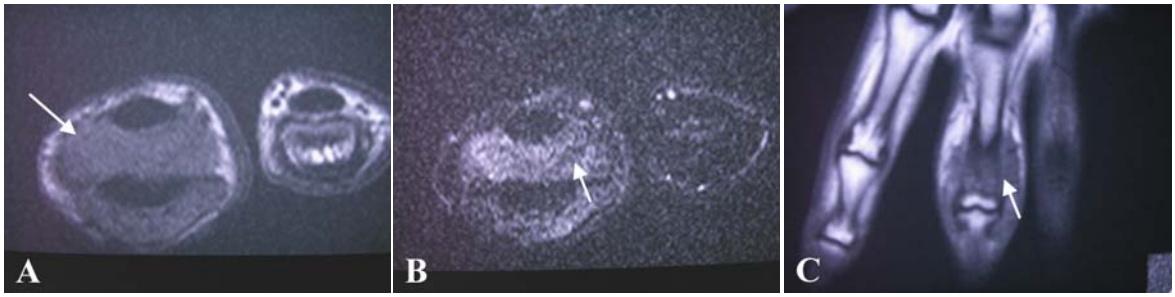

Fig. 4 Giant cell tumor of tendon sheath involved PIP joint of third finger in a 17 years old male patient
Axial T_1W (A), tumor had intermediate signal
Axial STIR (B), the signal was high
Coronal T_1W with contrast injection (C), the tumor had none to minimal enhancement

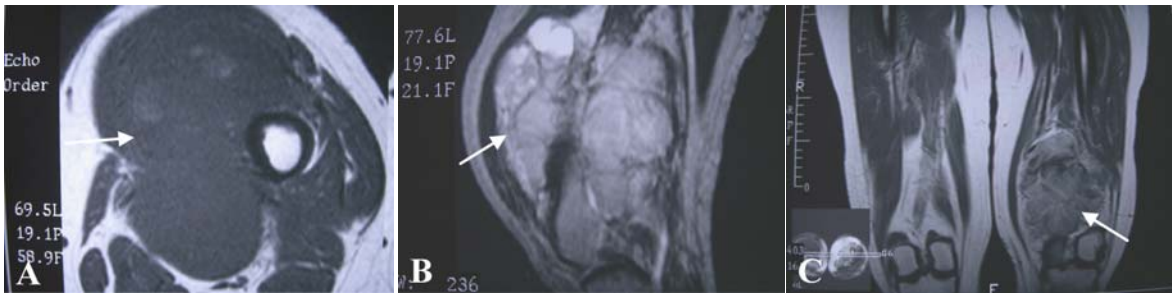

Fig. 5 Synovial sarcoma, the patient was a 33 years old came with a mass around right knee
The mass had lobulated margin, of intermediate signal with minimal inhomogeneity on axial T_1W (A)
Heterogeneous, multilobular appearance was seen on sagittal T_2W (B) with heterogeneous enhancement on coronal T_1W (C)

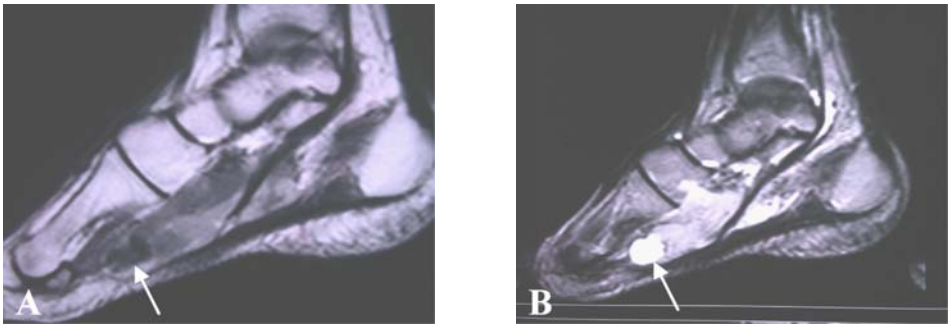

Fig. 6 Spindle cell sarcoma at left foot, plantar aspect in a male patient 17 years old
Sagittal T_1W after contrast injection (A) and sagittal T_2W (B)
The tumor had different compositions with cystic area seen as bright signal in B (←) and low signal in A (←)

hemangioma[14], neural tumor[15] periarticular cyst[16], hematoma[17], pigmented villonodular synovitis[18], giant cell tumor of tendon sheath[18] and abscess[19].

Malignant soft tissue tumors (Fig. 5, 6), liposarcoma, MFH, synovial sarcoma and spindle cell sarcoma were found in equal numbers (5 patients) in the present report. Most of these tumors attained large size (> 5cm), had heterogeneous signals on T2-weighted and variable amount of peritumoral edema or invasion as well as variable amount of necrosis. Benign and malignant masses demonstrated substantial overlap regarding to tumor size, origin, margin, signal homo-geneity on T1-weighted, hemorrhage, and bone and neurovascular involvements. Ma et al[20] showed rapid rim enhancement with delayed central fill-in for malignant mass, not present in benign mass. This MRI parameter could help differentiate indeterminate soft tissue mass. Moreover, knowledge of soft tissue tumor prevalence studied by Kransdorf[9,10] will further assist a suitably ordered differential diagnosis when a soft tissue tumor has nonspecific radiologic appearance.

In conclusion although no single MRI feature was diagnostic for any soft tissue tumors in the present study, the presence of heterogeneous T2 signal, perilesional edema or invasion and necrosis of the mass allowed MRI differentiation of malignant from benign soft tissue lesions.

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การศึกษาวิเคราะห์เกณฑ์ใน MRI เพื่อแยกโรคเนื้องอกของเนื้อเยื่อชนิดไม่ร้ายแรงและร้ายแรง

ศิริพรรณ กัลยาณรุจ

เป็นการศึกษาวิเคราะห์เนื้องอกของเนื้อเยื่อชนิดไม่ร้ายแรงและร้ายแรงด้วยเครื่องสนามแม่เหล็กไฟฟ้าของผู้ป่วยจำนวน 85 ราย ในระยะเวลา 5 ปี (พ.ศ. 2546 – 2550) มีเนื้องอกชนิดไม่ร้ายแรง 50 ราย ชนิดร้ายแรง 35 ราย ใน 82 รายได้รับผลพิสูจน์ชิ้นเนื้อทางพยาธิวิทยา ใน 3 รายมีลักษณะจำเพาะทางสนามแม่เหล็กไฟฟ้าว่าเป็นก้อนไขมัน เกณฑ์การวินิจฉัยทางสนามแม่เหล็กไฟฟ้าที่ใช้แยกระหว่างเนื้องอกชนิดไม่ร้ายแรงและชนิดร้ายแรง ขึ้นอยู่กับขนาดต้นกำเนิด สัญญาณภาพทางสนามแม่เหล็กไฟฟ้าในภาพ T1 และ T2 มีบวมหรือลุกลามบริเวณรอบ ๆ มีเลือดออก มีเนื้อตาย มีลุกลามเข้ากระดูก หลอดเลือด และเส้นประสาทหรือไม่ พบลักษณะภาพทางสนามแม่เหล็กไฟฟ้าที่มีนัยสำคัญทางสถิติระหว่างเนื้องอกชนิดไม่ร้ายแรงและร้ายแรง ($p < 0.05$) ซึ่งลักษณะดังกล่าวจะบ่งชี้ว่า เป็นเนื้องอกร้ายแรงได้แก่ สัญญาณภาพทางสนามแม่เหล็กไฟฟ้าไม่สม่ำเสมอในภาพ T2 มีบวมหรือลุกลามบริเวณรอบ ๆ และมีเนื้อตาย