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ORIGINAL ARTICLE

Magnetic Resonance Imaging Features and Assessment of Local Extent of Localised Giant Cell Tumour of the Tendon Sheath in Fingers

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ABSTRACT

Objectives: *To determine the magnetic resonance (MR) imaging features of localised giant cell tumour of the tendon sheath in fingers and to evaluate the preoperative diagnostic performance of MR imaging in assessment of the local tumour extent.*

Methods: *Between January 2003 and December 2013, MR images of patients with surgically resected and histologically proven giant cell tumour of the tendon sheath in fingers in a regional hospital in Hong Kong were retrospectively reviewed. MR imaging appearance and local tumour extent — including invasion of tendon, bone, joint, and tenosynovial space — were evaluated and compared with surgical findings.*

Results: *The MR signal intensity of giant cell tumour of the tendon sheath in fingers of 29 patients was consistently equal to or lower than that of skeletal muscle on T1- and T2-weighted images. More than half of the lesions (17 tumours, 58.6%) had a high signal intensity on T2-weighted images with fat suppression. All tumours demonstrated a variable degree of enhancement and almost all (12/13 tumours, 92.3%) demonstrated blooming artefacts. The local tumour extent with invasion of tendon, bone, joint, and tenosynovial spaces was consistent with surgical findings in most of the examined cases, with an accuracy of 100%, 93.1%, 100%, and 96.6%, respectively. The degree of tumour encasement of the tendon was the only statistically significant predictor for tenosynovial space invasion (odds ratio = 1.0; p = 0.008). All 29 cases were completely excised with no tumour recurrence after a mean follow-up of 3.4 years (standard deviation, 2.1 years; range, 0.6-8.0 years).*

Conclusion: *Giant cell tumour of the tendon sheath in the fingers is characteristic on MR images. MR imaging can accurately assess the local tumour extent and may help preoperative surgical planning, enable complete resection, and reduce tumour recurrence.*

Key Words: *Fingers; Giant cell tumors; Magnetic resonance imaging; Recurrence*

中文摘要

手指局限性腱鞘巨細胞瘤的磁共振成像特點和腫瘤局部侵犯範圍的評估

朱炳容、曾佩琪、王慧瑜、陳煥章、吳家榮、袁銘強

目的：發現手指局限性腱鞘巨細胞瘤的磁共振（MR）成像特點，以及MR成像在術前評估腫瘤局部侵犯範圍的診斷效用。

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方法：回顧分析2003年1月至2013年12月期間，香港一所分區醫院內進行手術切除並經病理學證實為手指腱鞘巨細胞瘤的患者。評估MR成像特點和局部腫瘤範圍（包括受侵犯的肌腱、骨骼、關節和腱鞘間隙），並與手術結果進行比較。

結果：29例手指腱鞘巨細胞瘤的MR信號強度在T1和T2加權圖像上均與骨骼肌信號相等或偏低。超過一半病灶（17個腫瘤，58.6%）在T2加權脂肪抑制圖像表現為高信號。所有腫瘤呈現出不同程度的強化，幾乎所有腫瘤（13個腫瘤中的12個，92.3%）顯示有「開花徵」。大多數病例中，MR圖像顯示的肌腱、骨骼、關節和腱鞘空間的受侵範圍與手術結果一致，準確度依次為100%、93.1%、100%和96.6%。腱鞘被腫瘤包繞的程度是腱鞘間隙受侵唯一一個具統計學顯著性的預測因子（比值比=1.0；p=0.008）。所有29個病例經手術完全切除巨細胞瘤，平均隨訪期3.4年（標準差2.1年；介乎0.6-8.0年）後無復發病例。

結論：手指腱鞘巨細胞瘤的MR成像具有特徵性。MR成像能準確評估腫瘤局部侵犯範圍，有助於制定術前計劃，促使完整切除腫瘤，繼而減少復發。

INTRODUCTION

Giant cell tumour of the tendon sheath is a benign synovial proliferative disorder of unknown aetiology. It has localised, intra-articular, and diffuse forms.[1] The localised form, also known as nodular tenosynovitis, is the most common form and is the second most common mass in the hand after ganglion cyst.[2] Most giant cell tumours of the tendon sheath in the hand occur in the fingers.[3,4] They usually present as a slow-growing mass in the volar aspect of the first three fingers, in the third to fifth decade, and with a slight female predominance.[1,4]

A giant cell tumour of the tendon sheath in the fingers can invade adjacent structures, including the tendon, bone, joint, and tenosynovial space.[4-6] The tumour can have a recurrence rate of 9% to 44%.[5] Surgeons need to make an accurate pre-surgical diagnosis, and know the exact tumour location, and extent and invasion of adjacent tissue and space, in order to decide surgical approach and plan the procedure. This may help achieve complete tumour resection and thus reduce recurrence.

Magnetic resonance (MR) imaging is useful in the preoperative diagnosis of giant cell tumour of the tendon sheath but few studies have evaluated the local tumour extent of this soft tissue tumour.[4,7]

In this study, we reviewed the MR imaging features of 29 surgically resected and pathologically proven giant cell tumours of the tendon sheath in the fingers, evaluate the local tumour extent and invasion of adjacent tissue and space, and compare them with the surgical findings.

METHODS

Subjects

This was a retrospective study conducted at Tuen Mun Hospital in Hong Kong and approved by the Institutional Clinical and Research Ethics Committee. Consecutive cases that involved MR imaging of the hand performed from January 2003 to December 2013 were retrieved from the Cluster Radiology Information System of the Hospital Authority, Hong Kong. The corresponding clinical information, surgical records, and pathology reports were retrieved from the electronic Patient Record (ePR). Only those finger lesions with surgical resection and a documented pathological diagnosis of giant cell tumour of the tendon sheath were included. A total of 29 patients were recruited. All lesions were the localised form of giant cell tumour of the tendon sheath.

Magnetic Resonance Examination

MR imaging examinations were performed in eight patients with a 3.0 T system (Philips Achieva 3.0 TX; Philips Healthcare, Best, Netherlands), 11 patients with a 1.5 T system (Philips Achieva 1.5 T; Philips Healthcare, Best, Netherlands), and 10 patients with a 1.5 T system (General Electric Signa, Milwaukee [WI], USA). The fields of view varied from 4 to 12 cm. The slice thickness varied from 1 to 3 mm and the slice gap varied from 0 to 0.3 cm. Matrices of 144-560 x 224-640 were used. Axial and either sagittal or coronal images, or both, were obtained for all lesions.

Turbo spin-echo (TSE) T1-weighted imaging (pulse

sequences: TR/TE 400-778/17-22) was used in all patients. TSE T2-weighted imaging (pulse sequences: TR/TE 1195-4100/100) and T2-weighted imaging with fat suppression technique (pulse sequences: TR/TE 1819-5622/40-100) were also used in all of the 29 patients. T2-weighted gradient-echo imaging (pulse sequences: TR/TE 450-550/5.8-23) was carried out in 13 patients. T1-weighted imaging with fat suppression technique and gadolinium contrast administration (pulse sequences: TR/TE 470-748/20) was performed in 29 patients.

Magnetic Resonance Imaging Analysis

MR images were reviewed by two Fellow radiologists (with experience or training in musculoskeletal imaging) using PACS station (IMPAX; Agfa Healthcare, NV, Belgium). Although the diagnosis of giant cell tumour of the tendon sheath in fingers was known, they were blinded to the surgical findings and any additional clinical data. If there was disagreement between the two readers, a consensus was reached after further discussion. Each lesion was evaluated for the following: location, mean size, shape, margination, signal intensity, signal homogeneity, contrast enhancement pattern, blooming artefact, tumour extent around the tendon, tumour extent around the phalanx, presence of peritendinous fluid, presence of joint fluid, presence of capsule and its continuity, and presence of septations with the tumour.

The signal intensity of giant cell tumour of the tendon sheath was compared with that of normal skeletal muscle and subcutaneous fat in the T1-weighted and T2-weighted images. The enhancement pattern was evaluated by comparing the post-contrast images with pre-contrast images and defined as none, mild, moderate, or avid enhancement. The signal homogeneity of the lesion in T1-weighted, T2-weighted and contrast-enhanced images was also evaluated and defined as either homogeneous or inhomogeneous. In T2-weighted gradient-echo sequences, the presence of very low signal foci was defined as blooming artefact.

Tumour extent around the tendon and phalanx was defined as the degree of circumferential encasement by the tumour around the tendon and phalanx on an axial plane respectively, as illustrated in Figure 1. The invasion of giant cell tumour of the tendon sheath in adjacent tissues and space, including tendon, bone, joint, and tenosynovial space, was evaluated. These invasions were compared with the surgical findings that served as the gold standard. We defined tendon invasion as abnormal tendon signal intensity, and enlargement or thinning of the tendon; bone invasion as cortex erosion and marrow invasion; joint invasion as extension of tumour into the joint space; and tenosynovial space invasion as presence of the tumour between the tendon and phalanx.

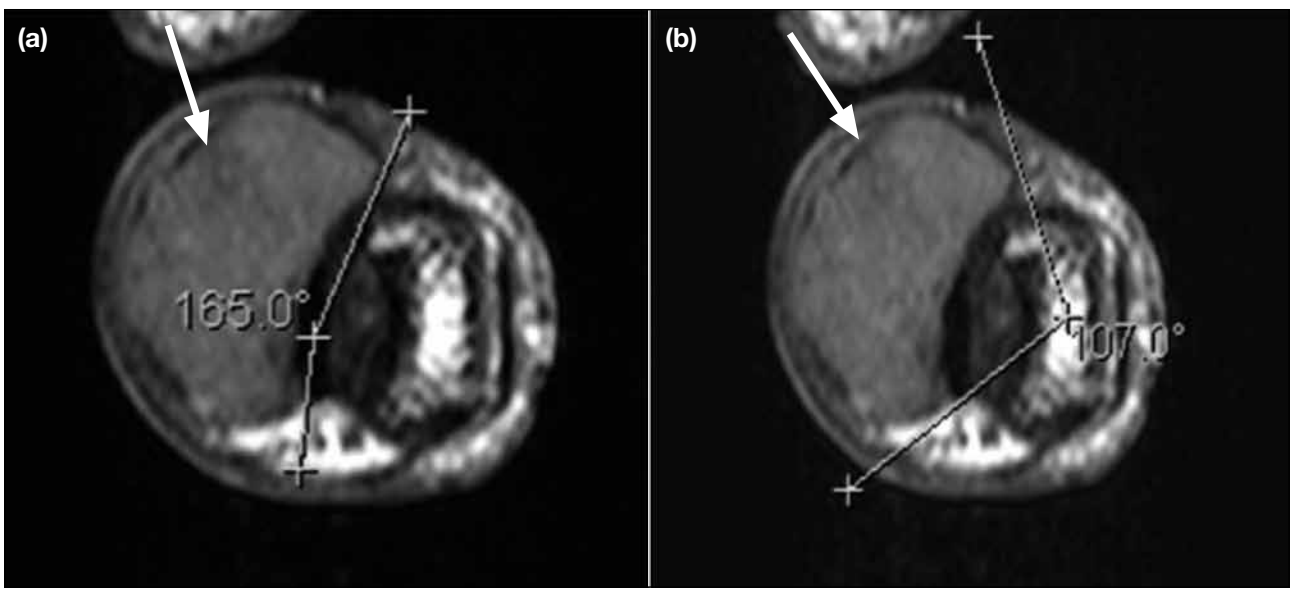

Figure 1. (a) Tumour extent around the tendon is determined by degree of circumferential encasement of the tumour (arrow) around the centre of the tendon on an axial plane. It was 195° (360°-165°) encasement in this patient. (b) Tumour extent around the phalanx is determined by degree of circumferential encasement of the tumour (arrow) around the centre of the phalanx on an axial plane. It was 107° encasement in this patient.

Statistical Analysis

Binary logistic regression forward step analysis was used to evaluate the association of the following with the definitive surgical diagnosis of tendon, bone, joint, and tenosynovial space invasion: age, gender and MR imaging characteristics including the tendon involved, size of tumour, shape of tumour, margination of tumour, presence of capsule in tumour, degree of tumour around tendon, degree of tumour around phalanx, presence of septations in tumour, presence of peritendinous fluid and joint fluid adjacent to tumour. An adjusted diagnostic odds ratio (OR) was calculated for each characteristic and $p < 0.05$ was considered statistically significant. All statistical analyses were performed using the Statistical Package for the Social Sciences (Windows version 18.0; SPSS Inc, Chicago [IL], USA).

Table 1. Demographic data of patients with giant cell tumour of the tendon sheath in fingers (n = 29).

Demographics	Data*
Age (years)	45.1 ± 15.2 (17-68)
Gender	
Male	7 (24.1)
Female	22 (75.9)
Presenting symptoms	
Mass	29 (100)
Pain	2 (6.9)
Numbness	5 (17.2)
Follow-up (years)	3.4 ± 2.1 (0.6-8.0)

* Data are shown as mean ± standard deviation (range), or No. (%).

Table 2. Distribution of giant cell tumour of the tendon sheath in fingers (n = 29).

Distribution	No. (%) of patients
Finger	
Thumb	7 (24.1)
Index	12 (41.4)
Middle	5 (17.2)
Ring	3 (10.3)
Little	2 (6.9)
Tendon involvement	
Flexor	23 (79.3)
Extensor	4 (13.8)
Both flexor and extensor	2 (6.9)
Level of involvement	
Proximal phalanx	13 (44.8)
Middle phalanx	8 (27.6)
Distal phalanx	4 (13.8)
Proximal and middle phalanx	3 (10.3)
Middle and distal phalanx	1 (3.4)

RESULTS

Of the 29 patients, seven (24.1%) were male and 22 (75.9%) were female. The mean age was 45.1 years (range, 17-68 years). All 29 patients presented with a solitary mass, 27 (93.1%) presented with a painless mass and two (6.9%) presented with a painful mass. Numbness was also present in five (17.2%). There was no recurrent tumour among the 29 patients. Demographics of these patients are shown in Table 1. The distribution of giant cell tumour of the tendon sheath in fingers is summarised in Table 2.

Extensive encasement of the tendon by the tumour was seen. The mean degree of tendon encasement was 211.7° (standard deviation [SD], 99.9°; range, 30°-360°) as determined by our measurement method. Tumour encasement of the entire circumference of the tendon was observed in six (20.7%) patients. The tumour extent around the phalanx was also extensive. The mean degree of circumferential occupation was 153.8° (SD, 72.3°; range, 20°-360°). Tumour extending to the entire circumference of the phalanx was seen in one (3.4%) patient. The MR imaging characteristics of giant cell tumour of the tendon sheath in fingers are shown in Table 3.

Table 3. Magnetic resonance imaging characteristics of giant cell tumour of the tendon sheath in fingers (n = 29).

Characteristic	Data*
Size (cm)	1.5 ± 0.5 (0.8-3.2)
Shape	
Oval or round	26 (89.7)
Irregular	3 (10.3)
Margination	
Good	27 (93.1)
Poor	2 (6.9)
Capsule	
Present	28 (96.6)
Absent	1 (3.4)
Continuity of capsule	
Continuous	0
Discontinuous	29 (100)
Tumour around tendon (degrees)	211.7 ± 99.9 (30-360)
Tumour around phalanx (degrees)	153.8 ± 72.3 (20-360)
Septations	
Present	17 (58.6)
Absent	12 (41.4)
Peritendinous fluid	
Present	0 (0)
Absent	29 (100)
Joint fluid	
Present	0 (0)
Absent	29 (100)

* Data are shown as mean ± standard deviation (range), or No. (%).

MR signal intensity of giant cell tumour of the tendon sheath on T1-weighted images was consistently equal to or lower than that of skeletal muscle in the 29 patients. They were either homogeneous (n = 15, 51.7%) or inhomogeneous (n = 14, 48.3%). On T2-weighted images with no fat suppression, the signal intensity also tended to be low or equal to that of skeletal muscle (n = 28, 96.6%); only one (3.4%) patient had a higher signal intensity. Nonetheless, on T2-weighted images with fat suppression, 17 (58.6%) patients had high signal intensity, nine (31.0%) had intermediate signal intensity, and three (10.3%) had low signal intensity. The signal intensity on T2-weighted images tended to be inhomogeneous (n = 27, 93.1%), with intermingling areas of low and intermediate signal intensity. All of the tumours demonstrated a variable degree of enhancement. Gadolinium-enhanced images with fat suppression sequence showed avid enhancement in 19 (65.5%) patients, moderate enhancement in nine (31.0%), and mild enhancement in one (3.4%). The enhancement tended to be inhomogeneous (n = 24, 82.8%). T2-weighted gradient echo sequences were performed in 13 patients; most of the cases (12/13, 92.3%) demonstrated blooming artefacts. MR imaging signal intensity, homogeneity, enhancement pattern, and blooming artefact of giant cell tumour of the tendon sheath in fingers are shown in Table 4. Figure 2 illustrates the MR imaging characteristics of localised giant cell tumour of the tendon sheath in a 66-year-old man who presented with a 2-year history of soft tissue mass in the middle finger.

The tumour invasion of adjacent tissues and space detected by MR imaging was consistent with surgical findings in most of the examined cases. There was no tendon invasion detected by MR imaging in any of the 29 examined cases or during surgery. In the case of invasion of bone by the tumour, MR imaging was able to detect three out of the four lesions with bone cortex erosion and abnormal marrow signal change (Figure 3a). MR imaging failed to detect one case (Figure 3b) probably due to the small size of the lesion. Bone invasion was said to be present on MR imaging in one case but was not confirmed during surgery. In retrospective review of the case, there was buckling of the cortex by the soft tissue tumour in the volar aspect of the proximal phalanx of the right index finger but the cortex remained intact and no marrow signal change was found. This was a false-positive case. The accuracy of detecting bone invasion was 93%. Invasion of the joint was detected in both cases (Figure 3c), yielding an accuracy of 100%. MR imaging was able to detect tenosynovial space invasion (Figure 3d) in 13 cases, but overestimated the extent of tenosynovial space invasion in one case (Figure 3e).

True-positive, true-negative, false-positive, false-negative values; sensitivity, specificity, positive predictive value, negative predictive value; and accuracy of tumour invasion of tendon, bone, joint, and tenosynovial space are shown in Table 5.

With univariate analysis, the degree of tumour around the tendon was the only statistically significant feature for tenosynovial space invasion, p = 0.008 (OR = 1.0; 95% confidence interval [CI], 1.004-1.029). These results are illustrated in Table 6.

We then further divided the degree of tumour around the tendon into 0°-90° (n = 4), 91°-180° (n = 10), 181°-270° (n = 7), and 271°-360° (n = 8). Univariate analysis revealed that 271°-360° around the tendon was the only

Table 4. MR imaging signal intensity, homogeneity, enhancement pattern, and blooming artefact of giant cell tumour of the tendon sheath in fingers.

MR imaging sequences	No. (%) of patients										
	Signal intensity			Homogeneity		Enhancement				Blooming artefact	
	Low	Inter-mediate	High	Homo-geneous	Inhomo-geneous	None	Mild	Moderate	Avid	No	Yes
T1W	6 (20.7)	23 (79.3)	0	15 (51.7)	14 (48.3)	-	-	-	-	-	-
T2W	17 (58.6)	11 (37.9)	1 (3.4)	2 (6.9)	27 (93.1)	-	-	-	-	-	-
T2W_FS	3 (10.3)	9 (31.0)	17 (58.6)	-	-	-	-	-	-	-	-
T1W+C_FS	-	-	-	5 (17.2)	24 (82.8)	0	1 (3.4)	9 (31.0)	19 (65.5)	-	-
T2*W	-	-	-	-	-	-	-	-	-	1 (7.7)	12 (92.3)

Abbreviations: MR = magnetic resonance; T1W = T1-weighted; T2W = T2-weighted; T2W_FS = T2-weighted with fat suppression; T1W+C_FS = T1-weighted with fat suppression and godolinium contrast; T2*W = T2-weighted gradient-echo imaging.

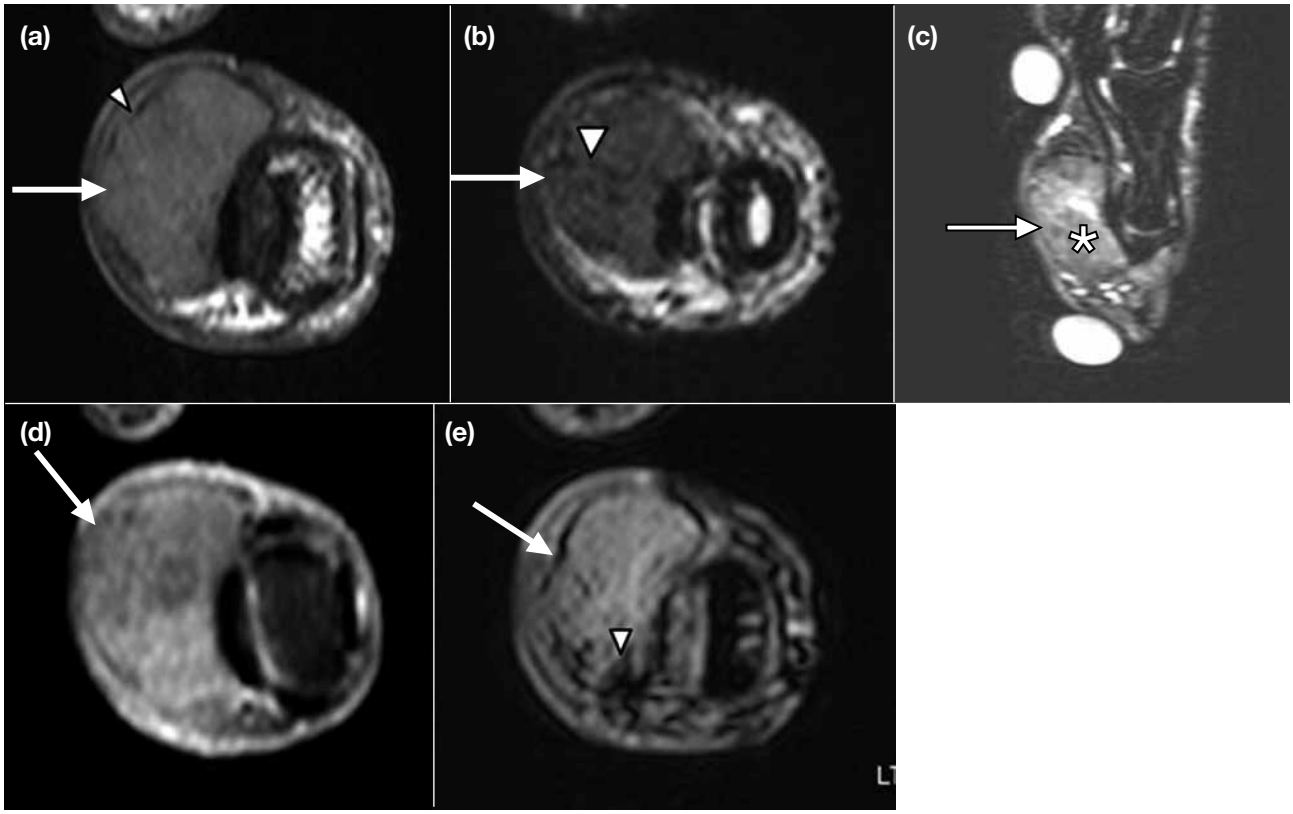

Figure 2. A 66-year-old man with giant cell tumour of the tendon sheath at the volar aspect of the middle finger. (a) An axial turbo spin-echo (TSE) T1-weighted magnetic resonance image (MRI) (TR/TE = 504/20) shows a well-marginated homogeneous oval soft tissue mass (arrow) with intermediate signal intensity. It has discontinuous low signal intensity capsule (arrowhead). (b) An axial TSE T2-weighted MRI (TR/TE = 3314/100) shows the soft tissue mass (arrow) is inhomogeneous and of low signal intensity. Thin septations are seen within the tumour (arrowhead). (c) A sagittal T2-weighted image with fat suppression (TR/TE = 4607/70) shows the soft tissue mass (arrow) is of high signal intensity and inhomogeneous with intermingling areas of low and intermediate signal intensity (asterisk). (d) An axial TSE T1-weighted image with fat suppression after gadolinium contrast (TR/TE = 550/20) shows avid enhancement of the soft tissue mass (arrow). (e) An axial T2-weighted gradient-echo image (TR/TE = 550/8.1) shows inhomogeneous intermediate signal intensity mass (arrow) with blooming artefact of low signal intensity foci (arrowhead) due to the presence of hemosiderin deposit.

statistically significant feature for tenosynovial invasion (p = 0.023; OR = 14.0; 95% CI, 1.4-137.3). These results are illustrated in Table 7.

Complete excision of the tumour was performed in all 29 cases. The mean follow-up was 3.4 (SD, 2.1; range, 0.6-8.0) years and no recurrence of the giant cell tumour of the tendon sheath was observed.

DISCUSSION

Our study found that giant cell tumour of the tendon sheath more commonly affected females (75.9%). The mean age of patients was 45.1 years and all lesions were solitary. Although most patients presented with a painless soft tissue mass, a few also presented with numbness or pain of the finger. The index finger was the digit most commonly affected, followed by the thumb and middle finger. Most lesions involved the flexor tendon sheath compared with its extensor counterpart. Giant cell tumour of the tendon sheath in fingers also tended to most commonly involve the proximal phalanx. These findings are consistent with published data.[3,8,9]

MR imaging features of giant cell tumour of the tendon sheath have been described in the literature.[1,4,10,11] They reflect the underlying histological characteristics. On T1- and T2-weighted spin-echo images, giant cell tumour of the tendon sheath had low or intermediate signal intensity. This was due to the presence of hemosiderin deposition within the lesion that exerted a paramagnetic effect that shortened T1 and T2 relaxation times.[10-12] Giant cell tumour of the tendon sheath also comprised fibrous collagenous tissue that also contributed to the low signal intensity on MR images.[1] This paramagnetic

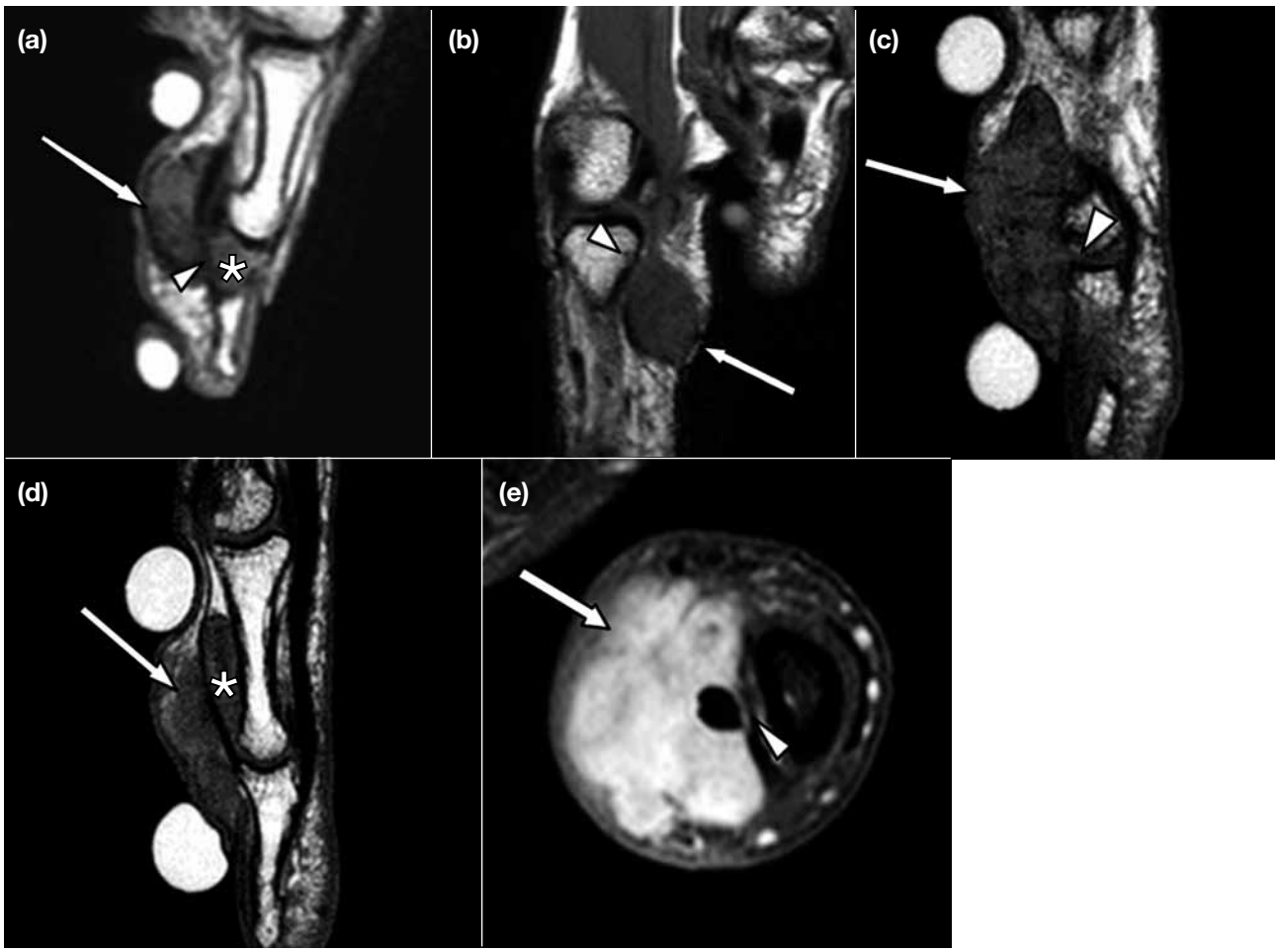

Figure 3. (a) A sagittal turbo spin-echo (TSE) T1-weighted magnetic resonance image (MRI) (TR/TE = 778/20) shows a giant cell tumour of the tendon sheath (arrow) erodes into the volar cortical surface (arrowhead) and extends into the proximal portion of the distal phalangeal bone (asterisk). (b) A sagittal TSE T1-weighted MRI (TR/TE = 504/20) shows a tiny focus of abnormal marrow signal intensity and cortical bone erosion (arrowhead) in the volar aspect of the proximal phalanx of right index finger adjacent to the soft tissue mass (arrow) .These findings were not detected by our two reviewers. At surgery, slight bony erosion was found. (c) A sagittal TSE T1-weighted MRI (TR/TE = 598/20) shows a giant cell tumour of the tendon sheath (arrow) invading into the joint (arrowhead). (d) A sagittal TSE T1-weighted MRI (TR/TE = 598/20) shows a giant cell tumour of the tendon sheath (arrow) invading the space between the extensor tendon and the phalanx (asterisk), which suggests invasion of the tenosynovial space. (e) An axial TSE T1-weighted MRI with fat suppression after gadolinium contrast (TR/TE = 556/20) shows an avidly enhancing soft tissue mass (arrow) with apparent soft tissue in the space between the flexor tendon and the phalanx (arrowhead). However, no invasion of the tenosynovial space was found in the surgery.

effect of hemosiderin was exaggerated on gradient-echo sequences due to increased magnetic susceptibility, resulting in areas of very low signal intensity (blooming artefact). The absence of blooming artefact in one patient may have been due to the small amount of hemosiderin in the lesion.

Microscopic examination by Monaghan et al[2] of 71 cases of giant cell tumour of the tendon sheath revealed that all of them were well-circumscribed and lobulated or multilobulated. A fibrous capsule was universally present. Another study by Lancigu et al[6] also found that a capsule was present in 96% of cases. The capsule penetrated the tumour and divided it into smaller nodules.[7] Giant cell tumours of the tendon sheath comprise a variable amount of histiocytic mononuclear cells, multinucleated giant cells, xanthoma cells, and collagenous strands.[7] Varying degrees of hyalinisation are also seen.[2] These microscopic features were well-illustrated in MR images in our study. The heterogeneity of the MR images may also be due to these histological features.

Table 5. Tumour invasion of tendon, bone, joint, and tenosynovial space.

Adjacent structure invasion	TP	TN	FP	FN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Tendon	0	29	0	0	0	100	0	100	100
Bone	3	24	1	1	75	96	75	96	93.1
Joint	2	27	0	0	100	100	100	100	100
Tenosynovial space	13	15	1	0	100	93.8	92.9	100	96.6

Abbreviations: FN = false negative; FP = false positive; NPV = negative predictive value; PPV = positive predictive value; TN = true negative; TP = true positive.

Table 6. Univariate analysis of demographic data and MR imaging characteristics with bone, joint, and tenosynovial space invasion by giant cell tumour of the tendon sheath in fingers.

Demographics and MR characteristics	p Value		
	Bone invasion	Joint invasion	Tenosynovial space invasion
Age	0.117	0.419	0.924
Gender	0.193	1.000	0.071
Tendon involved	0.686	1.000	0.146
Size	0.072	0.178	0.467
Shape	0.300	0.248	0.823
Margination	0.558	1.000	0.153
Capsule	0.684	1.000	0.164
Degree of tumour around tendon	0.787	0.708	0.008
Degree of tumour around phalanx	0.185	0.808	0.061
Septations	0.070	0.248	0.717

Abbreviation: MR = magnetic resonance.

Table 7. Univariate analysis of degree of tumour around tendon with tenosynovial space invasion by giant cell tumour of the tendon sheath in fingers.

Degrees	p Value	Odds ratio	95% Confidence interval
0°-90°	0.116	0.4	0.3-0.7
91°-180°	0.757	0.3	0.1-1.6
181°-270°	0.102	1.6	0.3-8.9
271°-360°	0.023	14.0	1.4-137.3

Contrast enhancement was seen due to the presence of numerous proliferative capillaries in the collagenous stroma,[10,11] which was mild-to-moderate in the T1-weighted spin-echo images after gadolinium contrast. The enhancement was more conspicuous on fat suppression sequence, in which most lesions demonstrated strong contrast enhancement.

We believe these characteristic MR findings can enable correct pre-surgical diagnosis of giant cell tumour of the tendon sheath, particularly in the upper extremity. The major differential diagnosis of soft tissue mass in the hand is fibroma of the tendon sheath. It can be clinically, radiologically, and even pathologically confused with giant cell tumour of the tendon sheath.[13,14] In MR imaging, it usually appears hypointense-to-isointense on both T1- and T2-weighted sequences with no or little enhancement due to abundant acellular fibrous tissue with areas of hyalinisation.[14] Nonetheless, there may be areas of high T2 signal or enhancement, depending on composition of the fibrous tissue, myxoid changes, and cellularity.

To our knowledge, there have been few reports on assessment of the local extent of localised giant cell tumour of the tendon sheath.[4,7] Kitagawa et al[4] showed that MR imaging provided accurate assessment of tumour extent around the phalanx and invasion of the joint and tenosynovial space. Our study confirmed these findings with even higher accuracy, may be due to high-field-strength magnets (1.5 T or 3.0 T), multiple planes of the images, and the use of multiple sequences including T2-weighted with fat suppression sequence and T1-weighted with fat suppression and gadolinium contrast administration. In Kitagawa et al's study,[4] MR imaging failed to detect five cases of bone invasion that

was identified during surgery. The authors suggested that this might have been due to the small size of the lesions in the bone and a relatively low signal of the lesions. In their study, they defined bone invasion as marrow invasion or focal bulging of cortex into the marrow. In our study, we defined bone invasion as cortical erosion and abnormal marrow invasion by the tumour. This may be more appropriate as these can be easily identified on gross inspection during surgery. By these criteria, we were able to identity three out of the four lesions with bone invasion. We failed to detect one case (Figure 3b), probably due to the small area of cortical erosion and abnormal marrow signal change. In our study no tendon invasion was evident in any patient, and none was found during surgery. Identification of tendon invasion in the MR imaging report was important as it has been shown to be associated with recurrence.[6,15]

Giant cell tumour of the tendon sheath has a characteristic growth pattern with enveloping of the affected tendon.[10] Good margination of the tumour in the fingers on MR imaging enables easy assessment of the extent around the tendon and phalanx.[4,7] Our study found extensive occupation of the tendon and phalanx by the tumour. This could affect the surgical management of giant cell tumour of the tendon sheath in fingers.[4]

Degree of tumour around the tendon was the only statistically significant feature for tenosynovial space invasion in the fingers: 271°-360° encasement of the tendon by the tumour had an OR of 14.0 for tenosynovial space invasion. This finding was important as it alerted both reporting radiologists and operating surgeons to look carefully at the tenosynovial space if encasement of the tendon by the tumour was extensive. This may assist with complete resection of the tumour and thus reduce recurrence. We have also shown that age, gender, and other MR characteristics are not associated with bone, joint, or tenosynovial space invasion. To the best of our knowledge, our study is the only one to date to evaluate risk factors for tendon, bone, joint, and tenosynovial space invasion by giant cell tumour of the tendon sheath in fingers.

Careful surgical resection is the mainstay of treatment for giant cell tumour of the tendon sheath in fingers. Recurrence after resection has been a consistent problem and reported to vary from 7% to 44%.[5,6,8] Risk factors for recurrence include incomplete excision, bone erosion, intra-articular invasion by the lesion, and tendon invasion.[5,6,15] To minimise recurrence, complete marginal excision with accurate preoperative assessment of the local extent of tumour and selection of the appropriate surgical approach are needed. Our study showed that MR imaging can accurately detect local tumour extent and tendon, bone, joint, and tenosynovial space invasion. Complete surgical resection was achieved in all 29 patients with no recurrence after a mean follow-up of 3.4 years.

To our knowledge, the present study is the largest to date to examine the MR features and local extent of giant cell tumour of the tendon sheath in fingers. It is the only study to date that describes a series of patients with giant cell tumour of the tendon sheath in fingers, who underwent both MR imaging and surgical resection and who had no recurrence on follow-up.

There are several limitations to this retrospective study. It has a small sample size and patients had only one or two follow-up sessions. If there were no complications, no further follow-up was arranged. It is possible that if the patient had tumour recurrence, he/she could seek medical advice from the private sector. Such clinical information would not then be retrieved from ePR of the Hospital Authority of Hong Kong and the true recurrence rate could therefore be higher. Moreover, the recurrence rate of those giant cell tumours of the tendon sheath in fingers with no preoperative MR imaging in our hospital was unknown, thus the true recurrence rate in our centre is not definitive. We used the records of operative findings as our gold standard for the invasion of the tendon, bone, joint, and tenosynovial space. Small lesions and some minor findings on invasion of the tendon, bone, joint, and tenosynoival space might not be mentioned. Nonetheless, we remain certain that MR imaging can accurately detect local extent of giant cell tumour of the tendon sheath in fingers.

CONCLUSION

We present the MR imaging features of 29 surgically resected and histologically proven cases of localised giant cell tumour of the tendon sheath in fingers. Their characteristic MR findings can enable correct pre-surgical diagnosis. MR imaging can accurately assess local tumour extent. This is essential in preoperative planning and may help achieve complete resection and thus reduce tumour recurrence.

DECLARATION

No conflicts of interest were declared by authors.

REFERENCES

1. Llauger J, Palmer J, Rosón N, Cremades R, Bagué S. Pigmented villonodular synovitis and giant cell tumors of the tendon sheath: radiologic and pathologic features. AJR Am J Roentgenol. 1999;172:1087-91. cross ref
2. Monaghan H, Salter DM, Al-Nafussi A. Giant cell tumour of tendon sheath (localised nodular tenosynovitis): clinicopathological features of 71 cases. J Clin Pathol. 2001;54:404-7. cross ref
3. Adams EL, Yoder EM, Kasdan ML. Giant cell tumor of the tendon sheath: experience with 65 cases. Eplasty. 2012;12:e50.
4. Kitagawa Y, Ito H, Amano Y, Sawaizumi T, Takeuchi T. MR imaging for preoperative diagnosis and assessment of local tumor extent on localized giant cell tumor of tendon sheath. Skeletal Radiol. 2003;32:633-8. cross ref
5. Reilly KE, Stern PJ, Dale JA. Recurrent giant cell tumors of the tendon sheath. J Hand Surg Am. 1999;24:1298-302. cross ref
6. Lancigu R, Rabarin F, Jeudy J, Saint Cast Y, Cesari B, Fouque PA, et al. Giant cell tumors of the tendon sheaths in the hand: review of 96 patients with an average follow-up of 12 years. Orthop Traumatol Surg Res. 2013;99(4 Suppl):S251-4. cross ref
7. Sherry CS, Harms SE. MR evaluation of giant cell tumors of the tendon sheath. Magn Reson Imaging. 1989;7:195-201. cross ref
8. Ushijima M, Hashimoto H, Tsuneyoshi M, Enjoji M. Giant cell tumor of the tendon sheath (nodular tenosynovitis). A study of 207 cases to compare the large joint group with the common digit group. Cancer. 1986;57:875-84. cross ref
9. Ozalp T, Yercan H, Kurt C, Ozdemir O, Coskunol E. Giant cell tumour of the tendon sheath involving the hand or wrist: an analysis of 141 patients [in Turkish]. Acta Orthop Traumatol Turc. 2004;38:120-4.
10. Jelinek JS, Kransdorf MJ, Shmookler BM, Aboulafia AA, Malawer MM. Giant cell tumor of the tendon sheath: MR findings in nine cases. AJR Am J Roentgenol. 1994;162:919-22. cross ref
11. De Beuckeleer L, De Schepper A, De Belder F, Van Goethem J, Marques MC, Broeckx J, et al. Magnetic resonance imaging of localized giant cell tumour of the tendon sheath (MRI of localized GCTTS). Eur Radiol. 1997;7:198-201. cross ref
12. Kransdorf MJ, Murphy MD. MR imaging of musculoskeletal tumors of the hand and wrist. Magn Reson Imaging Clin N Am. 1995;3:327-44.
13. Chung EB, Enzinger FM. Fibroma of tendon sheath. Cancer. 1979;44:1945-54. cross ref
14. Fox MG, Kransdorf MJ, Bancroft LW, Peterson JJ, Flemming DJ. MR imaging of fibroma of the tendon sheath. AJR Am J Roentgenol. 2003;180:1449-53. cross ref
15. Williams J, Hodari A, Janevski P, Siddigui A. Recurrence of giant cell tumors in the hand: a prospective study. J Hand Surg Am. 2010;35:451-6. cross ref