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Magnetic resonance imaging aspects of giant-cell tumours of bone

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Abstract

Introduction: This study aimed to describe the magnetic resonance imaging (MRI) features of giant-cell tumours of bone.
Methods: We analysed the clinical and MRI features of patients diagnosed with giant-cell tumours of bone confirmed by histopathology at our institution between 2010 and 2012.
Results: The peak incidence was between the second and third decades of life. There was no gender predominance. The most frequent locations were the knee and wrist. Pain and swelling were the prevailing symptoms. Fifty-one per cent of the patients were found to have associated secondary aneurysmal bone cysts on histopathology. On MRI, lesions demonstrated signal intensity equal to that of skeletal muscle on T1-weighted images and low signal intensity on T2-weighted images in 90% of cases. In gadolinium-enhanced T1-weighted images, 76.6% of cases demonstrated heterogeneous enhancement. We observed cystic components involving more than 50% of the lesion in 17 cases (56.6%). There was extra-osseous involvement in 13 cases (43.3%).
Conclusion: MRI offers a valuable diagnostic tool for giant-cell tumours of bone. Contrast-enhanced MRI can distinguish between cystic and solid components of the tumour. MRI is also the imaging modality of choice for evaluation of soft-tissue involvement, offering a complete preoperative diagnosis.

Key words: aneurysmal bone cyst; bone tumour; giant-cell tumour of bone; MRI; X-ray.

Introduction

Giant-cell tumours of bone (GCTB) account for 20% of all benign tumours and 5% of all bone tumours, with some of the highest incidence rates observed in China.[1,2] The lesion most commonly affects the younger population, usually during the second and third decades of life; occurrence before epiphyseal plate closure is uncommon.[1–8] Generally, there is no gender predominance.[1–6] Typical locations for presentation are the distal femur, proximal tibia, distal radius and sacrum.[1–6]

Pain is the most common symptom in GCTB because mechanical insufficiency resulting from bone destruction predisposes patients to fracture.[2] Soft-tissue swelling results from cortical rupture with extra-osseous involvement.[1,2,9] Malignant degeneration is extremely rare, occurring in less than 1% of cases and generally related to prior radiotherapy of the lesion.[4,6] Lung metastases have been reported in 1–6% of cases.[1,5,6]

Treatment of GCTB is controversial.[2–6,8] There are several treatment regimens, including curettage, cementation, resection, radiotherapy, embolization and chemotherapy.[2–4] GCTB has a high incidence of local recurrence after curettage.[10–14] The rate of recurrence may reach 37%.[2,3,5,6,10,11] Recently, the use of the chemotherapy agent denosumab, a monoclonal antibody that inhibits osteoclastic activity of GCTB cells, has shown good results in attempts to reduce the dimensions of the lesion, making subsequent surgical resection easier in cases of aggressive tumours.[5,12–15]

In this article, the clinical records and magnetic resonance imaging (MRI) findings of patients with a GCTB were reviewed to define the typical MRI features of this

tumour. We discuss atypical imaging features of GTCB and how they may affect classification.

Methods

This study analysed the clinical and MRI features of 60 patients diagnosed with GCTB, confirmed by histopathology at our institution between 2010 and 2012. Our institutional review board approved the study.

The medical records of all patients were evaluated to obtain data regarding gender, age, site of the lesion and symptoms. Of the total, 30 patients (50%) underwent MRI. Only examinations performed in high-field 1.5-T equipment including at least T1- and T2-weighted sequences, with some T1-weighted images being fat-suppressed with intravenous gadolinium, were considered for analysis.

Each MRI examination was evaluated by two radiologists, one with 6 years of experience in musculoskeletal imaging (HMP) and one with more than 18 years of experience (AS), who independently read the images. Discrepancies were resolved by a consensus reading. We evaluated the signal intensity in the T1- and T2-weighted sequences compared with normal adjacent muscles as intermediate, low or high and the contrast enhancement pattern as homogeneous or heterogeneous. We also determined whether there were multiple cysts intermingled with the solid component (involving more than 50% of the lesion). Fisher's exact test was performed to determine the correlation between the appearance of cysts on MRI and the confirmation of GCTB/associated aneurysmal bone cyst (ABC) by histopathology.

We examined MRI sequences for extra-osseous involvement of lesions, presenting as cortical bone destruction and tumour infiltration of fat planes. In cases where such involvement was found, we also evaluated radiographs for better staging, considering those taken within 1 month of the MRIs. We examined MRI sequences for extra-osseous involvement of lesions, presenting as cortical bone destruction and tumour infiltration of fat planes. In cases where such involvement was found, we also evaluated radiographs considering those taken within 1 month of the MRIs for better staging followed Campanacci and Enneking.[2,4,8]

Results

Pain and soft-tissue swelling of the limb affected by the lesion were the leading symptoms, occurring in 86% of cases. The other cases were diagnosed on imaging after radiography, with no identifiable complaints in the medical records.

There was no gender predominance. The mean age was 39 years and the median 35 years (14 to 70 years). The most common sites affected were the distal femur (34%); proximal tibia (28%); distal radius (17%); metacarpals (9%); distal tibia (6%); proximal humerus and femur and distal ulna (4%); and sacrum, metatarsals, and proximal ulna and pelvis (2%).

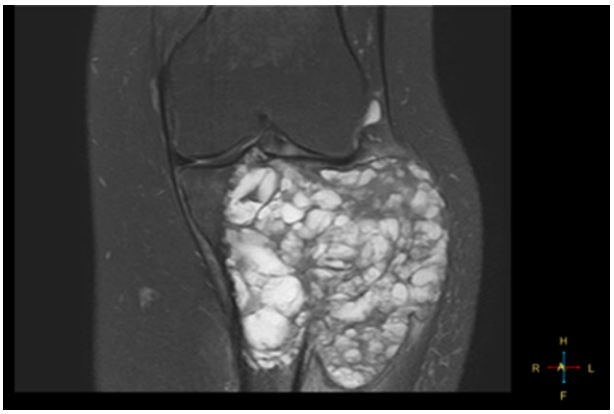

Fig. 1. A 26-year-old woman with a voluminous expansile lesion involving the proximal tibia with cystic predominance and solid areas of reduced signal in T2-weighted sequence. Giant-cell tumour of bone was confirmed by histopathology. The presence of a secondary aneurysmal bone cyst was not observed.

Of the 60 patients, 51.6% (31 patients) presented with associated secondary ABC confirmed by histopathological examinations. The solid components of these lesions showed moderate signal intensity in the T1-weighted MRI sequence and low signal intensity in the T2-weighted sequence in 90% of the cases (27 patients), and heterogeneous contrast enhancement predominated in 76.6% of cases (23 patients). Multiple cysts intermingled with the solid component of the lesion (involving more than 50% of the lesion) were present in 56.6% of cases (17 patients). This finding could suggest the possibility of an associated secondary ABC component.[5,16,17] However, Fisher's exact test did not show a statistically significant correlation (*P*-value = 0.1590; Fig. 1 and Table 1).

Lesions with heterogeneous enhancement predominated and were found in 76.6% of patients (23 cases), and homogeneous enhancement was seen only in small lesions (<5 cm) with no intermingled cystic components or extra-osseous involvement. The MRI showed extra-osseous involvement in 43.3% of cases (13 patients); this was also observed on radiography in only 9 of them.

Table 1. Contingency table for observation of cysts on MRI and histopathological confirmation of aneurysmal bone cysts

MRI	Histopathology	
	Aneurysmal bone cysts present	Aneurysmal bone cysts absent
Cysts involving >50% of lesion	10 cases	7 cases
Cysts absent or involving <50% of lesion	4 cases	9 cases

Fisher's exact test showed no association at 99% confidence level between observation of cysts on MRI and the presence of aneurysmal bone cyst components in giant-cell tumours of bone ($P = 0.1590$).

Discussion

GCTB is a benign lesion that affects the younger population and typically presents eccentrically in the epiphysiometaphyseal region of long bones.[2–6,8,18] In this study, the patients diagnosed with GCTB had a mean age of 39 years. There was no evidence of gender predominance, although some previous case series showed a slightly higher incidence in female patients when the site involved was the spinal column.[7–9,19] The locations most often affected were the distal femur, proximal tibia and distal radius. These findings are in accordance with those of various other authors.[1,5,6,8,12,13]

The differential diagnosis for a possible case of GCTB should include ABC, chondroblastoma and clear-cell chondrosarcoma, as all these lesions are eccentrically located.[2,3,5,6] Other potentially epiphyseally located lesions should also be considered, such as purely lytic or giant-cell-rich osteosarcoma, brown tumour of hyperparathyroidism, malignant fibrous histiocytoma or fibrosarcoma of the bone, plasmacytoma, and epiphyseal metastasis from a tumour elsewhere in the body.[2,3,6]

On radiographs, GCTB usually presents as a lytic lesion with non-sclerotic and sharply defined borders. The lesion is usually eccentric, extending to the subchondral bone. It may also display aggressive features, such as cortical thinning, expansile remodelling or even cortical bone destruction.[2–6,8]

Campanacci and Enneking's clinical radiological staging system divides GCTB into three stages. In stage I, the lesion is restricted to the bone marrow and bone contour is not affected, although the cortex can be thinned; in stage II, the lesion causes bulging of the cortex, but with no signs of rupture; and in stage III, there is cortical rupture with invasion of soft tissues.[8,9,16,20] This classification is used to guide treatment in most cases, despite not predicting the outcome.[2,3,16–20]

On MRI, the solid component of GCTB usually presents with intermediate signal intensity in the T1-weighted sequence and low signal intensity in the T2-weighted sequence[5,6,16] (Fig. 2a,b). In our study, 90% of the lesions demonstrated this feature. This appearance is due to the collagen content of the fibrous components as well as the deposition of hemosiderin within the tumour,[16,19] and although it is not exclusive to GCTB, it is quite useful in suggesting the diagnosis, as most other neoplasms with the same distribution show high signal intensity in the T2-weighted sequence.[6]

The use of intravenous gadolinium allows differentiation between the cystic and solid components of the lesion, preventing misdiagnosis of the lesion as a primary ABC (which would contain only cystic components) and allowing biopsy to be directed towards the solid portions of the lesions[5,6] (Fig. 2c). Cystic areas, evidence of haemorrhage and fluid–fluid levels may also be apparent in T1- and T2-weighted images. If cystic

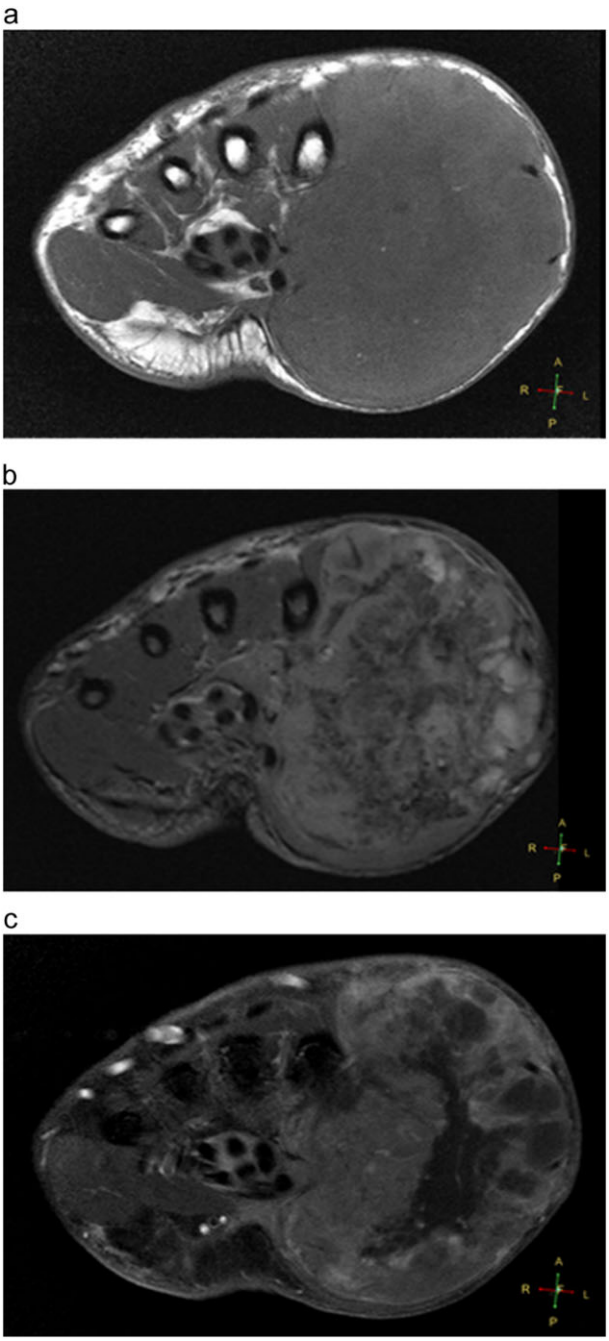

Fig. 2. A 58-year-old man with a solid expansile lesion involving the first metacarpal, presenting with intermediate signal intensity in the T1-weighted sequence (a) and low signal intensity in the T2-weighted sequence, with areas suggestive of interspersed deposition of hemosiderin (b) and heterogeneous enhancement after contrast (c). Giant-cell tumour of bone was confirmed by the histopathological exam. Peripheral cystic areas are also noted.

areas are noted within the lesion, a secondary ABC component may be suspected.[5,17] ABC is a benign cystic lesion of bone composed of blood-filled spaces separated by connective tissue septa and may be either primary or secondary.[5,17] GCTB is the lesion most commonly associated with secondary ABCs, representing 19% to 39% of such cases.[2,5,6,17] According to Kransdorf and Sweet, cases of GCTB associated with secondary ABCs may have an increased rate of local tumour recurrence.[10,17]

In our study, the incidence of secondary ABC components in GCTB confirmed by histopathology was much higher than in previous studies, representing 53.4% of GCTB cases (31 cases). This could be related to the profile of our institution, which tends to receive patients with more complex lesions for treatment, as GCTB associated with prominent ABC components may present with a more aggressive radiographic appearance, leading to misdiagnosis as a malignant lesion.

Although the literature has suggested that identification on MRI of multiple cysts may indicate the presence of associated secondary ABC components,[5,17] in this study, there was no statistically significant correlation. Perhaps novel MR imaging techniques such as diffusion-weighted imaging, perfusion scanning and magnetic resonance spectroscopy could help confirm this association.

Treatment of GCTB is still based primarily on radiographic staging following Campanacci and Enneking. MRI is still an expensive method of examination and not widely available in developing countries, and some orthopaedic surgeons do not use MRI for small lesions (stages I and II). We believe these are some of the reasons only 30 patients in our population had undergone MRI.

We observed extra-osseous involvement on MRI in 43.3% of cases (13 patients), but in 4 cases the extra-osseous involvement was not visible on radiography. Thus, in our study, the two methods gave divergent results in one-third of the patients (Fig. 3). Accordingly, we recommend that orthopaedic surgeons should always use MRI for GCTB, even in small lesions, because of its improved accuracy in terms of staging.

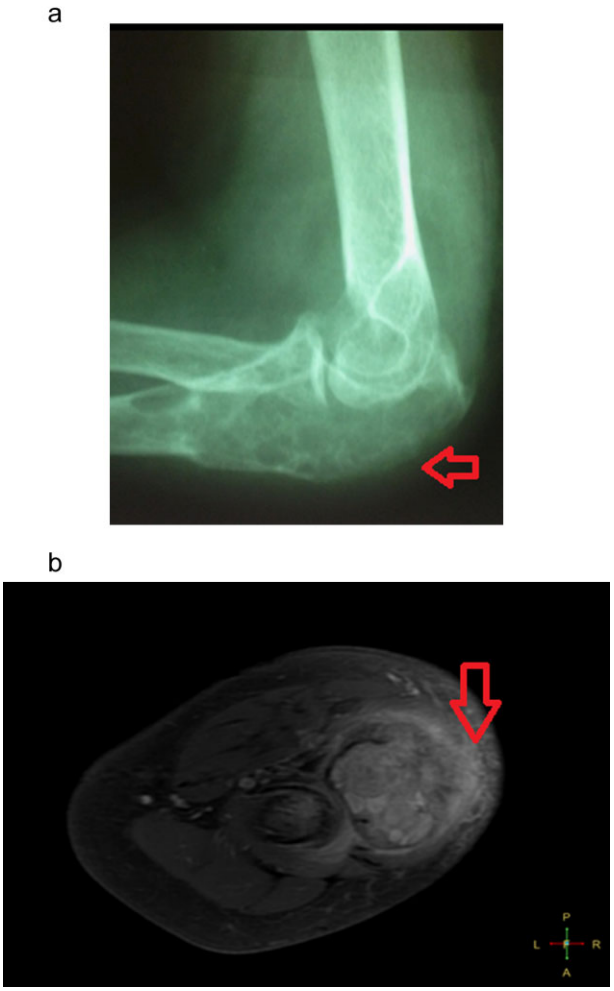

Fig. 3. (a) A 32-year-old woman with an osteolytic expansile lesion involving the proximal ulna, with no signs of extra-osseous involvement observed on radiography (Campanacci II). (b) Axial MRI T1-weighted sequence with fat suppression after intravenous contrast injection, performed after radiography, demonstrating extra-osseous involvement (Campanacci III).

Conclusions

As GCTB is a high-incidence lesion that is commonest in the young population, early diagnosis and treatment are necessary in order to avoid greater bone compromise and to allow preservation of joint function. Although radiography may suggest a diagnosis of GCTB, in doubtful cases, MRI can help confirm the diagnosis, given the typical low signal intensity of GCTB in T2-weighted sequences.

The appearance of multiple cysts on MRI is not sufficient diagnostic confirmation of ABC components in GCTB; histopathological confirmation is still required. Nevertheless, MR imaging has the potential to assist in secondary ABC detection, and novel MRI techniques may become reliable, high-validity, non-invasive methods for this.

Preoperative planning and therapy are still based primarily on radiographic staging following Campanacci and Enneking. However, as MRI provides better evaluation of extra-osseous involvement than does radiography, it is probable that radiography results in underdiagnosis of some lesions. Thus, MRI can play an important role in diagnosis, even in small lesions.

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