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Research paper

Marrow signal mimicking tumor on MRI T1-weighted imaging after neoadjuvant chemotherapy in extremity osteosarcomas

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ABSTRACT

Purpose: Many studies had demonstrated that MRI T1-weighted imaging was the most accurate method to evaluate the intramedullary extent of extremity osteosarcoma. However, we found that after neoadjuvant chemotherapy new low signal of MRI T1 imaging was detected near tumor, which mimicked the tumor progression. The aim of this study was to describe the incidence and type of this new signal, to reveal the pathological correlation with this imaging change.

Methods: We included 74 extremity osteosarcomas managed between June 2011 and November 2012 in this retrospective study. The T1-weighted MRI images of the affected extremity before and after neoadjuvant chemotherapy were reviewed and compared. The subjects were then classified according to the appearance of the border between the area involved by osteosarcoma and the normal marrow with attention paid to whether the border was continuous and the width of the zone of transition. The study population was classified into one of four classifications: 'clear', 'continuous diffuse', 'discontinuous island-like' and 'discontinuous diffuse'. 11 patients underwent MRI of bilateral extremities, and for these patients we assessed the appearance of the uninvolved extremity with that with osteosarcoma. Following surgical resection of the tumor, the pathologic appearance was compared with the pre-operative MRI findings.

Results: According to our classification system, all 74 subjects were 'clear' before neoadjuvant chemotherapy. After neoadjuvant chemotherapy, 30 subjects (40.5%) were still clear. Of the 44 subjects (59.5%) not classified as 'clear', 22 (29.7%) were classified as 'continuous diffuse', 4 (5.4%) as 'discontinuous island-like', and 18 (24.3%) as 'discontinuous diffuse'. Of the subjects with MRI of bilateral femurs, no radiologic difference was noted in the normal marrow bilaterally. No significant difference in overall survival and relapse free survival was noted between patients grouped according to the subtypes of MRI noted.

Conclusions: Neoadjuvant chemotherapy for extremity osteosarcoma can result in a variety of changes of the MRI appearance of tumor and adjacent bone and marrow. Areas of signal change beyond the tumor that represent marrow conversion and not tumor progression appear on T1 weighted imaging to be lower in signal than subcutaneous fat and higher in signal than muscle. Recognizing the existence of the effect of neoadjuvant chemotherapy on the MR appearance of the tumor and surrounding bone and myeloid elements is important so as to plan for oncological sound tumor resections while avoiding resecting more normal bone than necessary.

1. Introduction

Many studies had demonstrated that magnetic resonance imaging (MRI) T1-weighted imaging is the most accurate method to evaluate the intramedullary extent of extremity osteosarcoma [1–4]. However, we have found that after neoadjuvant chemotherapy, an area of low signal intensity on T1-weighted MRI was detected near tumor, the radiologic appearance of this suggested tumor progression, but on subsequent pathologic examination showed no involvement by tumor. The aim of this study was to describe, and classify the different types of these signal changes and to report their incidence. Correlation of these imaging findings with pathological findings was also performed.

2. Materials and methods

The prospectively collected sarcoma database of the Orthopaedic

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Fig. 1. 'Clear' type with distinct boundary between tumor and the normal marrow.

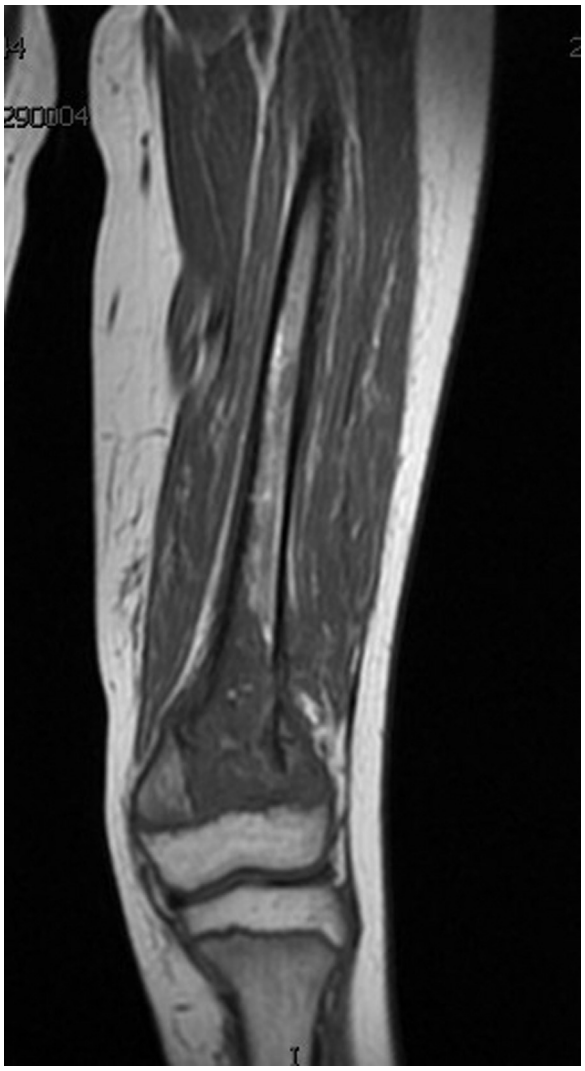

Fig. 2. 'Continuous diffuse' type with area of intermediate signal contiguous with the area of tumor.

Oncology Department of Beijing Jishuitan Hospital was searched to identify all patients treated for osteosarcoma.

Of extremities between June 2011 and November 2012. Among these patients, we included patients with two or more pre-operative MRI scans available in the electronic picture archiving and communications system (PACS), including one pre-chemotherapy and one post-chemotherapy scan. All the patients were biopsied for the diagnosis of osteosarcoma. Patients with pathological fracture and who had previously undergone surgery at the site of the tumor were excluded. Patients with osteosarcoma of the fibula were excluded because the marrow space was too narrow to evaluate on MRI.

The study group thus consisted of 74 patients [male, 45; female, 29; median age: 15 years (range, 9–25 years)]. The tumor was located in distal femur in 39 patients, proximal tibia in 26 patients, proximal humerus in 7 patients, proximal femur and distal tibia in 1 patient each.

Neoadjuvant chemotherapy was given following histologic confirmation of the diagnosis. The chemotherapy regimen included high-dose Methotrexate, Ifosfamide Cisplatin and Doxorubicin. The leukopenia was found in all patients during chemotherapy and the G-CSF was given to stimulate the marrow hyperplasia. Staging studies included plain radiographs, computed tomography (CT) and MRI of the limb, CT scans of the chest and total body scintigraphy. MRI of the affected extremity was the most important imaging modality for evaluation of the local extent of the tumor. All these patients received limb salvage surgery and the planning of the bony resection level was done by the operating orthopaedic oncologist and a radiologist.

MRI examinations, performed at our institution, were included in the study if they contained at least pre-chemo and post-chemo T1-weighted imaging. The imaging was analyzed on our PACS for this study. The coronal section was reviewed by one senior surgeon and one radiologist independently. After neoadjuvant chemotherapy, the signal change types were recorded. Eleven patients received the bilateral limb MRI examination and the normal side imaging was compared with the side affected by osteosarcoma.

Following surgical resection, specimens underwent pathological examination with the specimen prepared in a coronal section with a band saw. Areas noted on MRI with specific imaging characteristics were correlated with the pathologic findings in the specimen. A separate biopsy was performed at the time of surgery in the areas of intermediate signal intensity area when this area was not within the resection specimen.

All the patients were followed up according to our protocol, which included follow up every 3 months for the first 2 years, every 4 months for the third and fourth years, and every 6 months for the fifth year. Their oncological outcomes were recorded from a review of their case notes.