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Primary diaphyseal osteosarcoma in long bones: Imaging features and tumor characteristics

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ABSTRACT

Objective: This study aims to assess retrospectively the imaging features of diaphyseal osteosarcoma and compare its characteristics with that of metaphyseal osteosarcoma.
Materials and methods: Eighteen pathologically confirmed diaphyseal osteosarcomas were reviewed. Images of X-ray ($n=18$), CT ($n=12$) and MRI ($n=15$) were evaluated by two radiologists. Differences among common radiologic findings of X-ray, CT and MRI, and between diaphyseal osteosarcomas and metaphyseal osteosarcomas in terms of tumor characteristics were compared.
Results: The common imaging features of diaphyseal osteosarcoma were bone destruction, lamellar periosteal reaction with/without Codman triangle, massive soft tissue mass/swelling, neoplastic bone and/or calcification. CT and MRI had a higher detection rate in detecting bone destruction ($P=0.001$) as compared with that of X-ray. X-ray and CT resulted in a higher percentage in detecting periosteal reaction ($P=0.018$) and neoplastic bone and/or calcification ($P=0.043$) as compared with that of MRI. There was no difference ($P=0.179$) in detecting soft tissue mass among three imaging modalities. When comparing metaphyseal osteosarcoma to diaphyseal osteosarcoma, the latter had the following characteristics: a higher age of onset ($P=0.022$), a larger extent of tumor ($P=0.018$), a more osteolytic radiographic pattern ($P=0.043$).
Conclusion: As compared with metaphyseal osteosarcoma, diaphysial osteosarcoma is a special location of osteosarcoma with a lower incidence, a higher age of onset, a larger extent of tumor, a more osteolytic radiographic pattern. The osteoblastic and mixed types are diagnosed easily, but the osteolytic lesion should be differentiated from Ewing sarcoma. X-ray, CT and MRI can show imaging features from different aspects with different detection rates.

1. Introduction

Osteosarcoma is one of the most common primary malignant bone tumor that produces osteoid matrix and variable amounts of cartilage matrix and fibrous tissue [1]. Most osteosarcoma occurs in the metaphysis of long bone, and diaphyseal osteosarcoma accounts for less than 10% of all osteosarcomas [2,3]. The typical radiographic appearances of osteosarcoma are a destructive mass and immature cloudlike bone formation in the metaphyses of long bones [4], and the classic radiographic findings associated with diaphyseal osteosarcoma have included thickening or destruction of the diaphyseal cortex with neoplastic bone and periosteal reaction extending into a broad-based soft tissue mass [2,5–9].

Imaging plays an important role in the diagnosis of osteosarcoma and ultimately in patients' survival because the diagnosis is on the basis of a combination of pathological and radiological findings. The imaging features of diaphyseal osteosarcoma frequently overlap with Ewing sarcoma, creating substantial diagnostic challenges [6]. To the best of our knowledge, previous literatures concerning diaphyseal osteosarcoma included only a small amount of patients with limited radiographic evaluation or principally reviewed from a clinical and/or pathological perspective, and most of them were case reports. In addition, the CT and MRI features of diaphyseal osteosarcoma in long bone have not been extensively evaluated.

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In this study, 18 cases pathologically confirmed diaphyseal osteosarcoma in long bone were retrospectively analyzed. The purpose of this presentation was to assess the imaging features of diaphyseal osteosarcoma and compare its characteristics with that of metaphyseal osteosarcoma.

2. Materials and methods

2.1. Patients

Between March 2000 and December 2011, 191 patients with histologically proven osteosarcoma in long bones were collected at our institution, of which 18 (9.4%) were in the diaphysis of long bone. There were 11 male (61%) and 7 female (39%) patients with an age range of 12–65 years (average age, 28.4 years). Patients' ages were distributed as follows: 11–20 years old in 7 cases, 21–30 years old in 5 cases, 31–40 years old in 2 cases, 41–50 cases in 2 case, above the age of 51 in 2 cases. The most frequent lesion location was the diaphysis of the femur ($n = 12$), followed by tibia ($n = 2$), humerus ($n = 2$), fibula ($n = 1$) and ulna ($n = 1$). The duration of symptoms ranged from 1 week to 7 months, with a mean of 3 months. The main symptoms were local swelling/mass and pain, of which 6 cases with local swelling/mass and pain, 7 cases only with local swelling/mass and 5 cases only with pain as the initial symptoms.

2.2. Imaging procedures

All 18 patients were undergone radiography, and 12 CT plain scan. Magnetic resonance imaging was performed in 15 patients, of which 9 were undergone contrast-enhanced scanning. Many kinds of X-ray devices were used for anterior–posterior and lateral plain radiographs of diseased region.

CT examination was performed with a 4- or 16-slice multidetector spiral computer tomography (MSCT) scanner (HighSpeed or LightSpeed, General Electric Medical Systems, Milwaukee, WI, USA) according to an established protocol. Scanning parameters: matrix 512×512, field of view 25–42 cm, tube voltage 120 kV, tube current 100–320 mA, section thickness and intervals 2.5–5.0 mm. The range of scanning was decided according to radiography and CT topogram which tried to cover the whole lesion and included at least one adjacent joint. After thinning to section thickness and intervals 1.25 mm, the bone window and soft tissue window and 2D or 3D reconstruction of the cross-sectional images were used for observation.

MRI was performed on a 1.5-T Signa HD MR system (General Electric Medical Systems, Milwaukee, WI, USA) using our routine protocol for evaluating the extent of bone tumor. An appropriate surface coil was used. A combination of axial, sagittal, and coronal images was obtained using T1-weighted spin-echo sequence (TR range/TE range, 360–590/13–21; matrix size, 256×256), T2-weighted fast spin-echo sequence (TR range/TE range, 3000–5180/62–101; matrix size, 256×256) and STIR sequence (TR range/TE range/TI range, 3000–5000/53–91/150–170; matrix size, 256×256). Contrast-enhanced images of axial, sagittal and coronal plane were obtained using a T1-weighted spin-echo sequence with and without fat suppression (TR range/TE range, 360–590/13–21; matrix size, 256×256) after the injection of 0.1 mmol/kg of body weight of gadopentetate dimeglumine (Magnevist; Schering [now Bayer Health-Care]) injected at 2 ml/s, followed by a 20 ml normal saline flush. Field of view, slice thickness, and interslice gap varied depending on diseased region and tumor size.

2.3. Imaging interpretation

All images were reviewed retrospectively and independently by two experienced musculo-skeletal radiologists. Definition of the diaphyseal site of the lesion was according to Dahlin's criteria: 5 cm clear of the end of the bone [10]. The X-ray, CT and/or MRI findings of all lesions were identified, including the features of bone destruction, range of infiltration, continuation or interruption of cortical bone, periosteal reaction, neoplastic bone and calcification, range of soft tissue mass, signal characteristics and degree of lesion enhancement. In the event of disagreement, consensus was arrived at by discussion.

2.4. Definition of study parameters

Tumor length was defined as the greater longitudinal extension of the tumor. Procedures to define the tumor extents included plain radiography, computed tomography and magnetic resonance imaging of the primary tumor. Patterns on plain radiography were classified into three types: predominantly lytic in 10 (55.6%), predominantly blastic in 4 (22.2%), and mixed in 4 (22.2%). All 18 surgical/biopsy specimens were reviewed by a pathologist expertized in musculoskeletal oncology to reconfirm the diagnosis. Pathologic subtypes were osteoblastic ($n = 10$), chondroblastic ($n = 2$), fibroblastic ($n = 2$), telangiectatic ($n = 1$), giant cell rich ($n = 1$), small cell ($n = 1$) and mixed ($n = 1$). Histologic responses of tumors to adjuvant chemotherapy were determined using tumor necrosis percentages of resected specimens as Grades III and IV (necrosis of 90% or more), indicating a good response, and Grades I and II (less than 90% necrosis), indicating a poor response [11].

2.5. Statistical analysis

The Chi-Square test was used to identify differences among the common radiologic findings of X-ray, CT and MRI, and the Chi-Square test and Student's t-test were used to identify differences between cases with diaphyseal osteosarcoma and patients with metaphyseal osteosarcoma in terms of tumor characteristics. Analyses were performed by SPSS version 13.0 (SPSS, Chicago, IL), and P values of less than 0.05 were considered to indicate a statistically significant difference.

3. Results

3.1. Imaging features

On radiography, 10 (55.6%) of 18 cases demonstrated local or patchy high density inside and/or outside the medullary cavity and different degrees of bone destruction (Fig. 1a), and pathological fracture in 3 cases (Fig. 1a). 14 cases (77.8%) with periosteal reaction manifested stratiform periosteum with or without Codman triangle (Figs. 1a, 2a and 3a). 12 cases (66.7%) exhibited shadow of fusiform or massive soft tissue mass which made subcutaneous fat deformation and displacement (Figs. 1a and 2a). 8 cases (44.4%) manifested neoplastic bone and/or calcification inside and outside of the medullary cavity (Figs. 1a, 2a and 4a). With the development of lesions, the typical signs of osteosarcoma such as lamellar periosteal reaction, Codman triangle, radiatiform or needle-like neoplastic bone were more and more obvious.

12 cases (100%) had different degrees of bone destruction on CT, of which 7 cases (58.3%) presented extensive bone destruction and 2 (16.7%) pathological fracture (Fig. 1b and c). CT could clearly demonstrate the appearance of periosteal reaction and 9 patients (75%) showed lamellar periosteal reaction (Figs. 1b, c, 2c and 3c). 5 cases (41.7%) disclosed Codman triangle formation (Figs. 2c and 3c). 9 cases (75%) with soft tissue mass penetrated cortical bone and invaded surrounding soft tissue (Figs. 1b, c and 3b, c). 7 cases (58.3%) exhibited neoplastic bone and/or calcification (Figs. 1b, c, 2b, c, 3b, c and 4b). CT can clearly manifest the osteoblastic bone destruction, the microstructure such as the shape of the