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MR imaging assessment of juxta cortical edema in osteoid osteoma in 28 patients

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Abstract. Osteoid osteoma (OO) is a benign skeletal neoplasm. Twenty-eight patients with proven OO were studied with MRI regarding soft tissue involvement which was diagnosed when high proton-density and T2-weighted signal intensity and low signal intensity on T1-weighted images were found close to bone. Most tumors were located in the femur and tibia; 6 cases diaphyseal, 12 metaphyso-diaphyseal, and 10 epiphyseal. In relation to the cortex, 15 were located centrally or in its outer margin. Soft tissue involvement was found in 15 patients (53.6 %). A statistical relationship was found between soft tissue involvement and the tumor's location with regard to the cortex, being more frequent in peripherally located tumors. Therefore, soft tissue involvement is a frequent finding in peripherally located OO.

Key words: Bone neoplasms – MR imaging – Tissue characterization – Osteoma

Introduction

Osteoid osteoma (OO) is a benign skeletal neoplasm composed of osteoid and woven bone. It rarely exceeds 1.5 cm in its greatest dimension. It occurs in young patients, with a male predominance. Local pain is the most frequent symptom; it worsens at night and calms with aspirin. The lesion is commonly located in the cortex of long bones in the lower extremity, at the diaphysis or metaphysodiaphysis regions, where it is associated with dense, fusiform, and reactive bone sclerosis. Less often it may be cancellous, where reactive sclerosis is less intense and sometimes distant from the lesion [1]. Intra-articular OO (most frequently in the hip) may cause associated synovitis and joint effusion [2]. Rarely, osteoid OO occur in a subperiosteal location.

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In most cases plain films are diagnostic. Osteoid osteoma behaves as a lucent area within the cortex, called nidus, centrally located in a fusiform sclerotic area of a long bone diaphysis. The nidus has a variable degree of mineralization. However, findings may be subtle, especially in intra-articular lesions. In these cases the use of scintigraphy, CT, or MR may be useful in identifying the nidus and characterizing the lesion [1, 3]. Soft tissue involvement is a less-known finding in OO and could consequently be mistakenly regarded as a sign of malignancy [4–6].

Magnetic resonance remains the most valuable imaging modality for demonstration of intra- and extraosseous extent of musculoskeletal disease, and the aim of this work is to analyze cases of OO studied with MR imaging in order to assess the frequency of soft tissue involvement.

Materials and methods

Patients with proven OO from two referral hospitals were retrospectively reviewed. Criteria for inclusion were the diagnosis of OO obtained with either biopsy (22 cases) or by established clinical and radiological criteria (6 cases). Four patients were excluded because of insufficient histological sample or lack of adequate clinical and radiological follow-up studies. Twenty-eight patients entered the study group. All had MRI with T1-, proton-density and T2-weighted images obtained in the coronal and axial planes with standard spin echo, gradient echo, and inversion recovery sequences. Magnetic resonance was performed on either a 0.5- or a 1.5-T magnet.

Soft tissue involvement was diagnosed on MR images when an increased signal intensity was observed close to the lesion (Figs. 1, 2) on proton-density and T2-weighted images, and a decreased or isointense signal on T1-weighted images, as compared with the normal adjacent muscle signal intensity. Other studied variables were gender and age of patients, the presence

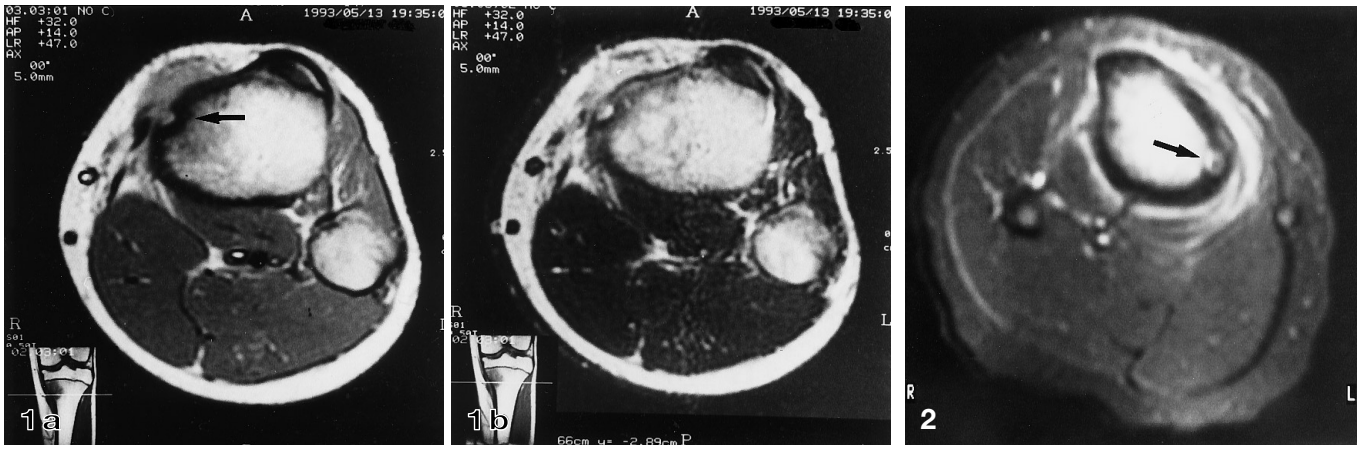

Fig. 1. Metaphyseal osteoid osteoma with soft tissue involvement. **a** The transverse T1-weighted MR image shows the cortical nidus surrounded by a sclerotic rim *(arrow)*. There is low signal intensity in the adjacent soft tissue mass and bone marrow. **b** The transverse T2-weighted MR image demonstrated high signal intensity within the nidus, and in the soft tissue mass and bone marrow edema

Fig. 2. Short TI inversion recovery image obtained in a diaphyseal OO, clearly showing the increased signal intensity of the nidus, bone marrow, and adjacent soft tissue involvement surrounding the whole section of the affected tibia *(arrow)*

Table 1. Relationship between soft tissue involvement with regard to cortical location. More peripheral tumors (in the outer and central aspect of the cortex) showed significantly increased soft tissue involvement compared with those located in the inner aspect of the cortex

	Outer and central cortical	Inner cortical
With soft tissue involvement	12	3
Without soft tissue involvement	3	10

of pain and its duration before diagnosis, and the size of the neoplasm and its location. Bone involvement was classified according to the type of bone involved (long, short, or cuboid) and to the location within the bone (epiphysis, metaphysodiaphysis, or diaphysis). Lesions within small bones were considered epiphyseal in location. Bearing in mind that most OO are cortical, we established three different groups depending on their relationship to the cortex: those who are centrally located and those at the inner or outer aspect of the cortex.

Statistical analysis with contingency tables relating soft tissue involvement and the other variables was made using the two-tail Fisher's exact test. A statistically significant difference was established for $p < 0.05$.

Results

From the 28 patients with a final diagnosis of OO and MR examination, there were 19 men (67.9 %) and 9 women (32.1 %), with 19.4 years average (7–39 years). Most OO were located in the femur ($n = 12$, 42.8 %) with the tibia as the second most frequent localization ($n = 6$, 21.4 %). There were 2 cases (7.14 %) in the fibula, talus, and humerus, respectively, and 1 case (3.6 % each) in the patella, sacrum, a dorsal vertebra, and the tarsal scaphoid. As for intraosseous location, 10 cases (35.7 %) were epiphyseal, 12 (42.9 %) were located at the metaphyso-diaphyseal region, and 6 cases (21.4 %) were diaphyseal. In relation to the cortex, 12 OO (42.9 %) were located centrally, 13 (46.4 %) cases in the inner aspect, and 3 (10.7 %) in the outer aspect of the cortical bone. Average size of the nidus was 6.25 mm, with range 2–12 mm.

Soft tissue involvement was found in 15 patients (53.6 %; Figs. 1, 2). Results regarding the relationship of this finding to several variables are expressed as number of cases with and without soft tissue edema and the p-value for contingency tables. There were no statistically significant relationship between soft tissue involvement and nidus size (12 and 10 for nidus smaller than 1 cm; 3 and 3 for equal or larger than 1 cm; $p = 0.6$), duration of pain (5 and 5 for 6 months or less; 10 and 8 for more than 6 months; $p = 0.5$), patient's age (6 and 4 for 14-year-old patients or younger; 9 and 9 older than 14 years; $p = 0.7$) or gender (4 and 5 for female; 11 and 8 for male patients; $p = 0.7$), long vs short bone location (14 and 8 for long bones; 1 and 5 for short bones; $p = 0.06$), and intraosseous location (3 and 7 for epiphyseal; 12 and 6 for metaphyso-diaphyseal; $p = 0.1$). However, there was a statistically significant relationship ($p = 0.006$) between soft tissue involvement and tumor location with regard to the cortex, considering outer and central cortical location vs inner cortical location (Table 1).

Discussion

Osteoid osteoma can induce an inflammatory edematous reaction in the juxta cortical soft tissues. Why this highly vascular small tumor induces large reactions remains speculative but is probably related to the initial immature phase of the nidus in their natural history. The MR appearance of OO in our series correlated with the pathological findings. The nidus was seen as a

rounded, more or less well-circumscribed lesion within the cortical or cancellous bone, with size between 2 and 12 mm, with intermediate or low signal intensity on T1-weighted and variable signal intensity on T2-weighted images. The surrounding bone exhibits sclerotic response, cortical thickening, and periosteal new bone formation and showed very low signal intensity with all pulse sequences. The variables of gender, age, size, affected bone, and intraosseous location in our group of patients were consistent with the features typical of OO. There was a male prevalence (67.9 %) with an age average close to 20 years. Most OOs were located in long bones (78.6 %) of the lower extremity (89.3 %) and in metaphyseal and metaphyso-diaphyseal locations (78.6 %). Average nidus size was smaller than 1 cm.

Soft tissue involvement was found in more than half of our cases. When present, adjacent soft tissue masses showed decreased signal intensity on T1-weighted images (Fig. 1 a) and increased signal intensity on proton-density and T2-weighted images (Figs. 1 b, 2) [5]. From a pathological point of view, these areas represent inflammatory infiltrates, confirmed in the 15 pathological specimens in our series. With MRI the increased water content associated with inflammation is clearly depicted. We consider that the prevalence of this finding in our series may have been overestimated because patients selected for MR study were mainly those clinically symptomatic and radiographically uncertain. Consequently, the exact prevalence of soft tissue involvement with OO remains to be determined.

Osteoid osteomas with soft tissue involvement are usually tumors located in the outer and central aspect of the cortex, whereas OOs in the inner aspects usually lack soft tissue involvement (Table 1). This may be related to inflammatory tissue formation in places where the periosteum is loosely attached due to the tumor [4]. The inflammatory response can be explained by the production of prostaglandins by the tumor, generating a vasodilatory effect with concomitant increase of the capillaries' permeability [5]. This effect is not related to nidus size.

However, although statistically not significant, we found increased soft tissue involvement in diaphyseal tumors, as compared with epiphyseal and metaphyso-diaphyseal locations. Epiphyseal and metaphyseal OOs are considered intra- or juxta-articular, and they generate joint effusion rather than soft tissue masses [1]. Nevertheless, we consider the increased soft tissue involvement in diaphyseal tumors in our study mainly due to the cortical location of these tumors, this factor being more important than the diaphyseal location.

Tumors located in short bones showed less frequently a soft tissue mass compared with tumors in long bones. The lack of statistical significance is probably due to the limited number of cases.

In OO, a soft tissue mass, as well as bone marrow edema and joint effusion, are common MR findings that may simulate an aggressive behavior. It is important to know this behavior of a benign tumor like OO and to rely on other imaging and clinical findings to establish the correct diagnosis. In this sense, another benign lesion can present with florid marrow and juxta cortical edema. The finding of the nidus or the sclerotic healing line of the stress fracture will establish the difference.

In conclusion, peritumoral soft tissue involvement depicted with MRI is a common feature of OO located either centrally or in the outer aspects of the cortex.

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