Research Article

Edema Surrounding Benign Tumors and Tumor-Like Lesions

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Received 18 June 2019; Revised 7 August 2019; Accepted 17 August 2019; Published 29 October 2019

Academic Editor: Antonio Pinto

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Objective. To explore the incidence and significance of intra- and extra-osseous edema associated with benign tumors and tumor-like diseases.

Methods. Magnetic resonance imaging (MRI) data from 300 benign osseous tumors and tumor-like diseases diagnosed by pathology were retrospectively reviewed. Borderline tumors, cases associated with pathological fractures, and skull lesions were excluded from the study. Bone marrow and soft tissue edema were defined on T2WI with fat suppression on MRI in all cases. The incidence rate of edema in benign tumors and tumor-like diseases was determined using the $\chi^2$ test. The preoperative diagnoses were reviewed, and the effect of edema on the differential diagnosis of benign and malignant tumors was analyzed.

Results. The incidence rate of bone marrow and soft tissue edema associated with benign tumors and tumor-like diseases was 35.7% (107/300), including 84.4% (27/32) Langerhans cell histiocytosis, 86.4% (19/22) osteoblastoma, 93.9% (31/33) osteoid osteoma, and 85.2% (23/27) chondroblastoma cases. There was no statistically significant difference in the incidence of edema among the four diseases ($\chi^2 = 1.7, P > 0.05$). Of 107 cases associated with edema, 49 (45.8%) were misdiagnosed as malignant tumors by MRI preoperatively.

Conclusion. Bone marrow and soft tissue edema are a common finding associated with benign bone tumors and tumor-like diseases, and they are frequently detected in Langerhans cell histiocytosis, osteoblastoma, osteoid osteoma, and chondroblastoma.

1. Introduction

The incidence of bone tumors and tumor-like lesions is 2%–3%, and the ratio of benign to malignant tumors is 0.83 : 1 [1]. The incidence of benign tumors and tumor-like lesions is 0.91%–1.36%; however, the incidence may be underestimated because benign lesions are usually asymptomatic and frequently remain undiscovered [2]. Benign tumors and tumor-like lesions are more likely to occur in patients aged 11–30 years with a ratio of men to women of 1.5 : 1, and the most common locations are the femur and tibia. The treatment of benign bone tumors and tumor-like lesions includes surgery, chemotherapy, radiotherapy, and interventional therapy. Asymptomatic benign tumors and tumor-like lesions can be monitored as a follow-up [3].

Bone marrow and soft tissue edema are a common finding associated with benign and malignant tumors or tumor-like diseases. In routine clinical practice, a lesion that is associated with remarkable surrounding edema is considered as an invasive active tumor by radiologists [4–6]. Yamamura et al. [7] showed that obvious surrounding edema disappeared and high serum levels of prostaglandin decreased after the resection of lesions in patients with osteoid osteoma and osteoblastoma. This phenomenon suggests that the inflammatory medium may lead to the development of soft tissue and marrow edema. The destruction of trabeculae increased pressure inside the bone marrow, discharging of inflammatory medium, and liquid exudate from capillary vessels inside tumors were suggested as possible causes of marrow and soft tissue edema surrounding a lesion [8, 9]. Hence, differentiating benign from malignant lesions with surrounding edema is important to prevent unnecessary surgery or over-resection of lesions with a larger area [10]. We retrospectively reviewed pathologically proven benign bone tumors and tumor-like diseases to explore the occurrence rate and characteristics of edema surrounding these lesions.

The diagnosis of bone marrow and soft tissue edema was based on the following criteria: magnetic resonance imaging (MRI) was used because it is sensitive for the detection of edema [5]. An abnormal signal, such as long T1 and long T2 compared with the surrounding normal bone marrow or soft tissue, and a high signal on T2WI with fat-suppression or a
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STIR sequence with a vague margin were considered indicators of bone marrow or soft tissue edema [6].

2. Materials and Methods

2.1. Patients. Between January 2016 and January 2019, 300 pathologically proven (after surgical operation or biopsy) benign bone tumors and tumor-like diseases with integrated MR data from our hospital were retrospectively analyzed. Informed consent was obtained from all participants included in the study. Borderline tumors such as giant-cell tumor of bone and desmoplastic fibroma, lesions with pathological fractures, and cranial lesions were excluded from the study. A total of 300 patients were included in the study, and the age and gender distribution of participants are shown in Figure 1.

2.2. Examination. All patients underwent MR plain scan within 10 days before the surgical procedure or other treatments. Enhanced MRI was performed in 50 cases. Follow-up MRI was performed 2 weeks to 3 months after treatment.

The location of lesions is shown in Figure 2.

MRI examination was performed using the GE Signa HDXT 3.0T MR scanner. The MR scan sequence and parameters are shown in Table 1.

2.3. Image Analysis. Two senior musculoskeletal radiologists reviewed all images on the PACS system, and differences in opinion were resolved by consensus. The presence of bone marrow and soft tissue edema was first determined using MR images. The types of tumor and tumor-like diseases associated with bone marrow and soft tissue edema and the numbers of preoperative misdiagnosis were determined using the pathology results. Post-operative changes in the incidence of edema were assessed.

2.4. Statistical Analysis. The occurrence rates of surrounding edema in different kinds of benign bone tumor and tumor-like diseases were compared. Statistical analyses were performed using the Chi-square test and SPSS software (version 20.0, IBM
Corporation, Armonk, NY). All P-values were two-sided, and a P-value <0.05 was considered statistically significant.

3. Results

3.1. Pathological Diagnosis. The 300 cases of benign bone tumors and tumor-like diseases included osteoid osteoma, osteoblastoma (Figure 3(a)), chondroblastoma (Figure 4(a)), Langerhans cell histiocytosis (Figure 5(a)), nonossifying fibroma, osteochondroma, fibrous dysplasia of bone, chondroma, simple bone cyst, osteoma, chondromyxoid fibroma, aneurysmal bone cyst, ganglion cyst of bone, capillary hemangioma of bone, and epidermoid cyst of bone. The pathology results and the number of cases of surrounding edema are shown in Table 2.

3.2. MRI Findings. Occurrence rate of surrounding edema: Surrounding edema was detected in 107 cases and the occurrence rate was 35.7% (107/300), among which eight cases (7.5%, 8/107) were only surrounding bone marrow edema (Figure 4(b)), six cases (5.6%, 6/107) were only surrounding soft tissue edema (Figure 3(b)), and 93 cases (86.9%, 93/107) were surrounding bone marrow edema together with soft tissue edema (Figure 5(b)).
three cases of Langerhans cell histiocytosis, four cases of osteoblastoma, six cases of osteoid osteoma, and four cases of chondroblastoma. The surrounding edema was still detected in two cases of osteoid osteoma at 1 month after the first surgical operation; post-operative CT scan showed the persistence of the tumor nest, suggesting that the tumor nests were not excised or were incompletely excised. After resection of the

TABLE 2: Pathology of 300 cases and number of cases with surrounding edema.

| Benign tumors and tumor like diseases | Cases | Edema |
|--------------------------------------|-------|-------|
| Osteoid-osteoma                      | 33    | 31    |
| Osteoblastoma                        | 22    | 19    |
| Chondroblastoma                      | 27    | 23    |
| Langerhans cell histiocytosis        | 32    | 27    |
| Nonossifying fibroma                 | 31    | 0     |
| Osteochondroma                       | 24    | 1     |
| Fibrous dysplasia of bone            | 23    | 0     |
| Chondroma                            | 24    | 0     |
| Simple bone cyst                     | 20    | 0     |
| Osteoma                              | 21    | 0     |
| Chondromyxoid fibroma                | 12    | 1     |
| Aneurysmal bone cyst                 | 11    | 2     |
| Ganglion cyst of bone                | 10    | 0     |
| Capillary hemangioma of bone         | 3     | 3     |
| Epidermoid cyst of bone              | 7     | 0     |

3.3. Misdiagnosis Rate. Forty-nine cases were misdiagnosed as malignant tumors before surgery. The misdiagnosis rate was 45.8% (49/107).  

3.4. Follow-Up and Changes in the Surrounding Edema after Treatment. Among 107 cases with surrounding edema, 89 underwent surgery; 19 cases were followed-up by MR during a period of 2 weeks to 3 months postoperatively. The surrounding edema disappeared after surgery in 17 cases, including
4. Discussion

4.1. Occurrence Rate of Surrounding Edema in Benign Bone Tumors and Tumor-Like Diseases. The results of the study by Kroon et al. [11] showed that surrounding bone marrow edema and soft tissue edema are detected in 42% (10/24) and 58% (14/24) of benign bone tumors and tumor-like diseases, respectively, which was a higher rate than that of the present study at 35.7% (107/300). One possible explanation for this difference is that the patient population was small (24 cases) and there were few disease types included in the study by Kroon et al. [11]. The occurrence of surrounding edema is closely related to the numbers of patients and disease types. In the present study, surrounding edema was not detected in nonossifying fibroma, fibrous dysplasia of bone, chondroma, simple bone cyst, osteoma, and ganglion cyst of bone. The inclusion of additional cases of these diseases may have decreased the occurrence rate of surrounding edema. Regardless of the higher or lower occurrence rate of edema, the above results indicate that surrounding edema was not a specific indicator of malignant bone tumors.

4.2. Surrounding Edema in Different Types of Benign Bone Tumor and Tumor-Like Diseases. The occurrence rates of surrounding edema are relatively high in certain kinds of benign bone tumors and tumor-like diseases. In the present study, the occurrence rate of surrounding edema was 84.4% (27/32) in Langerhans cell histiocytosis, which was slightly lower than that of 91% (20/22) reported by Jeh et al. [12]. The occurrence rate of surrounding edema in osteoblastoma was 86.4% (19/22), which was comparable to that of other studies. Kroon et al. [13] reported that the three cases of osteoblastoma analyzed were associated with surrounding edema. Shaikh et al. [14] reported that 10 of 11 cases of vertebral osteoblastoma were accompanied by surrounding edema. The occurrence rate of surrounding edema in osteoid osteoma in the present study was 93.9% (31/33), which was higher than that of 88.37% (38/43) reported by Davies et al. [15]. Surrounding edema was found in 85.2% (23/27) of chondroblastoma cases in the present study, which was comparable to the rate of 77–92% reported previously [16, 17]. Although the three cases of capillary hemangioma of bone included in the present study were associated with surrounding edema, the sample was too small, and the results need to be confirmed in a greater number of cases. Surrounding edema was found in 18.2% (2/11) of aneurysmal bone cysts in our study, which was a lower rate than that of 33% reported by Woertler et al. [18]. Because aneurysmal bone cysts are often accompanied by pathological fracture, whether the surrounding edema is caused by the pathological fracture or the expanding cortex in cases of aneurysmal bone cyst needs to be determined.

4.3. The Performance of Contrast-Enhanced MRI. Among 50 cases that underwent contrast-enhanced MRI, 38 had surrounding edema, and all cases showed enhancement. No new surrounding edema was observed in the enhanced images, and there was no significant difference in the incidence of surrounding edema between the plain scan and the enhanced scan. These results were consistent with those reported by Giraudo et al. [19]. The boundaries of surrounding edema and lesions are clearer in contrast enhanced than in non-contrast enhanced images, as shown by Liu et al. [20], who reported that enhanced MRI imaging can depict osteoid osteomas with greater accuracy than non-enhanced MRI, facilitating the detection of the size and morphology of the lesions.

4.4. Limitations of the Study. The present study had several limitations. Firstly, we did not examine the relationship between tumor size and surrounding edema or the relationship between the size of edema and the properties of the lesions. Secondly, although contrast-enhanced MRI was included, dynamic contrast-enhanced MRI was not performed. Thirdly, bone marrow and soft tissue edema were not examined separately because they were detected together in most cases (86.9%, 93/107). In addition, the disease types included in the present study were limited, and the inclusion of a larger cohort is needed. Foti et al. [21] reported that dual-energy CT represents an accurate imaging tool for bone marrow edema of the ankle compared with MRI. We did not perform a comparative study of MRI and dual-energy CT.
5. Conclusion

Marrow and soft tissue edema are a common occurrence associated with benign bone tumors and tumor-like diseases. There was no statistically significant difference in the incidence of edema between Langerhans cell histiocytosis, osteoblastoma, osteoid osteoma, and chondroblastoma.

Data Availability

The data used to support the findings of this study are available from the corresponding upon request.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interests.

Funding

This work was supported by the National Natural Science Foundation of China under Grant Number: 81571673 and 81671658.

References

[1] F. Schajowicz, “Tumors and tumorlike lesions of bone,” Skeletal Radiology, vol. 24, no. 1, p. 26, 1995.

[2] A. Franchi, “Epidemiology and classification of bone tumors,” Clinical Cases in Mineral and Bone Metabolism, vol. 9, no. 2, pp. 92–95, 2012.

[3] H. Fritzschke, K. D. Schaser, and C. Hofbauer, “Benign tumours and tumour-like lesions of the bone: general treatment principles,” Der Orthopade, vol. 46, no. 6, p. 484–497, 2017.

[4] C. E. Sherman and P. M. Murray, “Tumor-like conditions of the hand and upper extremity,” Journal of Hand Surgery, vol. 42, no. 12, p. 1009–1017, 2017.

[5] G. Jundt and D. Baumhoer, “Chondroblastoma,” Der Pathologe, vol. 39, no. 2, pp. 132–138, 2018.

[6] S. Yamamura, K. Sato, H. Sugiura, M. Asano, M. Takahashi, and H. Iwata, “Magnetic resonance imaging of inflammatory reaction in osteoid osteoma,” Archives of Orthopaedic and Trauma Surgery, vol. 114, no. 1, pp. 8–13, 1994.

[7] S. Yamamura, K. Sato, H. Sugiura et al., “Prostaglandin levels of primary bone tumor tissues correlate with peritumoral edema demonstrated by magnetic resonance imaging,” Cancer, vol. 79, no. 2, pp. 255–261, 1997.

[8] S. Eustace, C. Keogh, M. Blake, and R. J. Ward, P. D. Oder and M. Dimasi, “MR imaging of bone oedema: mechanisms and interpretation: pictorial review,” Clinical Radiology, vol. 56, no. 1, pp. 4–12, 2001.

[9] L. Janzen, P. M. Logan, J. X. O’Connell, D. G. Connell, and P. L. Munk, “Intramedullary chondroid tumors of bone: correlation of abnormal peritumoral marrow and soft-tissue MRI signal with tumor type,” Skeletal Radiology, vol. 26, no. 2, pp. 100–106, 1997.

[10] S. L. J. Jamieson and A. M. Davies, “Bone marrow oedema associated with benign and malignant bone tumours,” European Journal of Radiology, vol. 67, no. 1, pp. 11–21, 2008.

[11] H. M. Kroon and J. Schurmans, “Osteoblastoma: clinical and radiologic findings in 98 new cases,” Radiology, vol. 175, no. 3, pp. 783–790, 1990.

[12] S. K. Jeh, W. H. Lee, S. J. Hong et al., “Extracranial skeletal Langerhans cell histiocytosis: MR imaging features according to the radiologic evolutional phases,” Clinical Imaging, vol. 36, no. 5, pp. 466–471, 2012.

[13] H. M. Kroon, J. L. Bloem, H. C. Holscher et al., “MR imaging of edema accompanying benign and malignant bone tumors,” Skeletal Radiology, vol. 23, no. 4, pp. 261–269, 1994.
[14] M. I. Shaikh, A. Saifuddin, J. Pringle, C. Natali, and Z. Sherazi, "Spinal osteoblastoma: CT and MR imaging with pathological correlation," *Skeletal Radiology*, vol. 28, no. 1, pp. 33–40, 1999.

[15] M. Davies, V. N. Cassar-Pullicino, M. A. Davies, I. W. McCall, and P. N. Tyrrell, "The diagnostic accuracy of MR imaging in osteoid osteoma," *Skeletal Radiology*, vol. 31, no. 10, pp. 559–569, 2002.

[16] P. T. Weatherall, G. E. Maale, D. B. Mendelsohn, C. S. Sherry, W. E. Erdman, and H. R. Pascoe, "Chondroblastoma: classic and confusing appearance at MR imaging," *Radiology*, vol. 190, no. 2, pp. 467–474, 1994.

[17] J. W. Oxtoby and A. M. Davies, "MRI characteristics of chondroblastoma," *Clinical Radiology*, vol. 51, no. 1, pp. 22–26, 1996.

[18] K. Woertler, "Benign bone tumors and tumor-like lesions: value of cross-sectional imaging," *European Radiology*, vol. 13, no. 8, pp. 1820–1835, 2003.

[19] C. Giraudo, M. Weber, A. Puchner, J. Grisar, F. Kainberger, and C. Schueller-Weidekamm, "Which MR sequences should we use for the reliable detection and localization of bone marrow edema in spondyloarthritis?", *La Radiologia Medica*, vol. 122, no. 10, pp. 752–760, 2017.

[20] P. T. Liu, F. S. Chivers, C. C. Roberts, C. J. Schultz, and C. P. Beauchamp, "Imaging of osteoid osteoma with dynamic gadolinium-enhanced MR imaging," *Radiology*, vol. 227, no. 3, pp. 691–700, 2003.

[21] G. Foti, M. Catania, S. Caia et al., "Identification of bone marrow edema of the ankle: diagnostic accuracy of dual-energy CT in comparison with MRI," *La Radiologia Medica*, vol. 124, no. 10, pp. 1028–1036, 2019.