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Can imaging criteria distinguish enchondroma from grade 1 chondrosarcoma?

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ABSTRACT

Purpose: To minimize systematic bias and optimize agreement on imaging criteria in order to better define the accuracy of imaging criteria in the diagnosis of grade 1 chondrosarcoma.
Materials and methods: Study was IRB-approved and HIPAA compliant; informed consent was waived. Records were reviewed and disclosed 53 cases (38 women, 15 men ages 21–76) which were diagnosed as enchondroma or grade 1 chondrosarcoma and had available radiographs, contrast-enhanced MRI, and definitive diagnosis by histology or 5-year follow-up. 2 MSK radiologists read the studies independently after a session where they agreed on criteria for malignancy. Interobserver variability was determined as raw variability and with the kappa statistic. Accuracy was determined compared to final diagnosis. Reliability of imaging features of chondrosarcoma was determined using regression analysis.
Results: The correct diagnosis of enchondroma was made on radiographs in 43 (67.2%) of readings, and on MRI in 37/64 (57.8%). The correct diagnosis of chondrosarcoma was made on radiographs in 5/24 (20.8%) of readings, and on MRI in 14/24 (57.8%). A diagnosis of borderline lesion was made in 19/64 (29.7%) of enchondromas on radiographs and 18/64 (28.1%) on MRI. The false positive rate of radiographs for chondrosarcoma was 2/64 (3.1%) and the false positive rate of MRI was 9/64 (14.1%). There was substantial interobserver variability. Cortical thickening and bone expansion were rare but specific signs of chondrosarcoma.
Conclusions: Both radiographs and MRI have limitations in the evaluation of low-grade cartilage lesions. MRI has an increased rate of both true-positive and false-positive diagnosis compared to radiographs. Differences in the findings of this study compared to previous literature may reflect the influence of systematic biases.

1. Introduction

Enchondroma (EC) is a benign cartilage neoplasm which may occur in any bone formed by enchondral ossification [1,2]. Enchondromas are common; they occur as an incidental finding in 2.9% of routine knee MRI examinations [3]. Enchondromas may receive no follow-up or be followed on imaging studies [4].

Chondrosarcomas (CS) represent 10–20% of malignant bone lesions, with an incidence of 1/200,000/year [5,6]. Histologically, chondrosarcomas are categorized as grade 1 (low-grade), grade 2 (intermediate grade) or grade 3 (high grade). About 30% of chondrosarcomas are grade 1 chondrosarcomas, which are locally aggressive but do not metastasize [7,8]. A low-grade chondrosarcoma is treated with surgical excision, avoiding biopsy because of a high sampling error [9].

Enchondromas and low-grade chondrosarcomas can be difficult to distinguish on imaging and histology [1,6,9–11]. A recent large multicenter study found wide variability between radiologists and between pathologists in diagnosis of cartilage lesions [10]. A weakness of this study, however, is that diagnostic criteria were not defined. Previous work in the pathology literature has shown that defining criteria significantly improved interobserver consistency in diagnosis of borderline breast lesions [12,13].

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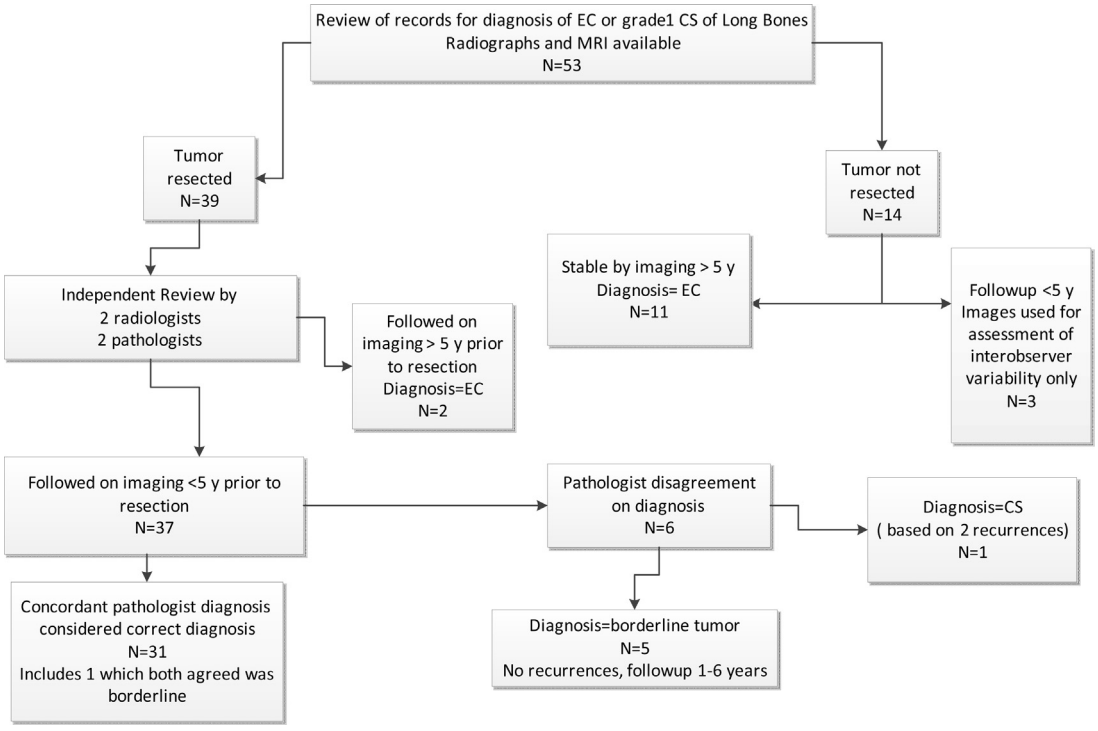
Table 1
Flow chart showing method of determination of diagnosis of cases in the study, utilizing STARD guidelines. EC—enchondroma, CS—chondrosarcoma.



A problem with previous studies of chondrosarcoma has been the presence of systematic biases, which may skew evaluation of diagnostic accuracy. These biases include incorporation bias, diagnostic review bias and inclusion bias [14]. Incorporation bias occurs when the results of the test under study are actually used to make the final diagnosis. Criteria for diagnosis of low-grade chondrosarcoma include clinical presentation, imaging findings and histopathology. Incorporation bias has occured in the chondrosarcoma literature when imaging findings which are thought to indicate chondrosarcoma are used to support a histologic diagnosis of chondrosarcoma [9,15]; the histologic diagnosis is in turn used to validate the imaging criteria [1,5,10,11,16,17]. Diagnostic review bias occurs when interpretation of the gold standard test (histology) is made with knowledge of the test under investigation (imaging criteria) or other clinical data. Diagnostic review bias has occured in the chondrosarcoma literature because of utilization of imaging and clinical data to inform the histologic diagnosis. A cartilage lesion in an older patient, a painful lesion and a lesion in the axial skeleton are considered more likely malignant and this clinical data may be used to favor the histopathologic diagnosis of chondrosarcoma [5,6,10,11,16–18]. Solitary lesions in the hands and feet are assumed to be probably benign [6,19]. Inclusion bias is due to nonrepresentative patient selection, including tumor grade and location.

In order to avoid systematic bias we needed to carefully choose our gold standard of diagnosis. Outcomes analysis is the most definitive method to distinguish most tumors. Outcomes are easy to determine if lesions are not resected. However, it is difficult to use outcomes to confirm the diagnosis of low-grade chondrosarcomas, since they have a low rate of recurrence and metastasis [5,7,16,20–22]. A combination of histology, outcomes analysis after tumor resection and/or stability of lesions on 5 years of imaging follow-up was therefore employed.

The purpose of our study was to minimize systematic bias and optimize agreement on imaging criteria in order to better define the accuracy of imaging criteria in the diagnosis of grade 1 chondrosarcoma.

2. Materials and methods

The study was IRB-approved and HIPAA compliant. Informed consent was waived. STARD guidelines for studies of diagnostic accuracy [23] were followed. Imaging and pathology records were searched for patients with a diagnosed cartilage neoplasm. These cases were reviewed by the lead author. Cases with radiographs and contrast-enhanced MRI and prospective histopathologic diagnosis of enchondroma or grade 1 chondrosarcoma, and cases diagnosed as enchondroma on imaging studies more than 5 years prior to initiation of the study were included. Lesions of the hands and feet and flat bones were excluded.

Lesions were given a final diagnosis of enchondroma, chondrosarcoma or borderline lesion based on imaging stability over time, recurrence or metastasis, or histology. De-identified slides were retrospectively reviewed by 2 subspecialty pathologists who had no knowledge of tumor location, clinical or imaging findings. Table 1 shows the decision tree used to establish diagnosis. Histologic criteria were those established by Dahlin and co-workeks [6,15] and Mirra and co-workers [1,9,19]. Histology was based on curettage or en bloc resection of the entire lesion in all cases. No biopsies were performed, in order to avoid the risk of tumor sampling error.

Imaging criteria for enchondroma and chondrosarcoma were based on literature review [3,17–19,24–27] and are described in Figs. 1 and 2. The following characteristics were assessed on XR: margin, matrix, endosteal scalloping and cortical breakthrough, cortical thickening, bone expansion and size. MR characteristics included size, cartilage, endosteal scalloping and cortical breakthrough, gadolinium enhancement and the presence of a soft tissue mass. Gadolinium enhancement was characterized as peripheral and around cartilage lobules, small areas of confluent enhancement, or large areas of confluent enhancement. We followed