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Research Article

The Performances of Radiographic Criteria for Bone Malignancy When Applied to Computed Tomography and Magnetic Resonance Imaging

Tugay Onal, MD[a*1], Guven Onur Afacan, MD[a1], Gur Akansel, MD[b], Arzu Serpil Arslan, MD[b], Yonca Anik, MD[b], Nagihan Inan, MD[b2], Bahar Muezzinoglu, MD[c] and Funda Corapcioglu, MD[d]

[a] *School of Medicine, Kocaeli University, Kocaeli, Turkey*

[b] *Department of Radiology, Kocaeli University School of Medicine, Kocaeli, Turkey*

[c] *Department of Pathology, Kocaeli University School of Medicine, Kocaeli, Turkey*

[d] *Division of Pediatric Oncology, Department of Pediatrics, Kocaeli University School of Medicine, Kocaeli, Turkey*

ABSTRACT

Background: The conventional radiologic features that differentiate benign from malignant bone lesions were originally described using radiography (X-ray [XR]). When evaluating sectional imaging studies such as magnetic resonance imaging (MRI) and computed tomography (CT), one may apply these principles to identify malignant bone lesions. The aim of this study was to evaluate the performances of these radiographic features for detecting malignity when applied to CT and MRI.

Materials and Methods: This retrospective study was approved by our institutional ethical board. Thirty-nine patients with histopathologic proof of a high-grade bone malignancy and preoperative imaging data obtained with a minimum of two different modalities were included in the study. Four radiologists reviewed the images and scored the lesions for distinctness of margins, presence and type of periosteal reaction, matrix mineralization, and presence of soft tissue mass. The average score for each modality was then tested for accuracy with regard to the histopathology.

Results: When lesion margins were considered, XR was the best modality to detect a high-grade malignancy. MRI, especially post-contrast T1-weighted sequence, was the least helpful in this regard. There was no significant difference between CT and XR and between CT and MRI. When the periosteal reaction was considered, XR was the best modality to detect the malignant type of periosteal reaction. In this regard, MRI and CT were misleading; either by not detecting or undergrading periosteal reaction. MRI was the best modality to detect soft tissue mass.

Conclusion: Conventional imaging criteria for bone malignancy can be misleading when applied to MRI or CT. When cross-sectional imaging features contradict those from XR, the latter should be the guide for clinical management.

RESUME

Contexte : Les caractéristiques radiologiques conventionnelles permettant de distinguer les lésions osseuses bénignes des lésions malignes ont été à l'origine décrites à l'aide de la radiographie (rayons X: RX). Dans l'évaluation des études d'imagerie sectionnelle comme l'imagerie par résonance magnétique (IRM) et la tomodensitométrie (TDM), on tend parfois à appliquer ces principes pour identifier les lésions osseuses malignes. Cette étude vise à évaluer le rendement de ces caractéristiques radiographiques pour la détection de la malignité lorsqu'on les applique à l'IRM et à la TDM.

Matériel et méthodologie : Cette étude rétrospective a été approuvée par notre comité d'éthique de la recherche. Trente-neuf patients présentant des preuves histopathologiques de malignité osseuse élevée et des données d'imagerie préopératoire obtenues par au moins deux modalités différentes ont été inclus dans l'étude. Quatre radiologistes ont examiné les images et noté les lésions selon la netteté des marges, la présence et le type de réaction périostale, la minéralisation de la matrice et la présence de masses dans les tissus mous. La note moyenne pour chaque modalité a ensuite été évaluée pour sa précision en comparaison de l'histopathologie.

Résultats : Lorsque les marges de la lésion sont prises en compte, la RX était la meilleure modalité pour détecter une malignité élevée. L'IRM, et plus particulièrement la séquence pondérée T1 post-contraste, était la moins utile à cet égard. Il n'y avait pas de différences significatives entre la TDM et la RX, non plus qu'entre la TDM

* Corresponding author: Tugay Onal, MD, Tuzla Public Health Center, Istanbul 34944, Turkey.
E-mail address: tugayonalx@gmail.com (T. Onal).

[1] Tuzla Public Health Center, Istanbul 34944, Turkey.

[2] Department of Radiology, Istanbul Bilim University Faculty of Medicine, 34394 Istanbul, Turkey.

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et l'IRM. Lorsque la réaction périostale est considérée, la RX était la meilleure modalité pour détecter la réaction périostale de type malin. À cet égard, la TDM et l'IRM étaient trompeuses, que ce soit en ne détectant pas la réaction périostale ou en la sous-évaluant. L'IRM était la meilleure modalité pour détecter les masses dans les tissus mous.

Conclusion : Les critères d'imagerie conventionnels pour la malignité osseuse peuvent être trompeurs si on les applique à l'IRM ou à la TDM. Lorsque les caractéristiques des images de coupe transversale contredisent celles de la RX, ces dernières devraient être utilisées comme guide pour la gestion clinique.

Keywords: Bone tumors; radiography; cross-sectional imaging; radiographic criteria

Introduction

The most important clues to the nature of a bone lesion are the patient's age and the location of the lesion. Following these are the imaging findings. Conventional imaging features to differentiate benign from malignant lesions originally were described using radiography (X-ray [XR]). These are mainly lesion margins, periosteal reaction, matrix mineralization, and cortical destruction [1–5].

Cross-sectional imaging has been used with increasing frequency in the initial workup of bone lesions. We observed a tendency to apply XR criteria of malignancy when interpreting cross-sectional imaging studies in our practice, often with misleading results.

Our aim of this study was to document if XR criteria can be applied to cross-sectional imaging studies such as magnetic resonance imaging (MRI) and computed tomography (CT).

Materials and Methods

Patients

This retrospective study was approved by the ethical board of our institution. We reviewed the data from 84 patients with the diagnosis of a high-grade malignant bone tumor from March 2009 to January 2015. Imaging, pathologic, and clinical data were obtained from the picture archiving and communication system and computerized medical records of our center. The inclusion criteria were histopathologic proof of a high-grade malignancy and imaging data of tumor site obtained with at least two different modalities. The exclusion criteria were the lack of preoperative imaging and non-diagnostic studies.

Of 39 patients who met the inclusion criteria, XR was available in 34 patients, CT was available in 25 patients, and MRI was available in 34 patients. The availability of multiple modalities is shown in Table 1. In 34 MRI studies, 21 studies were obtained using a 1.5-T scanner and 13 using a 3.0-T scanner.

Imaging Technique

MRI and CT studies were mostly performed at our institution using 1.5 and 3.0 T units (Philips, Eindhoven, the Netherlands) for MRI and 64-detector scanner (Aquilion 64; Toshiba Medical Systems, Tokyo, Japan) for CT.

MRI studies obtained using two different scanners were performed using similar parameters. Because of the variation of slices required for each patient/anatomy, a range is given in Table 2 for each parameter, instead of a single value.

Similarly, because of the variations in patient weight, size, and tissue thickness, CT parameters varied between patients/studies are shown in Table 3.

Image Evaluation

The data from 39 patients who met the inclusion criteria were evaluated by four radiologists from our department for the following imaging features: lesion margins, periosteal reaction/type, matrix mineralization, and presence of soft tissue mass on XR, CT, and T1-weighted (T1W), T2-weighted (T2W), fat-suppressed T2-weighted (FS-T2W/STIR) and post-contrast T1-weighted sequences (pc-T1W) of MRI. The scoring system and parameters are shown in Table 4. Lesion margin and periosteal reaction scores were evaluated independently, but matrix mineralization and presence of soft tissue mass were evaluated by consensus.

Data and Statistical Analysis

The scores from four radiologists for lesion margins and periosteal reaction parameters were averaged. The differences between imaging modalities for scores of lesion margin and periosteal reaction were tested using paired sample t-test and Wilcoxon signed-rank test. In addition, "Cohen's d" effect size was calculated to evaluate the strength of effect. The agreement of matrix mineralization between imaging modalities and histology was analyzed with Cohen's Kappa coefficient. An exact McNemar's test was used to analyze the difference for detecting soft tissue mass between imaging modalities. All statistical tests were performed using IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY).

Table 1
Availability of Multiple Modalities

Two Modalities		Three Modalities	
XR–CT	20	XR–CT–MRI	15
XR–MRI	29		
CT–MRI	20		

CT, computed tomography; MRI, magnetic resonance imaging; XR, conventional radiography.