

Association between radiographic findings and knee bone tumors

Asociación entre las características radiográficas y los tumores óseos de rodilla

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Abstract

Background: Bone neoplasms require an adequate clinical-radiographic evaluation for their diagnosis. Plain radiographs are the usual method to establish the diagnosis and evaluate differential diagnoses in the study of bone tumor pathology. **Objective:** To recognize the frequency of radiographic characteristics and associate them with bone tumor pathology. **Method:** Radiographic data were collected from 132 patients with tumor pathology confirmed by biopsy from bone tumors service of the Traumatology and Orthopedics Hospital Unidades Médicas de Alta Especialidad Dr. Victorio de la Fuente Narváez, Instituto Mexicano del Seguro Social, Ciudad de México, during 2019. **Results:** 132 patients were registered. The most frequent benign tumor was osteochondroma (27.3%), and malignant was osteosarcoma (9.8%). Active lytic lesions (odds ratio [OR]: 6.9; 95% confidence interval [95%CI]: 2.83-16.85) or aggressive (OR: 26.85; 95%CI: 3.21-224) were associated with giant cells tumors. Poorly differentiated intraosseous blast lesions of bone lineage (OR: 36.15; 95%CI: 4.4-295.5) were associated with osteosarcoma. The periosteal reaction (OR: 36.15; 95%CI: 4.4-295.5), the moth-eaten or permeative pattern (OR: 11.75; 95%CI: 1.26-109) and the central location of the lesion (OR: 3.03; 95%CI: 1.37-6.69) were associated with malignant tumor lesions. **Conclusions:** Poorly defined intraosseous blast lesions of bone lineage, periosteal reaction, and moth-eaten or permeative pattern of destruction are associated with malignant lesions.

Keywords: Bone neoplasms. Knee. Radiography. Diagnosis. Risk assessment.

Resumen

Antecedentes: Los tumores óseos requieren una adecuada evaluación clínico-radiográfica para su diagnóstico. Las radiografías simples son el método incruento usual para establecer el diagnóstico y evaluar diagnósticos diferenciales en el estudio de la patología tumoral ósea. **Objetivo:** Reconocer la frecuencia de las características radiográficas y asociarlas con patología tumoral ósea. **Método:** Se recolectaron datos radiográficos de 132 pacientes con patología tumoral confirmada mediante biopsia del servicio de tumores óseos del Hospital de Traumatología y Ortopedia Unidades Médicas de Alta Especialidad Dr. Victorio de la Fuente Narváez, Instituto Mexicano del Seguro Social, en Ciudad de México, durante el año 2019. **Resultados:** Integraron la muestra 132 pacientes. El tumor benigno más frecuente fue el osteocondroma (27.3%), y el maligno, el osteosarcoma (9.8%). Las lesiones líticas activas (odds ratio [OR]: 6.9; intervalo de confianza del 95% [IC95%]: 2.83-16.85) o agresivas (OR: 26.85; IC95%: 3.21-224) se asociaron a tumor de células gigantes. Las lesiones blásticas de estirpe ósea mal diferenciadas intraóseas (OR: 36.15; IC95%: 4.4-295.5) se asociaron a osteosarcoma. La reacción periosteal (OR: 36.15; IC95%: 4.4-295.5), el patrón apolillado o permeativo (OR: 11.75; IC95%: 1.26-109) y la ubicación central

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(OR: 3.03; IC95%: 1.37-6.69) se asociaron a lesiones tumorales malignas. **Conclusiones:** Las lesiones blásticas de estirpe ósea mal definidas intraóseas, la reacción perióstica y el patrón de destrucción apolillado o permeativo se asocian a lesiones malignas.

Palabras clave: Tumores óseos. Rodilla. Radiografía. Diagnóstico. Asociación de riesgo.

Introduction

Several factors complicate the characterization and categorization of bone tumor lesions into specific diagnoses. After the physical examination of a patient with suspected bone tumor, imaging studies of the lesion are advised to proceed with the diagnostic method. The least invasive and most specific method to achieve the differential diagnosis of primary bone tumors is plain x-rays.

Radiology provides detailed images of human diseases, and is essential to see the multiple details associated with visualized anomalies, including bone tumors. Also, in most cases, multiple characteristics related to these lesions allow us to distinguish between malignant and benign tumors. Therefore, radiology is crucial to conduct thorough reviews and specify the various findings associated with different bone tumor lesions to enable a more accurate approach to the definitive diagnosis.

Plain radiography provides more information than any other imaging modality in the study of bone tumor lesions and remains the cornerstone of the differential diagnosis of musculoskeletal tumors and tumor-like lesions, thanks to its specificity when it comes to detecting morphological tumor features¹.

The radiographic characteristics that help us diagnose bone tumors or, at least, narrow down all diagnostic possibilities, include patterns of bone destruction (geographic, moth-eaten, permeative), lesion margins (sclerotic, active, or aggressive borders), internal lesion features (blastic or lytic lesions), type of bone response (medullary or periosteal), location, site (metaphysis, diaphysis, or epiphysis), position of the lesion in the body and bone damaged (central, eccentric, or periosteal), soft tissue involvement, and whether we're dealing with a single or multiple lesions¹⁻³.

Simple x-rays of the bones damaged are also useful to detect bone metastases, although their sensitivity to detect these effects is lower⁴⁻⁵.

While current research focuses on innovative imaging modalities that show increasing advancements in the detection of bone tumors and bone metastases and is backed by studies such as bone scintigraphy, computed tomography, magnetic resonance imaging,

angiography, or positron emission tomography⁶⁻⁹, the value of clinical assessment and simple radiography remains irreplaceable when it comes to conducting low-cost differential diagnoses with proper results.

Unfortunately, although the radiographic features of bone tumor lesions have been described under certain diagnostic criteria^{2,3,10}, deficiencies have been found in the quantitative approaches to the presentation of radiographic features and their association with final diagnosis. Characteristics of aneurysmal bone cysts have been described, as well as the frequencies of each characteristic found¹¹. There is also literature available analyzing the radiographic features of chondrosarcomas¹², non-ossifying fibromas¹³, eosinophilic granulomas¹⁴, and unicameral bone cysts¹⁵.

We believe we should analyze the frequency of presentation of radiographic features to associate the risk of these features with the final diagnosis of bone tumor pathology.

Method

Data for this research were collected at the outpatient clinic of the bone tumor unit at Hospital de Ortopedia de la Unidad Médica de Alta Especialidad Dr. Victorio de la Fuente Narváez, part of the Instituto Mexicano del Seguro Social, Mexico City, Mexico throughout 2019. Information was obtained from the initial plain x-rays of patients with a previously established histopathological diagnosis through various types of procedures (incisional, excisional, and Tru-cut biopsies, etc.) performed at this hospital unit. All health records were collected through the hospital's electronic record system and image viewer. The plain x-rays were analyzed, and the features of the findings of each condition recorded. The present study included a total of 133 patients with knee tumor pathology. To be considered eligible for the study, participants should have early radiographic studies and a histopathological diagnosis performed at the hospital, or else, in the absence of histopathological diagnosis documents (considered non-essential due to ethical considerations), a previous clinical and radiographic diagnosis.

Table 1. Demographic characteristics of the different diagnoses of the sample

Type of tumor (n = 132)	Age	Sex		Side		Bone damaged		
	Mean (SD)	Man n (%)	Woman n (%)	Right n (%)	Left n (%)	Femur n (%)	Tibia n (%)	Fibula n (%)
Osteochondroma	22.5 ± 13.9	21 (15.9)	15 (11.4)	18 (13.6)	18 (13.6)	22 (16.7)	11 (8.33)	3 (2.3)
Non-ossifying fibroma	18.17 ± 11.4	14 (10.6)	14 (10.6)	17 (12.8)	11 (8.33)	16 (12.1)	12 (9.09)	-
Enchondroma	59.87 ± 8.9	1 (0.75)	14 (10.6)	11 (8.33)	4 (3.03)	13 (9.84)	2 (1.51)	-
1-chamber bone cyst	19.1 ± 17.4	2 (1.51)	9 (6.81)	5 (3.78)	6 (4.54)	3 (2.3)	4 (3.03)	4 (3.03)
Chondroblastoma	15.7 ± 0.6	2 (1.51)	1 (0.75)	-	3 (2.3)	-	3 (2.3)	-
Cavernous hemangioma	32	-	1 (0.75)	1 (0.75)	-	-	1 (0.75)	-
Fibrous dysplasia	3	1 (0.75)	-	-	1 (0.75)	-	1 (0.75)	-
Osteoid osteoma	27	-	1 (0.75)	1 (0.75)	-	-	1 (0.75)	-
Osteosarcoma	17.6 ± 6.8	7 (5.03)	6 (4.54)	5 (3.78)	8 (6.06)	10 (7.57)	3 (2.3)	-
Chondrosarcoma	25.7 ± 15.5	3 (2.3)	1 (0.75)	3 (2.3)	1 (0.75)	1 (0.75)	3 (2.3)	-
Malignant fibrous histiocytoma	9	-	1 (0.75)	1 (0.75)	-	-	-	1 (0.75)
Fusocellular mesenchymal presentation	67	1 (0.75)	-	1 (0.75)	-	-	1 (0.75)	-
Plasmocytoma	8	-	1 (0.75)	-	1 (0.75)	1 (0.75)	-	-

SD: standard deviation.

Data collected included epidemiological characteristics (age and sex), the bone damaged, lytic lesions (inactive, active, or aggressive, and with ground-glass appearance), amorphous calcifications, extra- and intraosseous cartilaginous blastic lesions, intra- and extraosseous bone lineage lesions (with well-demarcated and poorly defined borders), the periosteal reaction (laminated, sunburst-like, Codman triangle), the lesion site (metaphysis, diaphysis, epiphysis, metaepiphysis), position inside the bone (central, eccentric, parosteal, periosteal), and the pattern of bone destruction (geographic, moth-eaten, or permeative) (Table 1).

Data of the characteristics were entered into the statistical software package SPSS, version 21.0 (Demo), for Windows for statistical analysis. A descriptive analysis of the data was conducted, and the independence of binomial data (presence or absence of a specific characteristic) was assessed using the chi-square test. Odds ratios (OR) were extracted to determine any possible associations between the presence of a characteristic and the final pathology determined by the histopathological analysis.

Results

A total of 133 eligible patients were included in the present study. However, complete data from one

patient were missing in the medical records. A total of 55.6% of the sample obtained were men (n = 74) and 43.6% women (n = 58). The sample mean age was 26.03 ± 17.7 years (minimum age, 3 years; maximum age, 78 years).

The most common benign diagnosis was osteochondroma (27.1% of cases [n = 36]), followed by non-ossifying fibroma (21.1% of the cases [n = 28]) and giant cell tumor (12% [n = 16]). The most common malignant diagnosis in the sample was osteosarcoma (9.8% of the cases [n = 3]), followed by chondrosarcoma (3% [n = 4]).

The bones most frequently damaged were femur (54.1% of the cases [n = 72]), tibia (37.6% [n = 50]), and fibula (7.5% [n = 10]). The right side was most often affected (68 cases [51.1%]) compared to the left side (64 cases [48.5%]). None of the cases studied were associated with fractures of the bone damaged.

Inactive lytic lesions appeared in 25.6% of the cases (n = 34), active lytic lesions in 22.65% (n = 30), and aggressive lytic lesions in 6.8% of the cases (n = 9).

Cartilaginous extraosseous blastic lesions and intraosseous cartilaginous blastic lesions were present in 34 cases (25.6%) and 17 cases (12.8%), respectively. Poorly demarcated intraosseous blastic bone

lesions were found in 12 patients (9.0%), while poorly demarcated extraosseous blastic bone lesions were found in 3 (2.3%). Periosteal reaction in the form of Codman triangle occurred in 9 patients (6.8%), and the sunburst pattern in 11 (8.3%).

The most frequently damaged site was the bone metaphysis (33 cases [24.8%]), followed by the epiphyseal region (20 cases [15.0%]), the meta-diaphysis (12 cases [9.0%]), and finally, the diaphyseal region (3 cases [2.3%]). The most common location of the lesion was central (51 cases [38.3%]), eccentric (40 cases [30.1%]), parosteal (38 cases [28.6%]), and periosteal (3 cases [2.3%]).

The geographic pattern of bone destruction was seen in 61 cases (45.9%), moth-eaten in 7 (5.3%), and permeative in 5 (3.8%).

Lesions with inactive borders did not show a statistically significant association with malignant tumor lesions compared to benign lesions (OR, 0.18; 95% confidence interval [CI], 0.05-0.66). Similarly, cartilaginous extra- and intraosseous blastic lesions were not associated with malignant lesions compared to benign lesions (OR, 0.04 and 0.03, respectively; 95%CI, 0.006-0.37 and 0.06-1.44, respectively).

Active or aggressive lytic lesions (OR, 6.9 and 26.85, respectively; 95%CI, 2.83-16.85 and 3.21-224, respectively) were associated with giant cell tumors. Poorly demarcated intraosseous blastic bone lesions (OR, 36.15; 95%CI, 4.4-295.5) were associated with the presence of osteosarcoma. Periosteal reaction (OR, 36.15; 95%CI, 4.4-295.5), the moth-eaten or permeative patterns (OR, 11.75; 95%CI, 1.26-109), and central lesion location (OR, 3.03; 95%CI, 1.37-6.69) were associated with malignant tumor lesions.

In the data reported, statistical power > 80% was found, while the remaining characteristics that were not significant or whose statistical power > 80% are shown on table 2.

Discussion

The analysis of the plain x-rays of 132 patients from Hospital de Ortopedia del Servicio de Tumores Óseos at Unidad Médica de Alta Especialidad Dr. Victorio de la Fuente Narváez, Mexico City, Mexico revealed a predominance of men compared to women. The sample mean age was 26.03 ± 17.7 years, indicative of a higher rate of bone tumors within the first 3 decades of life, which is consistent with former studies that locate the occurrence of primary bone tumors within the second decade of life, corresponding to the peak

growth period in humans. The most common malignant conditions in the sample studied was osteosarcoma, which overall, is known as the most common primary malignant bone neoplasm of all.¹⁶⁻¹⁸ Similarly, the most common benign condition was osteochondroma, which is consistent with what other local series have reported¹⁹.

The analysis of radiographic features correlated lesions with inactive borders with benign lesions and radiographic lesions of cartilaginous lineage characterized by "rings and splashes," both intra- and extraosseous, with benign lesions. Giant cell tumor was associated with lytic lesions with active borders, especially with lesions considered aggressive. Given the potential for metastasis of this type of tumor, the presence of lytic lesions with active borders and aggressive growth requires careful monitoring. Blastic lesions with poorly demarcated borders, both intra- and extraosseous, were significantly associated with primary malignant tumor lesions. Periosteal reactions, in any presentation, were consistently associated with primary malignant bone tumors. The site of the radiographic lesion presentation, whether epiphyseal, metaphyseal, diaphyseal or metadiaphyseal was not associated with any specific benign or malignant condition. Central lesion location with respect to the bone axis was associated with malignant tumor lesions, while other locations (eccentric, parosteal, or periosteal) were not associated any specific type of tumor. The geographic pattern was associated with benign tumor lesions, while moth-eaten or permeative destructive patterns were strongly associated with malignant bone tumor disease.

These descriptive data of radiographic presentations of bone tumors are crucial to achieve more timely diagnoses using clinical assessments and plain x-rays. However, there are no studies correlating radiographic features and clinical findings. The frequency of presentation of tumor features has not been reported previously. The lack of knowledge among primary care physicians on these radiological features and how it delays neoplastic diagnoses is an undisputed fact to this date²⁰. That is why the present study includes such features that should be taken into consideration, at least, regarding their frequency of presentation related to a definitive histopathological diagnosis of bone neoplasm.

Due to the nature and type of study conducted, caution is advised when interpreting the association measures used. Further studies with more robust methodologies are needed to consolidate the

Table 2. Table of association between multiple radiographic features and malignant lesions

Feature (n = 132)	c2*	OR	95%CI	Statistical power (1-β)[†]
Lytic				
Inactive	0.009	0.18	0.05-0.66	> 80
Active	< 0.001	6.91	2.83-16.85	> 80
Aggressive	< 0.001	26.85	3.21-224	> 80
Amorphous calcification	0.612	-	-	-
Blastic				
Extrasosseous cartilaginous	< 0.001	0.04	0.006-0.37	> 80
Intraosseous cartilaginous	0.205	0.3	0.06-1.44	73.53
Intraosseous well demarcated	0.612	-	-	-
Intraosseous poorly demarcated	< 0.001	36.15	4.4-295	> 80
Extrasosseous well demarcated	0.612	-	-	-
Extrasosseous poorly demarcated	0.37	5.52	0.48-62.95	> 80
Periosteal reaction				
Codman triangle	< 0.001	31.66	3.84-261	> 80
Sunburst-like	< 0.001	36.15	4.4-295	> 80
Laminated	-	-	-	-
Site				
Epiphysis	0.275	1.97	0.73-5.32	48.29
Metaphysis	0.09	0.44	0.18-1.03	60.71
Diaphysis	0.37	5.52	0.48-62.95	> 80
Metadiaphysis	0.29	2.39	0.68-8.39	68.09
Location				
Central	0.009	3.03	1.37-6.69	> 80
Eccentric	0.92	0.87	0.37-2.04	9.34
Parosteal	0.01	0.22	0.07-0.68	> 80
Periosteal	0.67	-	-	-
Destructive pattern				
Geographic	0.77	1.2	0.56-2.60	10.74
Moth-eaten	< 0.001	22.93	2.7-194	> 80
Permeative	0.02	11.75	1.2-109	> 80

*c2 (α = 0.05).

†β = 0.20.

95%CI: 95% confidence interval; OR: odds ratio.

radiographic features into a diagnostic tool. Additionally, increasing the feature sample size with a statistical power < 80% is also deemed necessary to improve the statistical conclusions of this research study.

Conclusions

- Inactive border lesions were associated with benign bone tumors.
- Cartilaginous extra- and intraosseous blastic lesions were associated with benign lesions.
- Active or aggressive lytic lesions are radiographic features associated with bone tumors such as giant cell tumor.
- Poorly demarcated intraosseous blastic bone lesions, along with the presence of periosteal reaction and moth-eaten or permeative destructive patterns,

are associated with malignant bone lesions, in both cases, of predominant central location.

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Conflicts of interest

None reported.

Ethical disclosures

Protection of human subjects and animals in research. The authors declare that no experiments were performed on humans or animals for this study.

Patients' data protection. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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