Magnetic resonance imaging in the evaluation of periosteal reactions*

Ressonância magnética na avaliação das reações periosteais

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Abstract **The objective of the present essay was to encourage a careful evaluation of periosteal reactions on magnetic resonance images. The initial approach to bone lesions is made by conventional radiography and, based on the imaging findings, periosteal reactions are classified into classical subtypes. Although magnetic resonance imaging is considered as the gold standard for local staging of bone tumors, the utilization of such method in the study of periosteal reactions related to focal bone lesions has been poorly emphasized, with relatively few studies approaching this subject. The literature review revealed a study describing an experimental animal model of osteomyelitis suggesting that magnetic resonance imaging is superior to other imaging methods in the early identification of periosteal reactions. Another study has suggested a good correlation between conventional radiography and magnetic resonance imaging in the identification and classification of periosteal reactions in cases of osteosarcoma. The present essay illustrates cases of periosteal reactions observed at magnetic resonance imaging in correlation with findings of conventional radiography or other imaging methods.**

Keywords: Periostitis; Bone neoplasm; Magnetic resonance imaging.

Resumo **O objetivo deste ensaio iconográfico é estimular a avaliação cuidadosa das reações periosteais nas imagens de ressonância magnética. A abordagem inicial das lesões ósseas é realizada por meio das radiografias simples e pela avaliação destas se faz a classificação das reações periosteais em subtipos clássicos. Embora a ressonância magnética seja considerada o padrão ouro para o estadiamento regional das neoplasias ósseas, seu uso no estudo das reações periosteais relacionadas às lesões ósseas focais tem sido relativamente pouco enfatizado. A revisão da literatura evidencia um modelo experimental animal de osteomielite que sugere que a ressonância magnética seja superior às outras técnicas de imagem na identificação precoce das reações periosteais. Outro estudo encontrado na literatura sugere boa correlação entre as radiografias simples e as imagens de ressonância magnética na identificação e na classificação das reações periosteais no osteossarcoma. Neste ensaio foram ilustrados casos de reações periosteais observadas pela ressonância magnética, correlacionado-as com as radiografias convencionais ou com outros métodos de diagnóstico por imagem.**

Unitermos: Periostite; Tumores ósseos; Imagem por ressonância magnética.

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INTRODUCTION

The initial approach to bone lesions is based on the evaluation of conventional radiographic images. The classic radiological semiology of focal bone lesions includes the identification and characterization of periosteal reactions. Usually, periosteal reactions are classified into some classic subtypes and the identification of such subtypes may occasionally be useful and suggest the presence of a specific disease or neoplasm[(1,2)]. Generally, processes involving intense activity or fast progression result in more aggressive periosteal reactions, and indolent processes result in non-aggressive presentations[(1,2)]. Interrupted periosteal reactions indicate the presence of biologically aggressive processes. However, there is a considerable overlap of imaging findings and the simple classification of periosteal reaction does not sufficiently define the nature or aggressiveness of the lesion[(3)].

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Although magnetic resonance imaging (MRI) is considered as the best method for local staging of musculoskeletal lesions[4–6], it is possible that the MRI capability of evaluating periosteal alterations is being underestimated. For example, a recent published review about periosteal reactions intended to education of medical residents in imaging diagnosis does not include a specific discussion on the evaluation of periosteal reactions by MRI[1].

The present iconographic essay is aimed at stimulating a careful evaluation of periosteal reactions at MRI. Cases os periosteal reactions observed by MRI are illustrated and correlated with conventional radiography and other imaging diagnosis methods.

PERIOSTEAL REACTION

Figure 1 demonstrates a normal periosteum identified on MRI images. Frequently, the normal periosteum is not even individualized by MRI images. In the event of an insult that induces periosteal reaction, vascular proliferation and thickening of the normal periosteum are observed as a response to a triggering factor. The causes of periosteal reaction are extremely varied and a comprehensive list should include tumors, infection, trauma, drugs, venous stasis, congenital osteometabolic disorders and arthritis.

The morphology of periosteal reaction reflects the intensity, duration and aggressiveness of the triggering agent[1,2]. The periosteal reaction becomes visible at conventional radiography only in the presence of a certain degree of mineralization that takes about 10-21 days to be achieved[2].

TYPES OF PERIOSTEAL REACTION

Solid

Solid periosteal reaction represents a continuous bone neoformation attached to the external cortical surface, typically occurring as a response to indolent and benign processes[1,2]. Solid periosteal reaction can be thin (Figures 2 and 3) but, sporadically, chronic processes may cause thicker solid reactions (Figure 4).

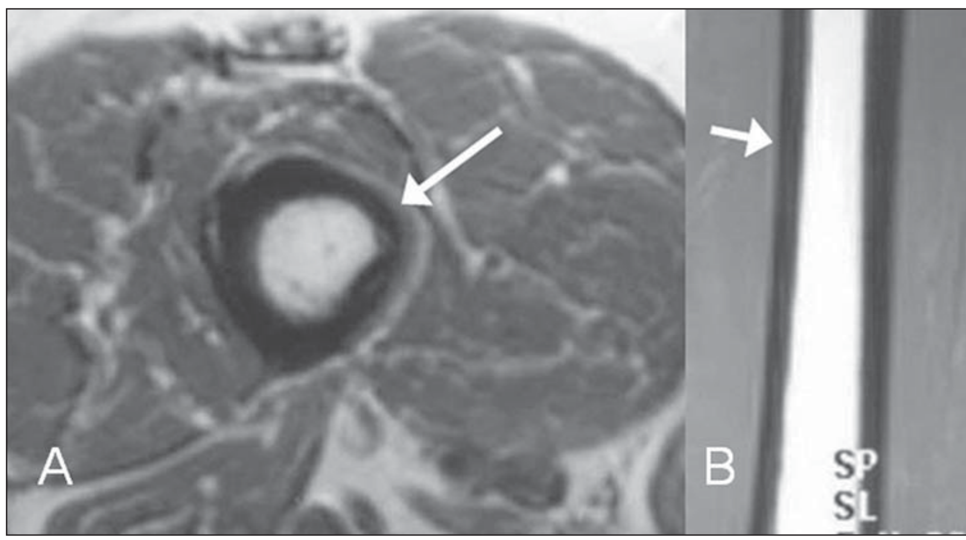

Figure 1. Magnetic resonance imaging demonstrating a thigh with a normal appearance. **A:** Axial, T1-weighted image demonstrates a thin concentric lamina with intermediate signal intensity on the periosteum (arrow). **B:** Coronal, T1-weighted image where an arrow also indicates the topography of a normal periosteum.

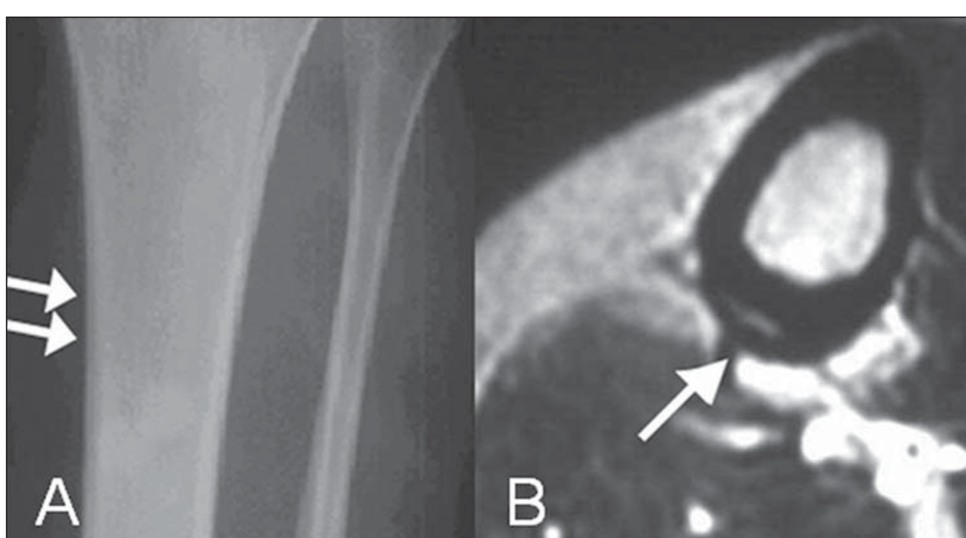

Figure 2. A: Lamellar periosteal reaction on the medial aspect of the tibial diaphysis in a case of stress fracture (arrows). **B:** Lamellar periosteal reaction on an axial MRI, T2-weighted image (arrow). Additionally, increased fluid signal can be observed at the adjacent soft tissues.

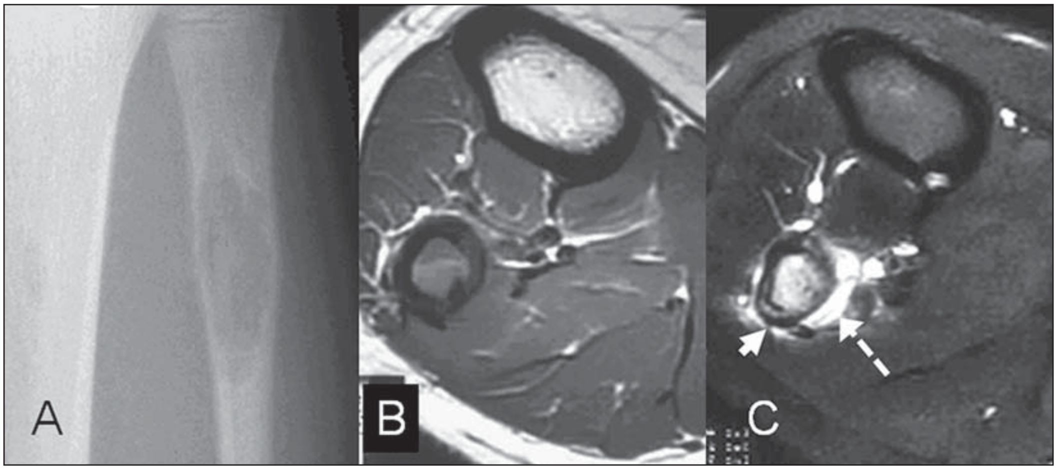

Figure 3. Lamellar periosteal reaction related to subtle pathological fracture of the fibular cortex in a fibroma non ossificans. **A:** Plain radiography demonstrates osteolytic lesion with geographic contour and slightly insufflative. **B:** Axial, T1-weighted image demonstrates decreased signal intensity in the fibular bone marrow and posterior cortical fracture. **C:** Axial T2-weighted image with fat saturation demonstrating increased intraosseous fluid signal and increased fluid signal at the adjacent soft tissues. The arrow indicates fracture-related periostitis.

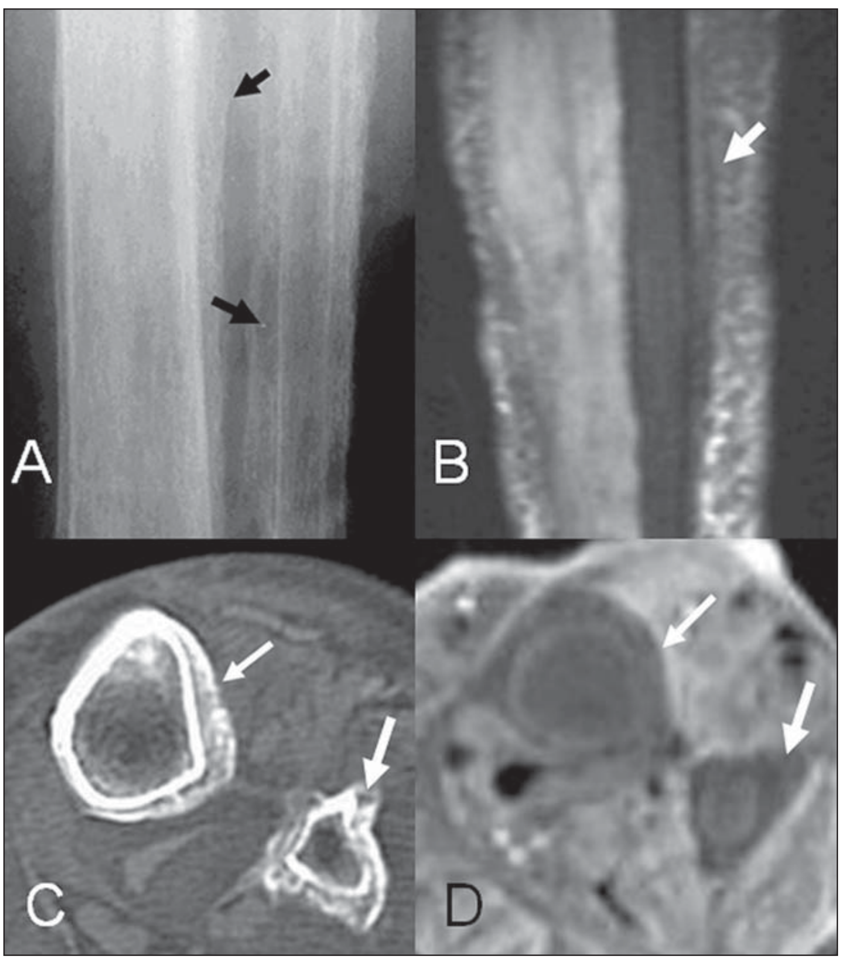

Figure 4. Solid periosteal reaction secondary to chronic venous stasis of lower extremity. **A:** Conventional radiography demonstrates periosteal reaction in the tibia and fibula (black arrows). **B:** MRI T2-weighted image with fat saturation also demonstrates periosteal reaction (white arrow). Axial computed tomography (**C**) and axial MRI T1-weighted image with fat saturation (**D**), both of them confirming the circumferential involvement of the periosteal reaction.

Lamellar or multilamellar

Multilamellar periosteal reaction (Figure 5), also denominated "onion skin" is caused by deposition of concentric, sheet-like layers of mineralized periosteal new bone, separated by vascular dilatation and loose connective tissue[1–3]. In cases of association with malignant tumors, the spaces between the layers may become secondarily infiltrated by malignant cells. Possible associations include: Ewing sarcoma, osteosarcoma, osteomyelitis and aneurysmal bone cyst, among others[3].

Spiculated pattern, arising perpendicular to the bone cortex

Spiculated periosteal reaction corresponds to thin spicules arranged perpendicular to the bone cortex (Figure 6). Such spicules are not neoplastic and originate from the ossification along periosteal vascular channels and fibrous bands (Shapey's fibers) stretched away from the bone cortex(1–3). The loose areolar tissue between spicules may be later replaced by a tumor or other tissues.

Sun ray pattern

In the divergent spiculated or "sun ray" periosteal reaction, the spicules extend into an epicenter in the bone tissue (Figures 7 and 8). Sun ray periosteal reaction is generally perceived as a sign of malignancy and is frequently associated with osteosarcoma(1,3), although it may be observed in benign lesions such as osteoblastomas and hemangiomas(3).

Codman's triangle

Codman's triangle is the interrupted version of the lamellar and multilamellar

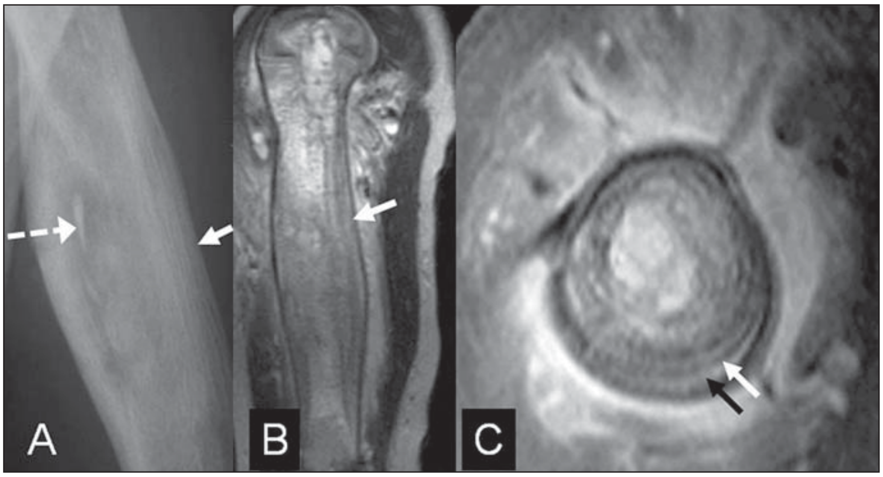

Figure 5. A: Multilamellar periosteal reaction (white arrow) with an "onion skin" pattern identified by plain radiography in the humeral diaphysis in a child aged approximately one year and eight months with surgically confirmed chronic osteomyelitis. Sequestrum is indicated by the dashed white arrow. **B:** Sagittal MRI T2-weighted image confirms the presence os multilamellar periosteal reaction (white arrow). **C:** Axial MRI T2-weighted image demonstrates multiple concentric lamellar depositions on the periosteum (arrows).

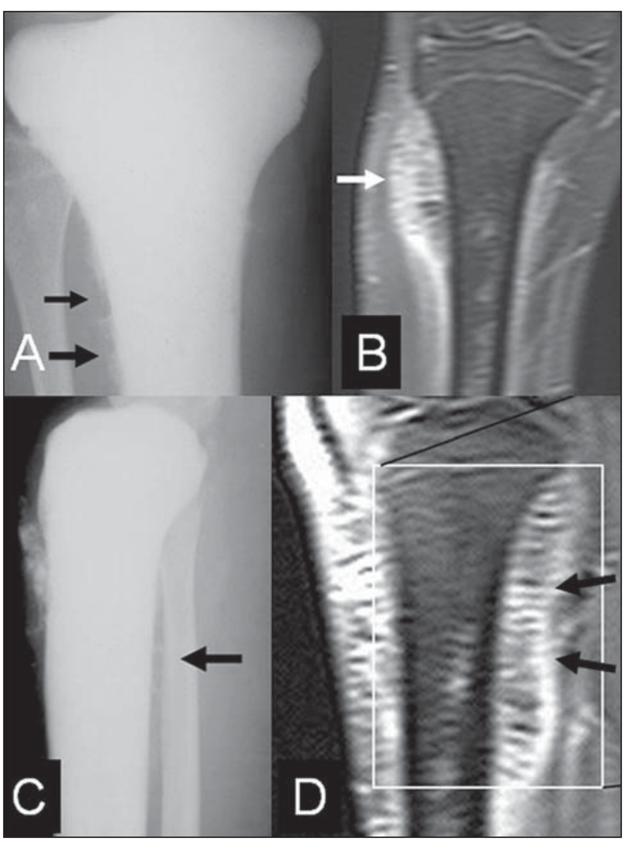

Figure 6. A,C: Tibial osteosarcoma presenting spiculate periosteal reaction perpendicular to the bone cortex surface (black arrow) identified at plain radiography respectively on anteroposterior and lateral views. **B,D:** Spicules with low signal intensity arranged perpendicular to the tibial axis demonstrated by MRI. In the present case, the periosteal reaction is more noticeable at MRI than at plain radiography. **B:** Coronal, gadolinium-enhanced MRI T1-weighted image with fat saturation. **D:** Sagittal MRI T2-weighted image with fat saturation.

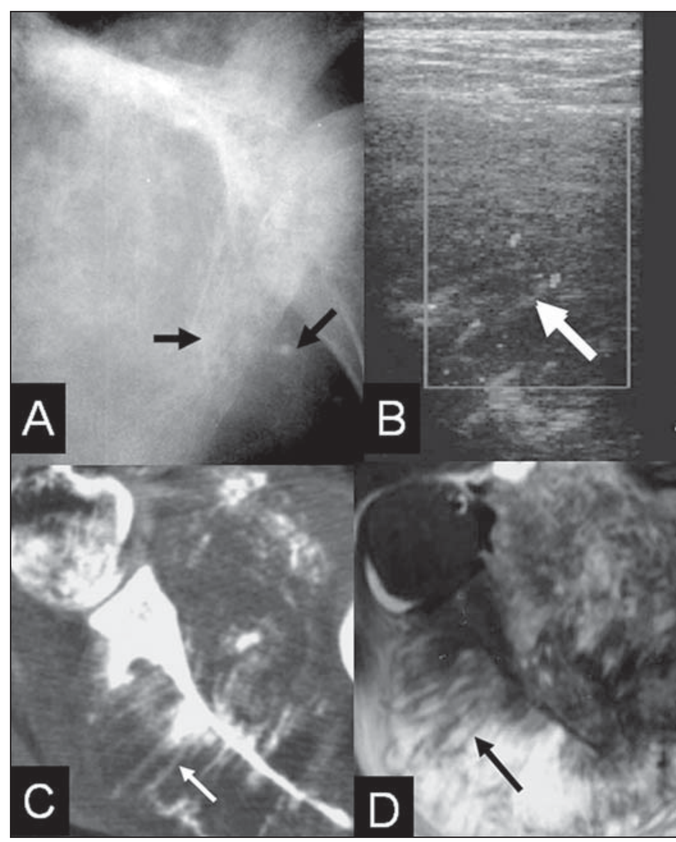

Figure 7. Spiculated "sun ray" periosteal reaction in an Ewing's sarcoma of the scapula. **A:** Plain radiography with arrows indicating periosteal reaction with some divergent spicules. **B:** Doppler ultrasonography confirming the presence of spicules (arrow) and increased periosteal vascularization. **C:** Axial computed tomography image. The Arrow indicates one of the spicules of the periosteal reaction. **D:** The same appearance can be identified on axial MRI T1-weighted image acquired following intravenous contrast agent injection. The arrow indicates one of the periosteal spicules.

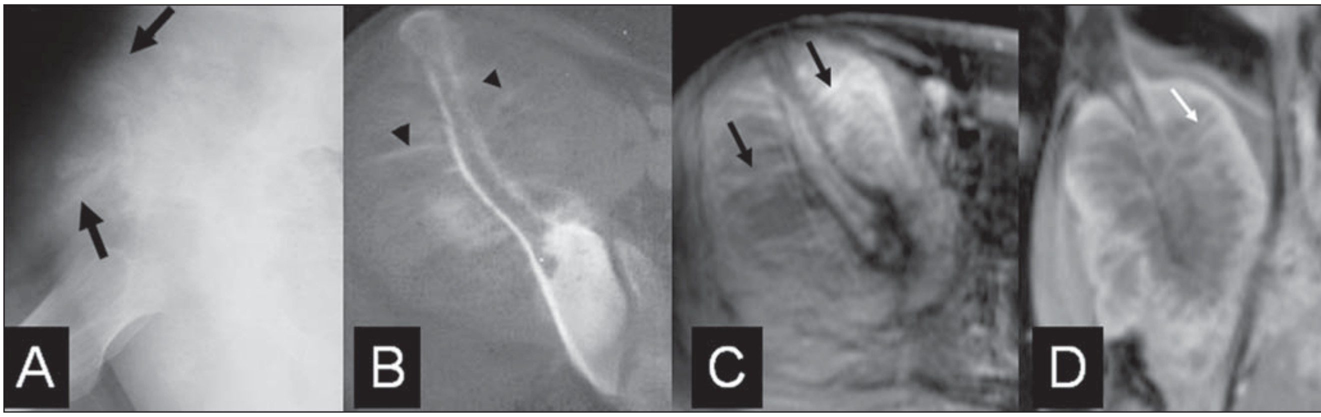

Figure 8. Divergent spiculated periosteal reaction indicated by arrows in a proved case of iliac osteosarcoma. **A:** Plain radiography. **B:** Axial computed tomography. **C,D:** Respectively, contrast-enhanced axial and coronal MRI T1-weighted images.

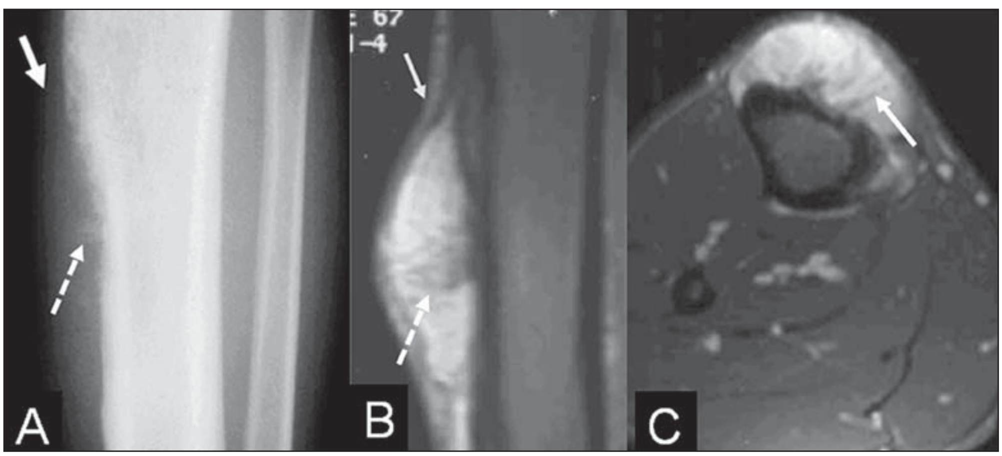

Figure 9. Periosteal osteosarcoma in the tibia. **A:** At radiography, one can identify interrupted (continuous arrow) and spiculated (dashed arrow) periosteal reactions. **B:** Coronal MRI T1-weighted image acquired following intravenous contrast injection demonstrating spiculated periosteal reaction (dashed arrow). On the same image, in the cranial region of the periosteal reaction, one can observe an area resembling the Codman's triangle pattern traditionally described at radiography. **C:** Axial, contrast-enhanced MRI T1-weighted image with Arrow indicating spiculated periosteal reaction.

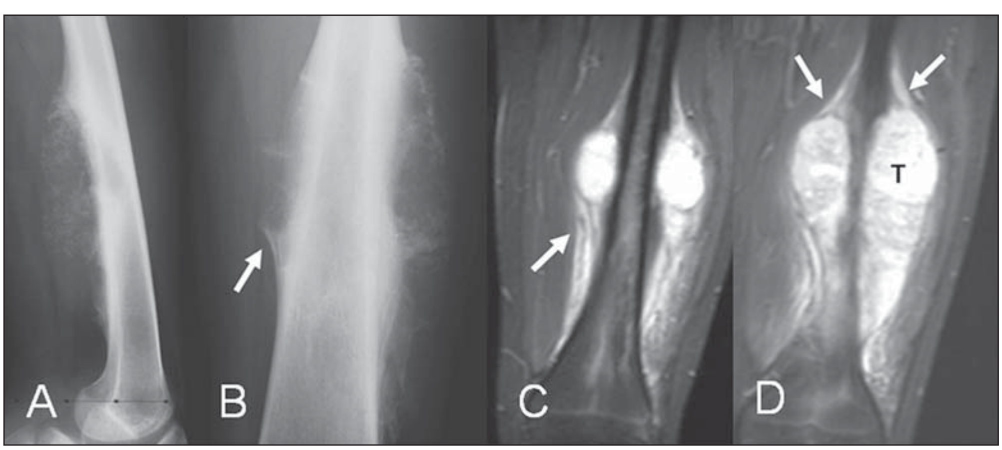

Figure 10. A,B: Plain radiography, orthogonal views of a femur in another case of osteosarcoma. Besides spiculated periosteal reaction, this case demonstrates a Codman's triangle (arrow). **C,D:** Coronal MRI T2-weighted images confirm the presence of interrupted periosteal reaction similar to the Codman's triangle observed at radiography.

periosteal reaction (Figures 9 and 10). Generally, the region of the Codman's triangle is tumor-free, but may be secondarily infiltrated[7]. This type of periosteal reaction was firstly described in cases of osteosarcoma, but it can be observed in other primary malignant tumors or bone metastases, in osteomyelitis, in trauma, and in benign, but active tumors, such as aneurysmal bone cysts[1,3].

DISCUSSION

The prevalence of the different types of periosteal reaction in each type of bone tumor is relatively poorly documented in the literature[3]. Notwithstanding, the description of the above described periosteal reaction subtypes is a usual practice in conventional radiological reports. Few descriptions are found in the literature about MRI in the study of periosteal reactions[8–10]. An experimental study has evaluated the most effective method for identifying periostitis following induction of leg bone infection in rabbits, comparing conventional radiology, contrast-enhanced computed tomography and MRI, using histology as the gold standard[8]. In such study, MRI was considered as the best method in the identification of periosteal elevation, being capable of identifying periostitis even in the absence of ossification. Two cases of false-positive result were observed with MRI.

Another study has blindly compared conventional radiology and MRI as to the presence and classification of periosteal reactions in osteosarcomas, observing a good correlation between both methods[10].

CONCLUSION

The semiological patterns of periosteal reactions observed at conventional radiography can be extrapolated to magnetic resonance imaging. Considering the relevance of the findings, the identification and characterization of periosteal reaction at MRI should be stimulated.

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