Osteochondroma: radiological diagnosis, complications and variants

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Abstract: Understanding and recognising the spectrum of appearances of osteochondroma is important because it represents the most frequent pseudotumoral bone lesion. There are pathognomonic radiological features that are evident with the currently available imaging methods. The recognition of these features and their potential complications and variants, enables a correct diagnosis to be made, the identification of possible complications and is a guide for the therapeutic decisions of non-conclusive cases.

Keywords: Bone tumors, Dysplasia, Exostosis, Osteochondroma.

Resumen: Conocer el espectro de apariencias del osteocondroma es importante, ya que representa lesión pseudotumoral más frecuente del hueso y posee unas características radiológicas patognomónicas evidenciables con los distintos métodos de imagen disponibles actualmente. El reconocimiento de estas características radiológicas, de sus posibles complicaciones y variantes permite establecer el diagnóstico correcto, identificar las posibles complicaciones y guiar el manejo terapéutico de los casos no concluyentes.

Palabras clave: Displasia, Exostosis, Neurológicas, Osteochondroma, Tumores óseos.

Introduction

Osteochondroma represents the most common pseudotumoral bone lesion. The radiological pathognomonic characteristic of this tumor is the cortical and marrow continuity of the lesions with the adjacent bone. The lesions may be solitary or multiple, the latter forming part of the hereditary multiple exostoses syndrome. These lesions may also appear with complications such as bone deformities, fractures, neurological or vascular compromise, bursa formation and more rarely, malignant transformation. The most common variants include subungual exostosis, dysplasia epiphysealis hemimelica (Trevor's disease), parosteal osteochondromatous proliferation (Nora's lesion) and Florid reactive periostitis. In general, the diagnosis can be made with an X-ray, according to the characteristics of the tumor, although other methods such as ultrasound imaging, especially CT and MRI may be useful in uncertain cases, or with the appearance of symptomatic lesions or in unusual places. The aim of this paper is to illustrate the various presentations of osteochondroma, as well as its complications and variants.

Pathophysiology and epidemiology

Osteochondromas are considered developmental lesions rather than true neoplasms. The lesion, according to the World Health Organization (WHO), is defined as an osteochondral exostosis with cortical and marrow continuity, respectively. It is believed that these lesions result from the separation of a fragment of the epiphyseal growth cartilage, which herniates through normal bone that surrounds the growth plate.

In the case of multiple osteochondromas its association has been described with mutations of the EXT 1 and EXT 2 genes, which intervene in the heparan sulfate proteoglycans biosynthesis, involved in the epiphyseal growth plate, and with radiation, which could produce dedifferentiation of the cartilaginous tissue growth, among others. In general, osteochondromas appear mostly in children or adolescents, without gender predilection, although some authors consider it more frequent in males.

Solitary osteochondroma

The vast majority of osteochondromas are solitary lesions. The most common sites are...
the long bones of the lower limb, mostly the distal end of the femur and proximal tibia\textsuperscript{(12)} (Figure 1) and in the upper limb, the humerus\textsuperscript{(1)}). Sites of rare occurrence described in literature include the bones of the hands and feet, the scapula, pelvis, spine\textsuperscript{(1,13-15)} (Figures 2a, b and 3a, b), ribs and sites rarer still such as the temporomandibular joint\textsuperscript{(16,17)} or soft tissues such as the Hoffa fat pad around the knee\textsuperscript{(18)} (Figure 4a, b), although it should be noted that an osteochondroma can arise in any bone that develops from endochondral ossification\textsuperscript{(1)}. The majority are asymptomatic lesions\textsuperscript{(18)} and discovered incidentally, and if they appear with symptoms, the most common of them is the development of a slow-growing mass\textsuperscript{(1)}.

\textbf{Figure 1.} X-ray AP of knee: an exophytic cortical bone lesion in the metaphyseal-diaphyseal junction of the medial distal femur can be observed, with cortical marrow continuity (arrow).

\textbf{Figure 2a.} X-ray of side of wrist: Pisiform Osteochondroma: benign aspect exophytic lobulated bone lesion dependent on the pisiform bone (arrow).

\textbf{Figure 2b.} Axial CT of the wrist with bone reconstruction: Pisiform Osteochondroma: benign aspect exophytic and lobulated cortical bone lesion dependent on the pisiform bone (arrow).

\textbf{Figure 3a.} Axial CT of the thorax with bone reconstruction: Scapular Osteochondroma: benign aspect cortical bone lesion dependent on the medial border of the left scapula (arrow).
pedunculated (Figures 5 and 6), radiography often being sufficient for diagnosis (1). The most frequent location in long bones is usually the metaphysis and tendon insertion sites (10). However, in flat bones diagnosis may be more difficult. Hyaline cartilage layer can be visualized in radiographs as areas of semicolon calcification, but in cases with absence of mineralization other imaging methods may be required. Ultrasound allows visualization of the cartilage layer, which is seen as a hypoechoic area on the bone cortex being studied, but proves more useful for the study of complications such as aneurysms, thrombosis or bursitis (10). Regarding CT, this allows excellent visualization of the cortico-medullary continuity of the lesion, and may be even more useful in areas of complex anatomy, such as the bones of the spine, shoulder or pelvis (10). However, some authors believe that this imaging method may not be suitable for measuring the thickness of the cartilage layer, an important criterion for differentiation with chondrosarcoma (1). Finally, MRI allows better visualization than radiography in the cortico-medullary continuity of lesions in complex areas (1). Cortical continuity is displayed as a thin hypointense line on all pulse sequences, and the bone marrow maintains a yellow marrow signal (Figure 7 a,b). In addition, MRI is considered as the best method for visualizing the structures surrounding the lesion, its effect on these (vascular and nerve compromise), data complication (pseudoaneurysms, edema) and unmineralized cartilage layer, which displays a high signal on T1 and on T2, due to its water content, allowing the adequate measurement of thickness for these features (1) (Figure 8). It must be noted that the presence of edema is a sign of complication and may indicate the presence of a chondrosarcoma (10).

Figure 3b. 3D CT scapula reconstruction. Scapular Osteochondroma: sessile exophytic bone lesion dependent on medial border of the scapula.

Figure 4a. Lateral knee X-ray: Femoral Osteochondroma: cortical exophytic bone lesion dependent on metaphysidiaphysis junction of distal femur (arrow).

Figure 4b. Right knee MRI, sagittal T1 sequence: Sessile Osteochondroma of the distal femur: exophytic lesion in distal femoral diaphysis with cortical medullary continuity (arrow).

The radiological features are quite typical, displaying an exophytic lesion with cortical and medullary continuity protruding from the adjacent bone (19). Regarding its implantation base, this can be wide or narrow, representing the two types of solitary osteochondroma, the sessile and

Figure 5. Axial MRI of thigh, Axial T1 sequence: Sessile Osteochondroma of the distal femur: exophytic bone lesion dependent on femoral diaphysis (arrow) with cortical and medullary continuity.
Multiple hereditary exostosis (MHE)

This is a syndrome characterized by the development of multiple osteochondromas and shows an autosomal dominant genetic pattern\(^1\). Some authors consider diagnosis, the radiological presence of at least two osteochondromas in yuxta-epiphyseal regions of long bones. It is considered that the appearance of solitary osteochondromas is six times more frequent than in this syndrome. The clinical aspect and complications are the same as for solitary lesions, although patients with this condition can experience a variety of orthopedic deformities, the most common amongst these being the shortening of the forearm\(^2\)\(^,\)\(^21\)\).

The presence of complications is greater in this syndrome, as there are a greater number of lesions\(^1\). It is believed that the genetic basis of this syndrome is related to mutations of the EXT1 and 2 genes\(^2\). The most feared complication is the malignization of the osteochondromas to chondrosarcomas, as we will see further on, but it is worth saying that it is thought that this transformation is more frequent in osteochondromas of patients with this syndrome\(^10\). In differential diagnosis, Trevor’s disease must be considered, in that this as well as osteochondroma are diagnosed at an early age and its development is related to the closure of the growth plate. However, lesions in Trevor’s disease affect the lower limbs unilaterally and are limited to the medial or lateral side of these (hemimelica). Finally, malignization of lesions has not been reported in the latter\(^2\).

Complications of osteochondroma

Among the most frequent complications can be found the presence of bony deformities, fractures, vascular and neurological compromise, bursa formation and malignization\(^22\)\(^,\)\(^23\).

**Bone deformity:** it is considered the most common presentation and is usually more frequent in MHE patients. The disease mostly affects the knees, hips and ankle, in order of frequency\(^1\).
Due to mass effect, in some cases, adjacent bone erosion can be observed and in the case of visceral contact, these may also be affected as, for example, the case of osteochondromas of the ribs which can produce pleural effusion and/or hemotherax\(^{(1,24)}\).

Fracture: This is another complication to consider and, consequently, causes pain, which can be a form of presentation\(^{(10)}\), being more frequent at the base of pedunculated lesions\(^{(1)}\). Considering the mass effect which these lesions can produce, being exophytic, it is not uncommon that complications such as vascular or nerve compression syndrome arise, and in fact, these can appear in various forms (Figure 9c).

**Figure 9c.** Lateral X-ray of knee: Fibular Osteochondroma: exophytic cortical bone lesion dependent on posterior metaphyseal-diaphyseal junction of the fibula, with cortical medullary continuity (arrow).

Vascular syndromes: Vessel displacement (Figure 10), stenosis, vascular occlusion and pseudoaneurysms may occur, the latter being more frequent at knee level, usually involving the popliteal artery\(^{(1,25)}\) or occurring as an arterial thrombosis\(^{(26)}\). Finally, in the case of rib lesions, the presentation has been described as thoracic outlet syndrome due to occlusion of the adjacent vessels\(^{(27)}\).

**Figure 10.** Angio CT of lower limbs, 3D reconstruction: tibiofibular bone lesion (arrow) producing evident ipsilateral tibiofibular trunk displacement.

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**9a.** Sagittal MRI of knee, SPIR DP sequence: Fibular Osteochondroma: exophytic bone lesion dependent on the fibula (hollow arrow), mass effect with displacement of posterior femoral neurovascular bundle (arrow).

**9b.** Sagittal MRI of knee, T1 sequence: Fibular Osteochondroma: mass effect can be observed at the level of the posterior muscle compartment of the calf.
**Nerve involvement:** Central and/or peripheral Osteochondromas can produce nerve compression syndromes, generating entrapment symptoms, the most common being the peroneal nerve caused by a tibial lesion\(^1\). More rarely described has been the sciatic nerve compression by femoral neck lesions\(^4\). In this aspect MRI is an excellent imaging method, as it is able to demonstrate the nerve signal change and muscle atrophy with fat replacement of the involved muscles (Figure 11)\(^{1,10}\). Finally, one interesting fact is that central lesions that produce nerve compression in patients with hereditary multiple exostoses, are usually solitary\(^1\).

**Bursa formation:** In general, this develops at sites where there is friction between structures, namely between the exostosis and an adjacent structure\(^1\). This usually occurs around the scapula\(^{11,28,29}\), in the hip and shoulder. This complication is seen as a soft tissue mass near an osteochondroma, which may contain mineralized chondroid areas that can simulate malignization. Ultrasound is very useful to distinguish the anechoic bursal collection from the solid hypoechoic tissue of a hyaline cartilage cap. The bursa, in turn, can become complicated, can cause infection, inflammation, or bleeding\(^1\); the presence of a mass due to a reactive infected bursa may clinically suggest the malignization of a lesion\(^30\). In this respect, MRI is an excellent imaging method that allows diagnosis by demonstrating the peripheral contrast enhancement or the presence of septa in the cases of super-infection (Figure 12 a-c)\(^{30}\). Another aspect to consider is the presence of a chondrometaplasia resulting in a secondary osteochondromatosis from the bursa synovia\(^1,31\).

**Malignization:** Malignant transformation is the most feared complication and it is due to a chondrosarcoma arising in the cartilage cap of the lesion\(^1,7\). The lesions most susceptible to malignant transformation are of the pelvis, hips and shoulders. Findings suggest malignization consists in the growth of a previously stable lesion, irregular borders, interior radiolucent areas, erosions or destruction of adjacent bone and soft tissue mass with irregular calcifications. The most important image criterion to consider is the thickness of cartilage cap, there being differences among authors as to the pathological and normal value of this\(^1,32\). Because of their high water content, on MRI it shows high signal intensity on T2 and low on T1. Usually found adjacent to an area of low signal representing the perichondrium\(^10\).

**Figure 11.** Axial MRI of hip, T2 STIR sequence, enlarged image: Osteochondroma of left femur with hyperintense cartilaginous cap and unchanged signal displacement of the adjacent sciatic nerve (arrow).

**Figure 12a.** Dorsal tumor ultrasound: Oval heterogeneous image with well-defined borders and subscapularis intramuscular location, corresponding to an infected bursa (arrow).

**Figure 12b.** Axial MRI of the chest wall, T1 SPIR sequence with gadolinium: Bursa between left scapular osteochondroma (not displayed) and chest wall: rounded image with localized peripheral enhancement at the level of left posterior chest wall, suggesting superinfection.
Variants: Dysplasia epiphysealis hemimelica (Trevor’s disease). This consists of an osteocartilaginous growth on the medial or lateral side of one or more epiphysis\(^{(1,33,34)}\). It largely affects the long bones of the lower limb and tarsal bones, especially the knee, ankle and talus\(^{(8,35)}\). There are rare cases reported of the hip, patella, spine\(^{(36-38)}\) and hand\(^{(39)}\).

We describe three forms, a localized, a classical, affecting more than one area in a single limb, and a generalized form, the bilateral affection considered rare\(^{(1,40)}\). The first usually affects the ankle; the second affects epiphysis, most often around the knee and ankle; and the last, the entire lower extremity\(^{(1,34)}\) (Figures 13 and 14 a-c). The radiological findings in pediatric patients show affected ossification centers prematurely eccentric, lobulated and increased in size. In addition, calcifications can be seen. Subsequently, typical epiphyseal exostosis with cortical and medullary continuity can be seen. The CT and MRI, allow viewing of these aspects, as well as cartilage component detail. You can also see areas with low signal on T1 and T2, which represent areas of calcification or ossification\(^{(1,41)}\). In differential diagnosis the osteochondromas must be considered\(^{(1)}\). The first usually affects the ankle; the second affects epiphysis, most often around the knee and ankle; and the last, the entire lower extremity\(^{(1,34)}\) (Figures 13 and 14 a-c). The radiological findings in pediatric patients show affected ossification centers prematurely eccentric, lobulated and increased in size. In addition, calcifications can be seen. Subsequently, typical epiphyseal exostosis with cortical and medullary continuity can be seen. The CT and MRI, allow viewing of these aspects, as well as cartilage component detail. You can also see areas with low signal on T1 and T2, which represent areas of calcification or ossification\(^{(1,41)}\). In differential diagnosis the osteochondromas must be considered, although Trevor lesions occur in pediatric patients and adolescents, and arises in the epiphysis. The osteochondroma, however, occurs between ages 10 and 30 years and originates in the metaphysis of long bones\(^{(42)}\).

Other Variants: Other rarer variants include Turret exostosis, which consists of an extracortical mass dependent on the proximal or middle phalanges of the hand. Similar lesions have been described at the level of tendon and ligament insertions, known as traction exostosis. Similar lesions have been described in feet and hands, the florid reactive periostitis and paraosteal osteochondromatous proliferation or Nora’s lesion\(^{(1)}\). The latter affects patients between the third and fourth decades of life, with no gender predilection\(^{(9)}\). It consists of an exophytic growth from a cortical bone surface and is composed of cartilage, bone and fibrous tissue, mainly affecting the proximal and middle phalanges and the metacarpals and metatarsals\(^{(43)}\) (Figure 15 a, b). The radiographs reveal, in a more advanced stage, bony excrescences, with a separation base between the lesion and bone, due to the existence of cartilage tissue interposed between them, although continuity with the lesion can be seen in some cases\(^{(1)}\). The CT as well as demonstrating these findings, also allows evaluation of the presence or absence of continuity with the adjacent cortex and the presence of soft-tissue involvement. The final diagnosis is provided by the pathological anatomy, as these lesions may be confused with paraosteo osteosarcoma and/or conventional osteochondroma. The first, rarely affects bones so small, and the second, in addition to the histopathological analysis, has other features such as cortical and medullary continuity. Lastly, this lesion can be confused with a malignant process, due to its high recurrence rate\(^{(1,43)}\).

Conclusion

Osteochondroma represents the most common bone tumor, and it presents some typical radiological features, mainly cortical and medullary continuity. In doubtful cases and to study variants and/or complications, other imaging with CT or MRI in particular may be necessary, to be able to arrive at a diagnosis in most cases. Knowledge of the spectrum of findings in this lesion allows the radiologist to make a correct diagnosis and assists in directing the management of the patient toward a correct treatment.
Figure 14a. X-ray of side of the knee: Trevor’s disease: exophytic bone lesion dependent on anterior tibial tuberosity (arrow), with “horn” appearance, corresponding to epiphyseal osteochondroma.

Figure 14b. MRI of knee, sagittal T1 sequence: Trevor’s disease: exophytic bone lesion with cortical medullary continuity dependent on anterior tibial tuberosity (arrow), with “horn” appearance, corresponding to epiphyseal osteochondroma.

Figure 14c. MRI of knee, SPIR DP sagittal sequence: Trevor’s disease: exophytic bone lesion with cortical medullary continuity dependent on anterior tibial tuberosity (arrow), with “horn” appearance, corresponding to epiphyseal osteochondroma, showing a hyperintense area at the base corresponding to edema.

Figure 15a. X-ray AP of left hand: Nora’s lesion: benign aspect cortical bone tumor, dependent on diaphysis radial slope of proximal phalanx of 4th Finger.

Figure 15c. Axial CT of hand, 2nd and 3rd fingers: Nora’s lesion: cortical bone tumor dependent on phalanx of 4th Finger and of benign aspect.

Bibliography