Large Osteochondromas During Growth: A Case Series and Literature Review

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ABSTRACT

Introduction: Osteochondromas are the most common benign osteochondral tumors. Their size is rarely an indication for surgery, and large osteochondromas are usually reported as isolated cases. However, although rare, the potential for malignant transformation exists. We present a series of large osteochondromas in a pediatric population treated surgically, along with a review of the literature. **Materials and Methods:** A retrospective, multicenter cohort study was conducted in skeletally immature patients with large osteochondromas who underwent surgical treatment. Tumor volume was assessed using preoperative imaging. Demographic and surgical variables were analyzed. **Results:** Twenty patients (16 males and 4 females) from eight sites were included; four had multiple osteochondromatosis and the mean age at surgery was 14 years. Nineteen patients had lesions in the extremities, and one had an extraspinal osteochondroma. Four patients were asymptomatic. Magnetic resonance imaging was used to determine tumor volume; the mean volume was 65 cm³ (range: 43.75–904.78 cm³). Surgical treatment included marginal resection in 10 cases, wide resection in 8, and intralesional resection in 2. Mean follow-up was 4 years and 8 months. There were two immediate postoperative complications, two late complications, and one recurrence. **Conclusions:** Surgical removal of large osteochondromas in the extremities and in extraspinal locations should be considered even in asymptomatic patients due to the risk of malignant transformation. Intralesional resection should be avoided because of the risk of recurrence. Marginal resection is the preferred approach, although selected cases may require wide resection with reconstruction.

Keywords: Osteochondroma; pediatric; staging; surgical treatment.
Level of Evidence: IV

Osteocondromas voluminosos durante el crecimiento: serie de casos y revisión bibliográfica

RESUMEN

Introducción: Los osteocondromas son los tumores osteocartilaginosos benignos más frecuentes. Raramente su volumen es indicación de cirugía y los osteocondromas voluminosos, en general, se comunican como casos aislados. La posibilidad de malignización, aunque excepcional, existe. Se presenta una serie de osteocondromas voluminosos en una población pediátrica tratados quirúrgicamente, y se revisa la bibliografía. **Materiales y Métodos:** Investigación retrospectiva de cohorte multicéntrica de pacientes inmaduros esqueléticamente con osteocondromas voluminosos operados. Se evaluó el volumen en imágenes preoperatorias. Se analizaron diferentes variables demográficas y quirúrgicas. **Resultados:** Se incluyó a 20 pacientes (16 varones y 4 niñas) con una edad media al operarse de 14 años, provenientes de 8 centros, 4 con osteocondromatosis múltiple. Diecinueve tenían osteocondromas en las extremidades y uno, un osteocondroma extracanal en el raquis. Cuatro eran asintomáticos. Se

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usaron las imágenes preoperatorias de resonancia magnética para definir el volumen; el volumen general promedio fue 65 cm^3 (43,75-904,78 cm^3). La cirugía incluyó resección marginal (10 casos), amplia (8 casos) e intralesional (2 casos). Tiempo medio de seguimiento: 4 años y 8 meses. Hubo 2 complicaciones posoperatorias inmediatas, y 2 complicaciones posoperatorias alejadas y una recidiva. **Conclusiones:** Considerar la ablación quirúrgica de osteocondromas voluminosos de extremidades y extracanalares raquídeos, aun sin síntomas, ante la posibilidad de malignización. Evitar la ablación intralesional por los riesgos de recidiva. El procedimiento adecuado es la resección marginal; algunos casos seleccionados requieren resección amplia con reconstrucción.
Palabras clave: Osteocondroma voluminoso; niños; estadificación; tratamiento quirúrgico.
Nivel de Evidencia: IV

INTRODUCTION

Osteochondromas are the most common benign osteocartilaginous tumors[1] and are typically located in the lower extremities, with an estimated prevalence ranging from 0.44% to 4.5%.[2] Surgical resection is indicated when lesions are symptomatic, when associated complications are present, for cosmetic reasons, or when malignant transformation is suspected.[3] Size alone is rarely an indication for surgery in skeletally immature patients.

Reports of large osteochondromas are generally limited to isolated cases, and surgical management is relatively uncommon.[4–6]

The aim of this study was to evaluate our own case series of large osteochondromas in a skeletally immature population undergoing surgery, to analyze their main characteristics and the treatments performed, as well as short- and mid-term outcomes, and to conduct a literature review.

MATERIALS AND METHODS

A multicenter, retrospective cohort study was conducted across Orthopedic and Traumatology Departments in three countries (8 sites), through review of cases recorded over the past 20 years (2004–2023).

Patients <18 years of age or skeletally immature (based on bone age), with large osteochondromas who underwent surgical treatment and had a minimum follow-up of one year, were included. To be eligible, patients were required to have osteochondromas with a volume >40 cm^3; this threshold was selected because a pedunculated osteochondroma of the knee typically has a smaller volume.

Patients with intraspinal osteochondromas were excluded. However, patients with extraspinal vertebral osteochondromas without neurological risk were included if they met the specified volume criterion. Table 1 summarizes the variables analyzed in each case.

As this was a multicenter observational study, each participating institution's Ethics Committee determined that formal approval was not required. Nevertheless, all parents, legal guardians, or patients (depending on age, clinical context, and local regulations) provided informed consent for participation in the study and for publication of their data and images, ensuring preservation of patient confidentiality.

Statistical Analysis

Parametric variables were analyzed using Student's *t* test, and nonparametric variables using the chi-square test.

Preoperative tumor volume was estimated as an approximation of the actual volume based on the best available imaging study: tumor shape was matched to the closest geometric form, and volume was subsequently calculated mathematically (Figure 1). Although these measurements were approximate rather than exact, they were close to the true values.

Table 1. Variables analyzed in the study.

Sex
Associated syndromes or conditions
Age at the time of surgery
Anatomical location
Affected bone and location within the bone
Preoperative imaging studies
Estimated tumor volume
Preoperative symptoms
Preoperative biopsy*
Type of resection**
Use of grafts, bone substitutes, or other reconstruction methods
Postoperative immobilization*
Early complications
Fixation/osteosynthesis used*
Histopathological findings
Need for additional treatment
Follow-up duration
Age at last follow-up
Late complications
Recurrence
Sequelae and functional outcomes at follow-up
Follow-up imaging studies

* If applicable.
**According to the Enneking staging system.

Figure 1. Magnetic resonance imaging of the distal thigh in coronal and sagittal planes. Example of volume estimation of a distal femoral osteochondroma approximated to a truncated cone (case 4) (see Table 2).

RESULTS

A total of 20 patients (16 males and 4 females) with a mean age of 14 years at the time of surgery (range 10 years 8 months-18 years) from eight sites in three countries were included (Table 2).

Table 2. Characteristics of patients included in the study.

Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sex	M	M	M	M	M	F	M	M	M	M	M	M	M	F	M	M	M	M	F	F
Associated conditions and syndromes	-	-	Down syndrome	-	MO	-	-	-	-	-	-	-	-	-	-	MO	-	-	MO	MO
Age at surgery (years)	14	11.7	15.3	13.5	14	12	17	12	12.3	15	10	18	16	18	17	15.3	10.64	14.08	11.72	11.8
Affected bone	Distal femur	Proximal humerus	Proximal humerus	Distal femur	Proximal tibia	Proximal fibula	Distal femur	Scapula, body	T6 Vertebra, posterior arch	Distal femur	Proximal humerus	Proximal femur	Proximal fibula	Proximal femur	Distal tibia	Proximal fibula	Humerus	Proximal femur	Proximal humerus	Humerus
Tumor volume (approx. in cm^3)	209.84	57.5	179.6	273.68	70.5	135.12	904.78	56.5	103 (extra-canal)	53.27	60	65	65	65	65	217.6	43.75	46.8	79.5	51.84
Preoperative symptoms	No (mass detected)	No (mass detected)	Pain	No (mass detected)	Pain + deformity	CFN Paresthesia + Deformity	Pain	Pain	Painless mass that grows	Pain	Pain + paresthesia	Pain + limited mobility	Pain	Pain + limited mobility	Post-activity pain	Painless mass that is growing	No (mass found)	Pain	Painless mass that is growing	Painful mass
Previous biopsy	Yes/C-shaped	No	No	No	No	No	Yes/CT	No	Yes/CT	No	No	No	No	No	No	No	No	No	No	No
Resection (margins)	Marginal	Marginal	Marginal	Wide	Marginal	Marginal	Wide	Marginal	Intralesional	Marginal	Wide	Wide	Wide	Wide	Wide	Wide	Marginal	Intralesional	Marginal	Marginal
Surgical technique	Partial femoral resection with tumor mass + reconstruction and IF	Partial humeral resection with tumor mass + phenolization + reconstruction and IF	Partial humeral resection with tumor mass + phenolization + reconstruction and IF	Partial femoral resection with tumor mass + phenolization + reconstruction and IF	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Posterior approach + fragment resection + IF	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Complete en bloc resection	Partial resection (residual tissue remains)	Complete en bloc resection	Complete en bloc resection
Type of reconstruction	Graft + BS	BS	BS	Graft + BS	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
IF	Solid titanium IN + SL plates	Elastic IN	Titanium L-plates + wires	Extra-long titanium plate	No	No	No	No	Pedicle fixation	No	No	No	No	No	No	No	No	No	No	No
Early complications	No	No	No	No	No	No	No	No	No	No	No	Joint stiffness	CFN deficit	No	No	No	No	No	No	No
Follow-up (years)																				
Age at final follow-up (years)	16.5	18.6	18.3	15.5	21	18	19	18	13.5	16	12	19	18	22	18	19.6	13	19.4	12.4	13.9
Late complications	No	No	Humeral pseudoarthrosis	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Adductor pain	No	No
Recurrence	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No	No
Sequelae at final follow-up	No	No	Limited shoulder abduction	No	No	No	No	No	Scoliosis (12°)	No	No	No	No	No	No	No	No	No	No	No

M = male; F = female; MO = multiple osteochondromatosis; CF = in the territory of the common fibular nerve; CT = computed tomography; IF = internal fixation; BS = bone substitutes; IN = intramedullary nail; SL = self-locking; CFN = external popliteal sciatic nerve.

Five patients had associated conditions (4 with multiple osteochondromatosis and 1 with Down syndrome). The anatomical locations are shown in Figure 2: 12 lesions were in the lower extremities, 7 in the upper extremities, and 1 in the spine. No statistically significant differences were found between sex and age (p = 0.6), nor between sex and anatomical location (p = 0.53).

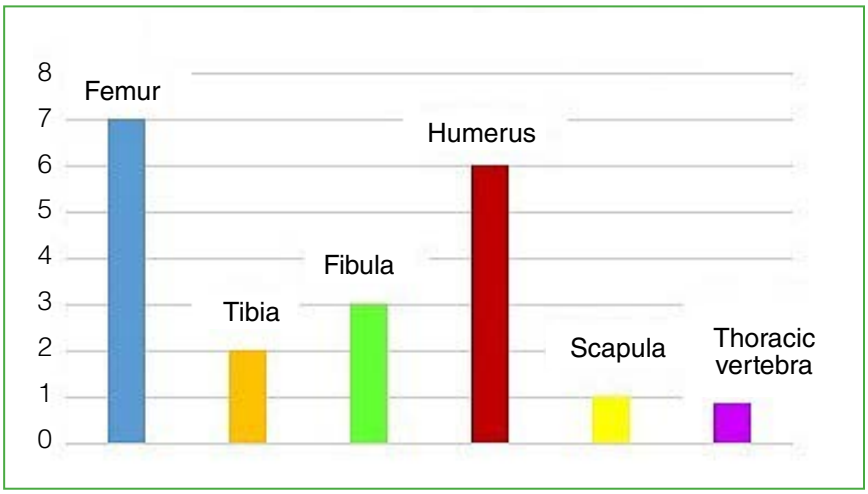

Figure 2. Anatomical distribution of skeletal osteochondromas.

Four patients were asymptomatic preoperatively; in these cases, the indication for surgery was based on tumor volume or patient and family concern. In the remaining 16 cases, symptoms included pain (12 cases) (Figure 3), progressive deformity or mass (4 cases), limitation of joint motion (3 cases), and neurological symptoms (regional paresthesia in 2 cases).

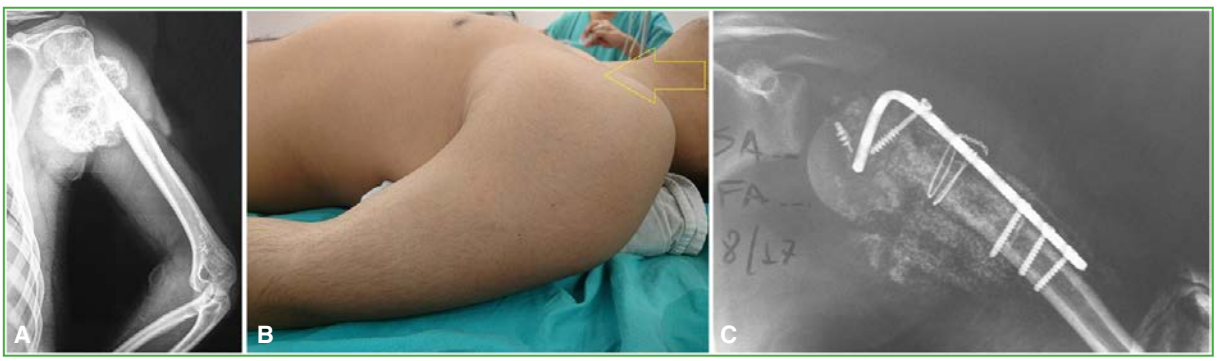

Figure 3. Case 3. Proximal humeral osteochondroma.**A.** Preoperative anteroposterior radiograph of a left proximal humeral osteochondroma (179.6 cm³). **B.** Preoperative clinical appearance. **C.** Radiograph at 18 months postoperatively showing pseudarthrosis.

All patients underwent plain radiographs; all but one also underwent magnetic resonance imaging (MRI), and 12 additionally underwent computed tomography (CT). MRI was primarily used to assess tumor volume. The mean tumor volume was 65 cm³ (range 43.75-904.78). No statistically significant differences were found in tumor volume between sexes (p = 0.51), nor between osteochondromas of the upper and lower extremities (p = 0.27).

Only three patients underwent image-guided percutaneous biopsy prior to resection; histopathological findings were consistent with the final surgical specimen.

Ten patients were treated with marginal resection, eight with wide resection, and two with intralesional ablation. All tumors were sessile osteochondromas on histopathological examination, with no evidence of malignancy or soft tissue invasion, and a cartilage cap thickness ≥3 cm.

The most performed procedure was simple tumor resection (16 cases: 15 in the extremities and 1 in the spine), either en bloc or piecemeal; reconstruction was required in only four cases. In the spinal osteochondroma, the procedure was supplemented with arthrodesis and pedicle instrumentation, without reconstruction.

Two early minor postoperative complications occurred, both in patients with extremity osteochondromas, and both resolved completely: one case of joint stiffness and one case of transient common fibular nerve deficit. No patient required additional treatment.

The mean follow-up was 4 years and 8 months (range 1–24 years), and the mean age at follow-up was 17 years and 2 months (range 12–22 years). Two late complications were observed: one case of proximal humeral pseudarthrosis that was not treated because it did not affect activities of daily living (patient with Down syndrome and significant cognitive impairment) (Figure 4), and one case of persistent pain in the adductor region, which resolved with injections and tenotomies.

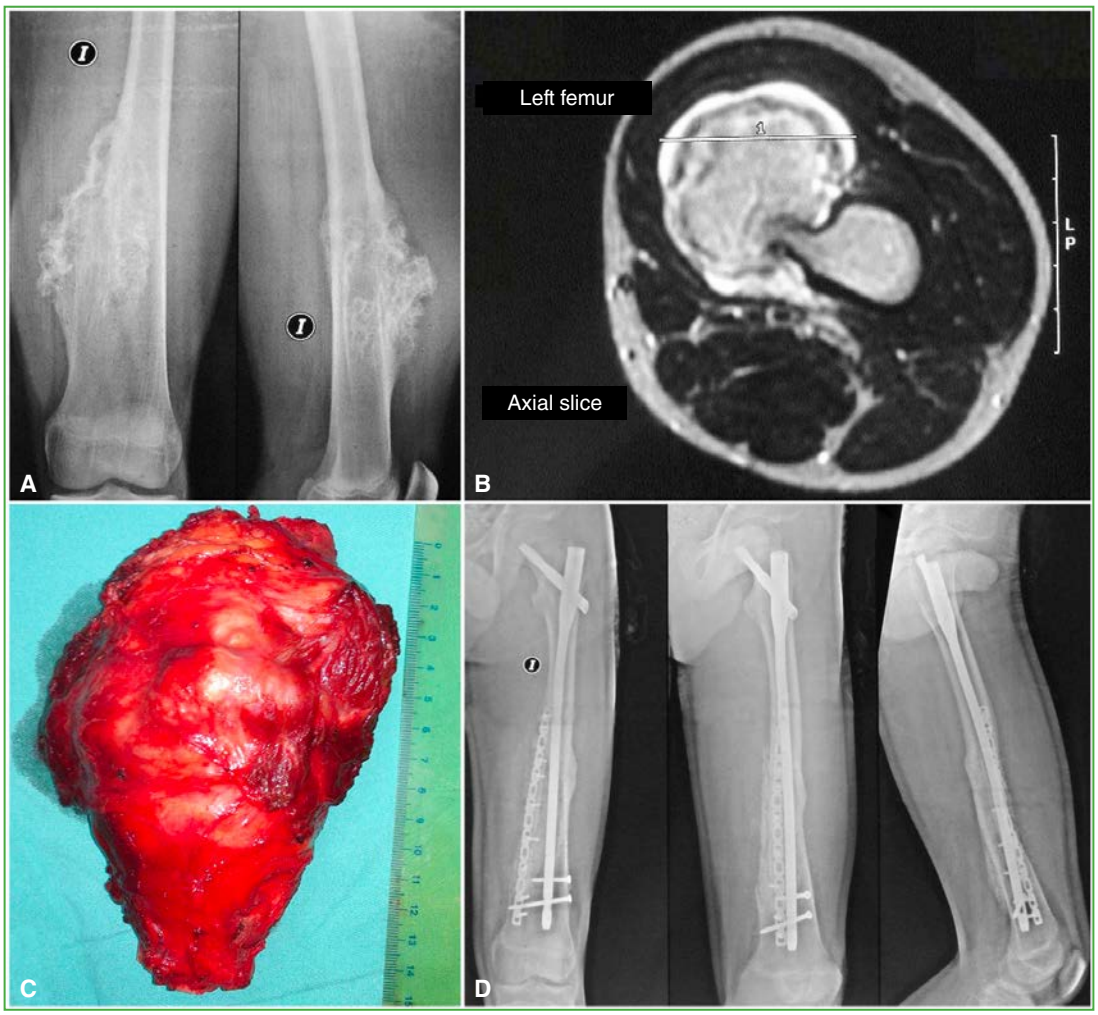

Figure 4. Case 1. Large osteochondroma of the left femur (209.8 cm^3). **A.** Preoperative radiographs of the distal femur in anteroposterior and lateral views. **B.** Preoperative MRI of the same anatomical region, axial plane. **C.** Surgical specimen. **D.** Radiographs of the entire femur, including the hip and knee, in anteroposterior, lateral, and oblique views at 6 months postoperatively, after partial femoral resection including the tumor mass, followed by reconstruction with autologous fibular and iliac crest grafts, addition of bone substitutes, and osteosynthesis with a locked solid titanium intramedullary nail (proximal and distal locking), along with locking plates for the fibular graft.

Considering both early and late complications together, for extremity osteochondromas (n = 19), no statistically significant differences were found between upper and lower extremities (p = 0.53).

One recurrence occurred after incomplete resection, and the patient received expectant management (case 18).

Two patients had residual sequelae: one with limited active shoulder abduction (case of proximal humeral pseudarthrosis), and another with mild right thoracic scoliosis (12°), secondary to ablation; neither required further treatment.

DISCUSSION

The surgical indications for excision of osteochondromas in the immature skeleton are well established in the literature.[7] Tumor volume alone does not justify surgical resection; however, an increase in size after completion of skeletal growth has been associated with a higher risk of malignant transformation, although this relationship has not been clearly defined.[7]

We did not identify published case series of large osteochondromas treated surgically similar to this cohort, nor reliable methods for volumetric measurement on imaging studies. Therefore, preoperative tumor volume (CT, MRI) was estimated by approximating tumor morphology to the closest geometric shape.

Large osteochondromas of the extremities usually produce symptoms depending on their location; however, four patients in our series were referred while asymptomatic after incidental detection of a mass. In contrast, spinal osteochondromas are typically exophytic lesions arising from the posterior elements (Case 9, Table 2; Figure 5) and extending outside the spinal canal. They usually present as a palpable mass and rarely cause symptoms or neurological compromise.[8] In some cases, they may lead to secondary deformity.[9] However, growth toward the spinal canal, regardless of size, may result in severe neurological deficits, particularly in the cervical and thoracic regions.[10]

Biopsy is generally not required in cases of typical osteochondromas. In three patients in our series, biopsy was performed due to suspicion of malignant transformation based on rapid growth, although cartilage cap thickness and morphology remained within benign parameters.

Although spontaneous regression of osteochondromas has been described in children,[11] complete excision with free margins remains the treatment of choice.

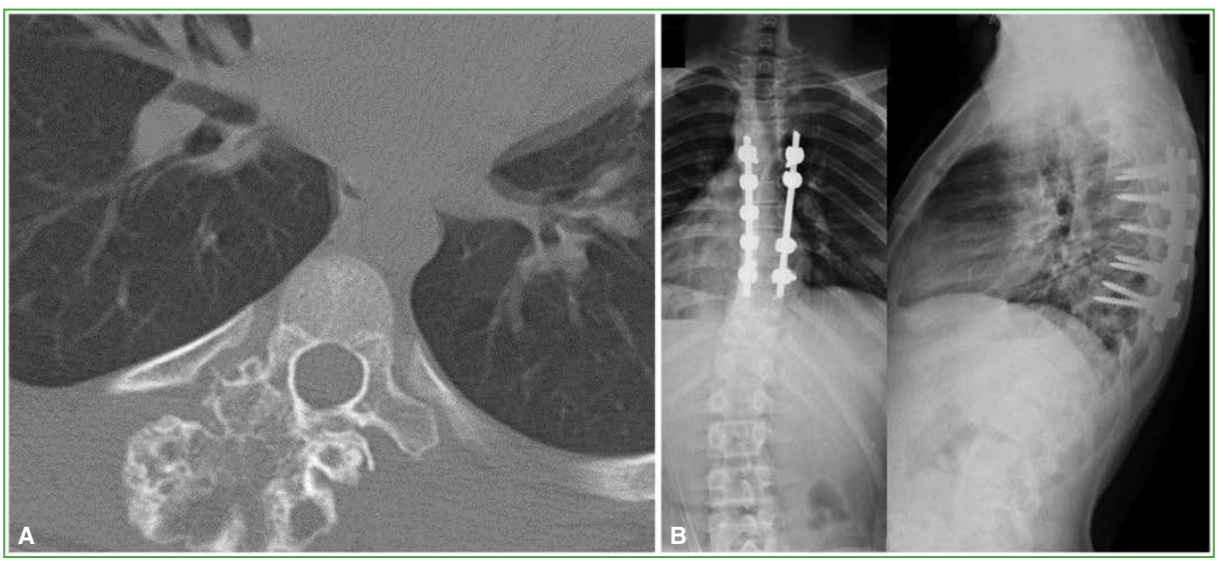

Figure 5. Case 9. **A.** Computed tomography of the thoracic spine, axial plane, showing a large extracanal osteochondroma (103 cm³) at T6. **B.** Anteroposterior and lateral radiographs of the thoracic spine at 1 year and 5 months postoperatively, following intralesional resection and arthrodesis with pedicle instrumentation. Note the absence of tumor recurrence.

In large or rapidly growing tumors, the main concern, although uncommon, is malignant transformation into chondrosarcoma; osteosarcoma and other neoplasms have also been reported.[12,13] The risk of malignant transformation to chondrosarcoma is estimated to be <1% in solitary osteochondromas and 2–5% in multiple osteochondromatosis.[14,15] Four patients in our series had multiple osteochondromatosis. Although malignant transformation is more common in adults, pediatric cases have been reported;[13] secondary chondrosarcomas account for more than half of cases in children and adolescents.[15]

In addition to tumor growth and multiplicity, the literature consistently highlights an increased risk of malignant transformation in lesions located in the spine and in the girdles (shoulder and pelvic), as well as in recurrent tumors.[15]

The differential diagnosis between osteochondroma and low-grade chondrosarcoma is based on clinical presentation (pain and progressive enlargement suggest malignancy) and imaging findings: size >5 cm, irregular margins, cortical disruption, soft tissue invasion, and cartilage cap thickness >2–3 cm should raise suspicion of malignant transformation.[3,16] We consider MRI an essential imaging modality for this evaluation.

Rapid tumor growth and a large mass in skeletally immature patients support surgical excision, even in the absence of symptoms. When malignant transformation is suspected, wide resection should be performed.[17,18] Image-guided percutaneous biopsy may not be representative in large tumors, as it may miss areas of histological atypia.[19] Furthermore, the differential diagnosis with low-grade chondrosarcoma is often challenging, which reinforces the indication for wide surgical resection.[16]

Most cases in this series were symptomatic or showed rapid growth, justifying surgical treatment. Four asymptomatic patients underwent surgery due to tumor volume and family concern.

There is no consensus on classifying osteochondromas of the extremities as active or aggressive according to the Enneking system; however, wide resection is generally accepted for aggressive lesions and marginal resection for active ones,[20] and marginal resection is adequate for most osteochondromas.[7] Wide resections may require reconstruction and tailored osteosynthesis (cases 1, 2, 3, and 4, Table 2).

In this cohort, the decision to perform wide resection was based on the following principles: (1) in very large osteochondromas, limited resection may fail to include occult atypical areas;[18] (2) as all tumors were sessile, margins were established through healthy tissue to reduce the risk of recurrence; and (3) when the tumor base involves a large portion of the bone circumference, excision may result in postoperative structural weakness or spinal instability (cases 1, 2, 3, 4, and 9; Figures 3, 4, and 5). Therefore, associated osteosynthesis with reconstruction or arthrodesis is essential in these cases.

In general, long-term functional outcomes are excellent for osteochondromas around the knee treated with marginal resection alone (cases 5, 6, and 13).[21] However, resection of osteochondromas located at the proximal fibula carries a risk of injury to the common fibular nerve (Figure 6).[22] One patient in our series developed a transient deficit following wide resection (case 14).

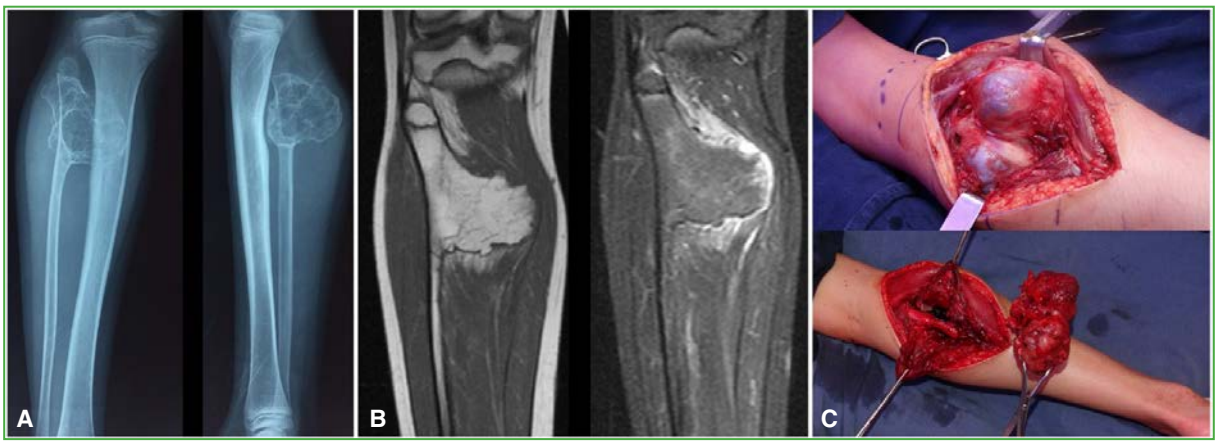

Figure 6. Case 6. **A.** Anteroposterior and lateral radiographs of the left leg showing a large proximal fibular osteochondroma (135.12 cm³). **B.** MRI of the same anatomical region, sagittal T1- and T2-weighted sequences. **C.** Intraoperative images.

We found no reports describing recurrence or prolonged postoperative pain in proximal humeral osteochondromas. However, one patient in our series developed proximal humeral pseudarthrosis following a postoperative fracture, despite osteosynthesis and reconstruction (Figure 3). In such cases, intramedullary nailing appears to be a more appropriate option (Figure 7).[5]

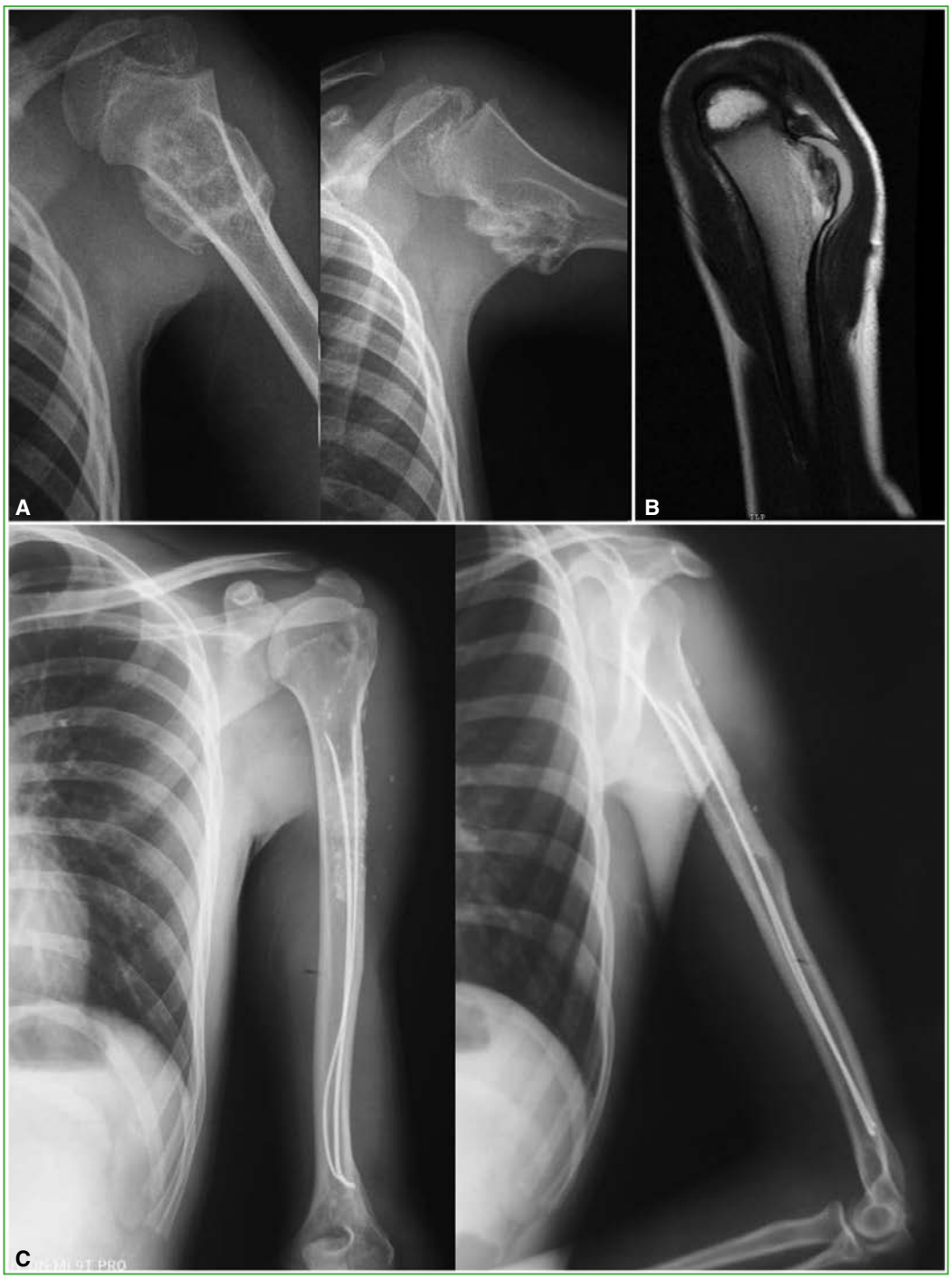

Figure 7. Case 2. **A.** Anteroposterior and lateral radiographs of the proximal humerus showing an osteochondroma (57.5 cm³). **B.** T1-weighted MRI of the shoulder in the coronal plane. Tumor dimensions and cartilage cap are visualized. **C.** Anteroposterior and lateral radiographs of the humerus more than 6 years after surgery, showing stable reconstruction.

In general, symptom resolution exceeds 90% when resection is complete in limb osteochondromas.[23]

Intracanal spinal osteochondromas frequently cause neurological deficits, even when small. In such cases, the indication for surgery depends on location rather than size.[24]

The postoperative recurrence rate is reported to be <2% after complete resection.[3] The only recurrence in our series occurred after intralesional resection (case 18; volume 46.8 cm³). The patient with a large exophytic thoracic vertebral osteochondroma (case 9; volume 103 cm³) showed no recurrence (Figure 5). Recurrence does not appear to be related to Enneking staging system stage, as it has been described even in latent lesions.[25] These findings suggest that recurrence is more closely related to intralesional resection than to tumor volume or stage.

The main limitations of this study are its retrospective design and the relatively small sample size, despite its multicenter nature. However, this cohort is highly specific, involving large osteochondromas in skeletally immature patients, and the number of cases appears sufficient for analysis. We found no comparable studies; most published data consist of case reports. The international multicenter nature of this series, including 20 patients, reflects both the rarity of large osteochondromas and current variability in diagnostic and therapeutic approaches.

CONCLUSIONS

Surgical resection of large osteochondromas of the extremities should be considered, particularly those located in the girdles (shoulder and pelvic) or in proximal regions, as well as large extracanal spinal osteochondromas, even in the absence of symptoms, given the potential for malignant transformation.

Intralesional resection of large osteochondromas should be avoided due to the risk of recurrence or residual tumor. Marginal resection is usually sufficient; however, in selected cases, wide excision may be indicated.

Conflict of interest: The authors declare no conflicts of interest.

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