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Long-term outcomes in primary spinal osteochondroma: a multicenter study of 27 patients

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Abstract

OBJECT—Clinical outcomes in patients with primary spinal osteochondromas are limited to small series and sporadic case reports. The authors present data on the first long-term investigation of spinal osteochondroma cases.

METHODS—An international, multicenter ambispective study on primary spinal osteochondroma was performed. Patients were included if they were diagnosed with an osteochondroma of the spine and received surgical treatment between October 1996 and June 2012 with at least 1 follow-up. Perioperative prognostic variables, including patient age, tumor size, spinal level, and resection, were analyzed in reference to long-term local recurrence and survival. Tumor resections were compared using Enneking appropriate (EA) or Enneking inappropriate surgical margins.

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Author Contributions

Conception and design: Sciubba, Gokaslan. Acquisition of data: Sciubba, Germscheid, Boriani, Bettegowda, Reynolds, Szövérfi, Zadnik, Rhines, Fisher, Varga. Analysis and interpretation of data: Sciubba, Germscheid, Bettegowda, Reynolds, Zadnik, Gokaslan, Fisher, Varga. Drafting the article: Sciubba, Macki, Bydon, Reynolds, Fisher. Critically revising the article: Sciubba, Macki, Bydon, Germscheid, Reynolds. Reviewed submitted version of manuscript: Sciubba, Macki, Bydon, Fisher, Germscheid, Bettegowda, Chou, Luzzati, Reynolds, Gokaslan, Fisher, Varga. Approved the final version of the manuscript on behalf of all authors: Sciubba. Statistical analysis: Germscheid. Administrative/technical/material support: Sciubba, Germscheid, Wolinsky, Boriani, Reynolds, Zadnik, Gokaslan, Fisher, Varga. Study supervision: Sciubba, Wolinsky, Boriani, Gokaslan, Fisher, Varga.

RESULTS—Osteochondromas were diagnosed in 27 patients at an average age of 37 years. Twenty-two lesions were found in the mobile spine (cervical, thoracic, or lumbar) and 5 in the fixed spine (sacrum). Twenty-three cases (88%) were benign tumors (Enneking tumor Stages 1–3), whereas 3 (12%) exhibited malignant changes (Enneking tumor Stages IA–IIB). Sixteen patients (62%) underwent en bloc treatment—that is, wide or marginal resection—and 10 (38%) underwent intralesional resection. Twenty-four operations (92%) followed EA margins. No one received adjuvant therapy. Two patients (8%) experienced recurrences: one in the fixed spine and one in the mobile spine. Both recurrences occurred in latent Stage 1 tumors following en bloc resection. No osteochondroma-related deaths were observed.

CONCLUSIONS—In the present study, most patients underwent en bloc resection and were treated as EA cases. Both recurrences occurred in the Stage 1 tumor cohort. Therefore, although benign in character, osteochondromas still require careful management and thorough follow-up.

Keywords

neoplasm; osteochondroma; spine; tumor; oncology

Osteochondroma, or osteocartilaginous exostosis, is the most common benign tumor of the long bones,²⁷ accounting for 40% of all benign bone tumors.¹⁸ The lesion appears in either single and sporadic form or multiple and hereditary form, known as hereditary multiple exostoses (autosomal dominant).²⁷ Rarely do osteochondromas affect the vertebral column; however, approximately 3% of solitary and 7%–9% of hereditary osteochondromas are found in the spine.²⁷

Spinal osteochondromas compose only 0.4% of all intraspinal tumors, and their unique characteristics are poorly understood.¹⁶ Some argue that osteochondromas are not true neoplasms but rather hamartomas herniating from the epiphyseal growth cartilage before children reach skeletal maturity.^{2,13,23,29} These lesions are not usually identified until adulthood, with a mean age of 39 years at diagnosis.²⁶ Given that these exophytic growths arise from the posterior elements of the spine, osteochondromas are commonly managed with posterior resection.

A paucity of evidence is available to guide the treatment of osteochondromas of the spine. Because of their low incidence, generating sufficient clinical data has been challenging. To date, most treatment regimens and reported outcomes have been based on anecdotal surgeon experience appearing as case reports and small case series.^{14,26,27,29} The aim of this study was to report long-term clinical outcomes from an international collection of 27 patients with spinal osteochondroma who had received surgical treatment between October 1996 and June 2012 and to determine the prognostic variables associated with local recurrence and survival.

Methods

An international, multicenter ambispective study on primary osteochondroma of the spine was performed with the support of AOSpine International through the AOSpine Knowledge Forum Tumor, a pathology-focused working group acting on behalf of AOSpine

International. Spine centers from around the world that demonstrated sufficient primary tumor patient volumes (at least 10 patients per year) with a good research track record were identified. This included 9 centers from 5 countries within North America and Europe. Institutional review board or ethics committee approval was obtained by each center.

Data Collection

A secure, web-based application to support data capture (REDCap [Research Electronic Data Capture], Vanderbilt University) was used where the AOSpine Knowledge Forum Tumor developed 7 custom modules, which included demographic, clinical, diagnostic, therapeutic, local recurrence, cross-sectional survival, and perioperative morbidity information. Data were gathered both prospectively and retrospectively from patient clinical charts and institutional databases; that is, information on osteochondroma cases was collected from both previous institutional cases and new case presentations. When mortality (including cause) information was unknown, governmental vital statistics databases were accessed. A study coordinator was employed to assist with data collection, data entry, and capture of cross-sectional survival data. Patients were included if they were diagnosed with an osteochondroma of the spine and received surgical treatment between October 1996 and June 2012 with at least 1 follow-up.

Definitions

Location of the osteochondroma was characterized by its site of origin in either the mobile (cervical, thoracic, or lumbar) or the fixed (sacrum) spine. Tissue involvement by the tumor was considered anterior, posterior, both, and complete, according to the 12 zones proposed by the Weinstein, Boriani, Biagnini (WBB) surgical staging system.³ Anterior involvement includes only anterior elements (Zones 4–9): vertebral body and/or pedicles. Posterior involvement includes only posterior elements (Zones 1–3, Zones 10–12): lamina, transverse process, spinous process, transverse process, and/or articular facet joints. Tumor involvement of “both” categories includes tumor invasion of both anterior and posterior elements, and “complete” tumor involvement invades all 12 zones.

Resection Methods

Surgical treatment was categorized based on the surgeon’s assessment of the resection method: intralesional versus en bloc (wide or marginal). Intralesional resection involves piecemeal dissection or curettage without achieving wide excisional margins.¹⁵ En bloc resection requires a wide or marginal excision that typically involves total vertebrectomy or spondylectomy. On the other hand, wide en bloc resections include a margin of normal tissue around the tumor, whereas marginal en bloc resections refer to an incision along the tumor pseudocapsule.⁵ For osteochondroma, the goal of en bloc excision is to resect the entire cartilaginous cap. Often en bloc excisions involve a vertebrectomy or spondylectomy. However, en bloc resection in osteochondromas that involve the posterior elements may be amenable to removal of the spinous process and lamina. Radical resections, which would entail resection of the entire anatomical compartment, are not clinically feasible in the spinal column.

Enneking Principles

The Enneking classification (EC) is a tumor staging system that reflects the interrelationship of biological grade, tumor extension, and metastasis.^{8,9} Ranging from Stage 1 to Stage IIIB, the tumor classification scheme is intended to guide resection.¹⁰ Curettage (intralesional) gross-total resection is acceptable for benign lesions such as Stage 1 (latent) and Stage 2 (active) tumors. For Stage 3 tumors, en bloc marginal excisions are recommended. For more aggressive tumors (Stages IA–IIB), en bloc resection with wide margins is the surgical goal. Additionally, in high-grade malignancies, adjuvant treatment is critical. Finally, metastases (Stages IIIA–IIIB) are managed with palliative treatment.⁵ Cases treated with the recommended resection are Enneking appropriate (EA), while those that are not treated according to the recommended resection are Enneking inappropriate (EI).

Statistical Analysis

Descriptive statistics (means \pm standard deviations or frequency and percentages) were generated. All statistical analyses were performed using Stata (version 12.0, Stata-Corp). Statistical significance was set at $p < 0.05$.

Results

Patient and Tumor Characteristics

Osteochondroma of the spine was diagnosed in 27 patients: 16 males and 11 females with a mean age of 37 ± 18 years. Details on patient demographics, tumor characteristics, surgical treatment, recurrence, and survival are presented in Tables 1 and 2.

Osteochondromas were more frequently located in the mobile spine (22 patients [81%]), whereas only 5 patients (19%) presented with a tumor in the fixed spine. Over 50% of cases were limited to 1 vertebral level, whereas 11% (3 cases) encompassed 4 or more vertebrae. Of the 20 cases reporting tissue involvement, most tumors invaded all or a portion of the posterior spinal elements (16 cases; Table 2). Twenty-six cases reported a mean tumor size of 3.23 ± 2.29 , 2.73 ± 1.95 , and 2.57 ± 2.02 cm³ in the anteroposterior, left-right, and cranial-caudal dimensions, respectively. Tumor size was not reported for 1 patient. Most of the benign tumors were classified as latent Stage 1 (16 cases [70%]), and malignant transformations were also observed (3 cases [12%]; Table 3). Pain was reported in 20 patients (74%), and on clinical presentation, 4 patients (15%) exhibited signs and symptoms of myelopathy.

Tumor Resection and Enneking Appropriateness

The EC was known for 26 cases and correlated with the pathologist's postoperative impressions on whether the surgery was EA or EI. All tumors were surgically managed: 10 patients (38%) underwent intralesional resection and 16 (62%) underwent en bloc resection (wide or marginal). The surgical margins were unknown in 1 patient. A posterior approach was performed in 20 patients (77%), an anterior approach in 5 patients (19%), and a combined approach in 1 patient (4%). Surgical approach was not reported in 1 patient. None of the patients received adjuvant therapy.

The Enneking appropriateness was not available for 1 patient. Of the 26 cases analyzed using the Enneking principles, 24 (92%) were classified as EA. Intralesional resections were applied to a Stage IB and IIA osteochondroma; therefore, these operations were EI. The follow-up period for EA cases ranged from 3 days to 15.4 years (median 11 months), whereas the follow-up in EI cases ranged from 2.4 to 4.9 years (median 3.7 years).

First Local Recurrence

A first local recurrence was reported in 2 patients (8%) within 5 years postoperatively: at 1.5 years in a patient with an osteochondroma in the fixed spine and at 4.6 years in a patient with an osteochondroma in the mobile spine. Both recurrences occurred in cases of latent Stage 1 tumors. In terms of surgical treatment, both recurrences occurred in patients managed with en bloc resections that were EA. All postoperative patients were routinely screened with serial radiographic images to monitor tumor recurrence.

Survival

Overall, 4 patients (15%) died within 2.4 years postoperatively; all causes were unrelated to the spinal osteochondroma. None of the patients who died reported a local recurrence. Patients were followed up for a mean of 2.7 ± 4 years (range 3 days to 15.4 years, median 1.5 years).

Discussion

We present the first and largest multicenter clinical study reporting local recurrence and survival outcomes in patients with diagnosed primary spinal osteochondroma. We found that the thoracic spine had the greatest number of tumor cases and that the sacral spine had the lowest number. These results differ from previous findings in which 50% of osteochondromas appeared in the cervical spine,¹ with the most commonly affected level at C-2, followed by C-3 and C-6;^{1,27} the thoracic spine has been reported to be the second most commonly affected region, most often at the T-8 level, followed by T-4.^{18,26,27} We attribute these discrepancies to the larger surface area of the thoracic versus the cervical spine.

Osteochondromas are thought to arise from the excessive cartilaginous tissue of secondary ossification centers in the posterior elements of the spine,²⁵ namely the tip of the spinous or transverse process.²⁶ Commensurate with this hypothesis, 60% of tumors in the present study had some type of posterior element involvement. Although some authors have speculated that the cellular cycle in the ossification centers is faster in the upper vertebrae,¹¹ others have postulated that repeated microtrauma of the mobile cervical spine probably displaces the epiphyseal growth cartilage, which in turn develops into hamartomas.^{1,18} Another risk factor contributing to the formation of osteochondromas includes radiation exposure to the epiphyseal growth zone.⁷ Approximately 12%–15% of these tumors arise secondary to the administration of more than 25 Gy of radiation in children younger than 2 years of age.²⁶

In agreement with data in other studies, osteochondroma in the present study was more frequently diagnosed in males.^{4,6,24–26,30} Given that osteochondromas arise from the tip of the posterior spinal elements, the outward growths are rarely symptomatic.^{21,26} The most

common presenting symptom is nonmechanical spinal pain, or biological (tumor-related) pain. When tumor does invade the spinal canal, compressive myelopathy and sciatica are the most common presentations.^{11,18,25,26} In the present series, 74% of patients reported pain, whereas 15% exhibited signs and symptoms of myelopathy. Signs and symptoms of spinal cord injury may not be apparent on taking a history and performing a physical examination; therefore, spinal tumors require a high index of clinical suspicion and thorough clinical examination before subjecting patients to imaging studies.

On gross surgical pathology, osteochondroma appears as a pediculated or sessile growth of hyaline cartilage centrally and perichondrium peripherally that is continuous with the periosteum of the underlying bone.¹⁹ Radiographically, osteochondromas have a stalk and body composed of mature bone, covered by a cartilaginous cap that does not ossify and is therefore unidentifiable on radiographs. The tumor characteristically exhibits a cortical margin continuous with surrounding bone. Computed tomography is helpful in determining the osseous origins of the tumor (Fig. 1A and C).¹⁴ On MRI, the cartilaginous cap is iso- to hyperintense on T1-weighted sequences and hyperintense on T2-weighted sequences (Fig. 1B and D).²⁷ Although the nonvascular cartilage does not enhance with Gd contrast, the tumor may exhibit peripheral enhancement due to the fibrovascular tissue overlying the cartilaginous cap.¹² Malignant changes should be suspected when the cartilaginous cap is thicker than 3 cm, when patients report the new onset of symptoms, or when the tumor rapidly increases in size.²⁷

The rate of malignant transformation for osteochondroma is less than 1% in solitary cases and approximately 3%–5% in hereditary cases.¹⁷ These figures are based on studies in the appendicular skeleton; unfortunately, the rate of malignancy has not been well established in the axial skeleton. In the present series, the rate of malignant transformation was slightly higher at 11% (3 cases). This rate may reflect an intrinsically higher incidence of malignancy in the spine or a selection bias given the tertiary referral centers included in the study. None of the participating centers reported a history of hereditary osteochondromas in affected patients.

Although Stage 1 and 2 tumors are amenable to intralesional resections per the Enneking principles, en bloc resections were performed in 14 patients (52%) with benign lesions because of the technical feasibility of the operation and/or the surgeon's comfort with and/or preference for en bloc resections. Nevertheless, the risk of postoperative recurrence for solitary osteochondromas after excision is low, ranging from 2% to 5% in limited case reports and case series without adequate follow-up.^{18,20,29} Here, we report a slightly higher overall recurrence incidence of 8% (2 cases). Both recurrences were treated with wide or marginal resections. While these findings may be counter-intuitive, these recurrences may reflect a failure to obtain marginal or wide margins after presumed gross-total resection. A failure to resect the cartilaginous tumor cap (unbeknownst to the surgeon) may also cause recurrences. Moreover, the en bloc cohort represented a disproportionately larger number of patients (16 patients [62%]). In addition, the en bloc resection cohort was followed up for a mean of 3.2 years (range 4 days–15.4 years, median 1.6 years), which was longer than for the cohort overall. Therefore, recurrence rates may reflect an uneven distribution of patients with a follow-up bias. Similarly, although both recurrences happened in patients who

underwent EA resections, the EA cohort (24 patients) represented the largest percentage of patients who were also followed up for the longest period of time. Again, the higher recurrence rate in the EA group may reflect the uneven distribution of patients in the EA cohort versus the EI cohort. In the EI cohort, 2 patients with Stage IB and IIA tumors were managed with intralesional resections. These 2 cases were treated with intralesional resections probably because of an unanticipated high-grade tumor diagnosis on surgical pathology. However, recurrences were not observed in these 2 patients.

We also observed that both recurrences appeared in patients with Stage 1 benign tumors. Morton contends that the reappearance of osteochondroma may not reflect a true recurrence.²² A recurrence would imply an aggressive character of the osteocartilaginous tumor cap, which is consistently removed during tumor resection. Instead, the reappearance of osteochondroma may represent a new primary lesion adjacent to the initial tumor site. Although multiplicative growth of osteochondromas has been well-established in hereditary multiple osteochondroma/exostosis (HME) syndrome,³¹ new research suggests that solitary osteochondroma and HME are a spectrum of diseases from the same family of tumor suppressor genes denoted *EXT*. Thus, even with solitary lesions, new tumors may arise in juxtaposition to the index lesion without the full onset of HME.

Given the characteristics of patients with recurrences in the present study, we infer that although osteochondromas are dormant lesions, the tumors still require careful surgical management. In a working diagnosis of osteochondroma, en bloc resections with EA margins are preferred because the pathological diagnosis of a benign-appearing lesion may return with malignant features. Moreover, even with benign lesions, osteochondroma can still recur at an incidence of 8%, as observed in the present study. Thus, proper follow-up with serial imaging is essential. Similar findings have been reported in the literature.^{5,10,28,29} In a study of primary spinal bone tumors, Talac et al. reported a local recurrence rate of 55.6% in patients with positive margins; however, recurrences persisted at an incidence of 16.7% with negative margins.²⁸ Of those patients with negative margins, the incidence of recurrence decreased to 11.1% with an en bloc resection and increased to 33% with an intralesional resection. According to the literature, these same principles apply to Enneking appropriateness. Although Fisher et al. reported a statistically higher recurrence rate following EI resection, the incidence of recurrence was still 20% following EA resection.¹⁰

Osteochondromas are characteristically associated with a favorable prognosis. Overall, none of the deaths in the present study were attributable to the osteochondroma. Because benign lesions are considered hamartomas rather than true neoplastic lesions, the disease-specific mortality is considered negligible. These findings are starkly different from those on other primary spinal bone tumors in which mortality is directly attributable to tumor recurrence.¹⁰

Study Limitations

While we report the largest multicenter analysis of ambispectively collected clinical data on the long-term first local recurrence and survival of patients with osteochondroma of the spine, this study remains limited because of the small sample size, the small number of events, and the unevenly distributed data. For rare diseases, obtaining enough data for scientific evaluation is challenging. Note that a central review of the neoplastic pathology

could not be performed in the present study. In addition, most patients were censored within 5 years postoperatively. Performing detailed prospective studies would broaden our understanding of the osteochondroma disease course.

Conclusions

We present the first and largest multicenter clinical study on primary spinal osteochondroma. After evaluating the 15-year surgical outcomes of 27 patients with spinal osteochondromas, we found that no deaths were attributable to the tumor. The incidence of local recurrence was 8% (2 patients). Most patients underwent en bloc resection and were treated as EA, and both recurrences had these 2 features. The recurrences appeared in cases of Stage 1 tumors. Thus, although they are benign lesions, osteochondromas still require careful surgical management and thorough follow-up.

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ABBREVIATIONS

EA	Enneking appropriate
EC	Enneking classification
EI	Enneking inappropriate
HME	hereditary multiple osteochondroma/exostosis

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Fig. 1. A 25-year-old man presented with a 4-month history of neck pain and left arm paresthesias. Preoperative CT (**A and C**) suggested an osteochondroma arising from the superior aspect of the C-5 vertebral body on the left with mild superior extension into the left aspect of the spinal canal. Preoperative MRI (**B and D**) revealed a sessile lesion arising from the dorsal and superior aspect of the C-5 vertebral body on the left with rightward displacement of the spinal cord.

Summary of tumor and treatment factors in 27 patients with spinal osteochondroma

TABLE 1

Case No.	Age at Op (yrs)	Tumor Level	Tumor Vol (cm ³)	Tumor Stage*	Resection Type	Local Recurrence
1	35, F	C-7	16	1	En bloc	
2	48, M	S-1	4	1	En bloc	Yes
3	46, M	C-7	3	2	Intralesional	
4	46, F	T9-10	2	1	Intralesional	
5	61, M	L-2	2	1	Intralesional	
6	65, M	C3-T2	4	1	En bloc	
7	48, M	S-1	120	1	En bloc	
8	43, F	C6-7	2	1	En bloc	
9	76, F	T11-12	4	2	Intralesional	
10	21, M	S-1	120	2	En bloc	
11	49, F	C5-7	1	1	Intralesional	
12	17, M	S-1	27	1	En bloc	
13	32, M	L4-5	1	1	Intralesional	
14	60, M	T-12	8	IIA	Intralesional	
15	68, F	L-2	4	2	Intralesional	
16	13, F	T-1	6	1	En bloc	
17	19, M	L-5	24	1	En bloc	
18	38, M	L4-5	6	1	En bloc	
19	20, M	L-5	4	1	En bloc	
20	36, F	T11-12	150	1	En bloc	Yes
21	26, M	C4-5	4	1	Intralesional	
22	33, F	L-1	152	3	En bloc	
23	21, M	T-7	36	IB	En bloc	
24	28, M	T1-2	Unknown	Unknown	Unknown	
25	13, M	L5-S3	616	2	En bloc	
26	17, F	C1-3	7	IB	Intralesional	

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Case No.	Age at Op (yrs)	Tumor Level	Tumor Vol (cm ³)	Tumor Stage*	Resection Type	Local Recurrence
27	22, F	T8–11	336	2	En bloc	

En bloc = wide or marginal.

* 1 = benign inactive; 2 = benign active; 3 = benign aggressive; IB = malignant low grade; IIA = malignant high grade.

TABLE 2

Summary of demographic and outcome data for 27 patients with spinal osteochondroma

Variable	No. (%)
Mean age at diagnosis in yrs	37 ± 18
Sex (n = 27)	
Male	16 (59)
Female	11 (41)
Mobile spine location (n = 22) *	
Cervical	7 (32)
Thoracic	9 (41)
Lumbar	7 (32)
Tissue involvement (n = 20)	
Anterior	4 (20)
Posterior	8 (40)
Both	7 (35)
Complete	1 (5)
Resection (n = 26)	
Intralesional	10 (38)
En bloc	16 (62)
Local recurrence (n = 27)	
No	25 (93)
Yes	2 (7)
Survival status (n = 27)	
Dead	4 (15)
Alive	23 (85)

n = total number.

* Tumors can involve multiple segments.

TABLE 3

Spinal osteochondromas stratified according to the Enneking classification

Variable	No. (%)
Enneking classification	
Benign	23 (88)
Malignant	3 (12)
Stage, benign cases	
Latent Stage 1	16 (70)
Active Stage 2	6 (26)
Aggressive Stage 3	1 (4)
Stage, malignant cases	
Stage IA–IIB	3 (100)
Other	0 (0)

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