Peripheral nerve injuries due to osteochondromas: analysis of 20 cases and review of the literature

Clinical article

Selçuk Göçmen, M.D., Ali Kivanc Topuz, M.D., Cem Atabey, M.D., Hakan Şimsek, M.D., Kenan Kelekçii, M.D., and Osman Rodop, M.D.

Departments of Neurosurgery and Orthopedics, Gulhane Military Medical Academy, Haydarpasa Training Hospital, Istanbul, Turkey

Object. Nerve compressions due to osteochondromas are extremely rare. The aim of this retrospective study was to investigate the mechanisms, diagnostic evaluations, and treatment of nerve lesions due to osteochondromas, and to review the literature.

Methods. The authors retrospectively reviewed their clinic data archive from 1998 through 2008, and 20 patients who were operated on due to peripheral nerve injuries caused by osseous growth were enrolled in the study. Patients' age, duration of symptoms, localizations, intraoperative findings, and modified British Medical Research Council (MRC) and electromyography data obtained from hospital records were evaluated. The literature on this topic available in PubMed was also reviewed. All 20 patients underwent surgery, which consisted of tumor excision performed by orthopedic surgeons and nerve decompression performed by neurosurgeons.

Results. There were 17 men and 3 women included in the study, with a mean age of 21 years (range 18–25 years). Three patients had multiple hereditary exostoses, and 17 had a solitary exostosis. All of the patients underwent en bloc resection. The most common lesion site was the distal femur (45%). The peroneal and posterior tibial nerves were the structures that were affected the most frequently. The mean follow-up was 3.9 years (range 2–7 years). After the surgery, all patients (100%) experienced good sensory recovery (modified MRC Grade S4 or S5).

Conclusions. To the authors' knowledge, no large series have reported peripheral nerve compression due to exostoses. The authors have several recommendations as a result of their findings. First, all patients with peripheral nerve compression due to an osteochondroma should undergo surgery. Second, preoperative electromyographic examinations and radiographic evaluation, consisting of MRI and CT to provide optimal information about the lesion, are crucially important. Third, immediate treatment is mandatory to regain the best possible recovery. And fourth, performing nerve decompression first and en bloc resection of osteochondroma consecutively in a multidisciplinary fashion is strongly recommended to avoid peripheral nerve injury.

Key Words • osteochondroma • exostoses • nerve compression • peripheral nerve • electromyography

Osteochondroma, also known as osteocartilaginous exostosis, is the most common of all benign bone tumors. There are 2 types of osteochondroma, solitary osteochondroma and multiple hereditary exostoses (MHE).18 In the MHE type, there is a strong familial incidence, and it is an autosomal dominant disorder with variable penetrance. Osteochondromas can arise in any bone that has undergone endochondral ossification, but they are more commonly associated with the metaphyseal regions of the lower femur, upper tibia, and upper humerus.15

Clinical symptoms can result from mechanical irritation or compression of adjacent structures (such as soft tissues, bone, internal organs, peripheral nerves, spinal cord, and blood vessels), fracture, and malignant transformation.44 Nerves can be damaged by direct trauma, pressure injuries, fractures, ischemic neuropathies, spontaneous hematomas, cysts arising from the joint, entrapments, and neoplasms. Nerve compression syndromes are the neurological symptom complexes caused by the mechanical or dynamic compression of a segment of a single nerve at specific sites as it passes through a narrow fibroosseous tunnel or an opening in a fibrous or muscular structure.21

In the literature, only individual cases of peripheral nerve compression secondary to solitary osteochondromas are available.2,4,5,6,8,9,20,22–34,36,38,40–47 This case series is the largest series of peripheral nerve compressions due to solitary osteochondromas, and our aim in this retrospective study was to investigate the mechanisms, diagnostic

Abbreviations used in this paper: EMG = electromyography; MHE = multiple hereditary exostoses; MRC = Medical Research Council.

This article contains some figures that are displayed in color online but in black-and-white in the print edition.
evaluations, and treatment of nerve lesions due to osteochondromas, and to review the literature.

Methods

Clinical Data Review

Twenty patients with osteochondroma were admitted to Gulhane Military Medical Academy (Haydarpasa Training Hospital Departments of Neurosurgery and Orthopedic Surgery) for management of exostoses between June 1998 and December 2008. Medical records and diagnostic imaging of these patients were obtained and reviewed (Table 1). Exostoses were classified as solitary or associated with a history of MHE. Medical records were evaluated for age, initial/chief complaint, duration of symptoms, and symptoms indicative of neural structure compression (peripheral nerve injuries). Physical examinations were reviewed for neurological deficits (modified British Medical Research Council [MRC] grade), palpable mass, and other pertinent findings. Electrophysiological studies, plain radiography, CT, and MRI in the preoperative and postoperative periods were available in all patients. Method of treatment, surgical margins, histopathology, and complications were evaluated. Diagnosis was confirmed histopathologically. Follow-up evaluations were reviewed for progression or recurrence of symptoms, and tumor enlargement or recurrence.

Literature Review

The literature was reviewed using the PubMed database and bibliographies of published papers. Cases were reviewed for clinical details including age, symptoms, method of treatment, resolution of symptoms, and tumor recurrence. The nerve injury and site of origin on the bone of the exostoses were recorded.

Surgical Data

In our patient series, the surgical indication was peripheral nerve compression due to a solitary osteochondroma. All patients underwent surgery for neurological involvement via a team-based approach, consisting of a neurosurgeon first exploring and preserving the nerve, followed by tumor resection by an orthopedic surgeon.

Our experiences and intraoperative observations show that there are 2 main categories of peripheral nerve compression due to osteochondromas: a direct extrinsic pressure to the nerve, and growth of the osteochondroma causing circumferential ring formation that surrounds the peripheral nerve (Fig. 1). Direct extrinsic compression comprises 2 subtypes: integrity of the nerve preserved, and integrity of the nerve impaired (splitting the nerve). As another point of interest, the neurovascular structures were found to be adherent to the osteochondroma by a fibrous band. Therefore, we had to carefully dissect the fibrous band and release the neurovascular structures before the tumor was removed to avoid surgery-related severe neurovascular complications during tumor excision.

After decompression surgery, it was observed during the follow-up period that patients recovered completely. Complete removal of the solitary exostoses provided a

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Type of Osteochondroma</th>
<th>Location of Exostoses</th>
<th>Nerve Injury/Chief Complaint</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20, M</td>
<td>solitary</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 2 yrs</td>
</tr>
<tr>
<td>2</td>
<td>21, M</td>
<td>solitary</td>
<td>rt proximal humerus</td>
<td>radial</td>
<td>no symptoms 5 yrs</td>
</tr>
<tr>
<td>3</td>
<td>21, M</td>
<td>solitary</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 6 yrs</td>
</tr>
<tr>
<td>4</td>
<td>25, M</td>
<td>solitary</td>
<td>lt proximal humerus</td>
<td>sciatic</td>
<td>no symptoms 2 yrs</td>
</tr>
<tr>
<td>5</td>
<td>20, M</td>
<td>solitary</td>
<td>lt proximal fibula</td>
<td>peroneal</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>6</td>
<td>22, F</td>
<td>solitary</td>
<td>rt clavicle</td>
<td>brachial plexus</td>
<td>no symptoms 5 yrs</td>
</tr>
<tr>
<td>7</td>
<td>21, M</td>
<td>solitary</td>
<td>rt fibula head</td>
<td>peroneal</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>8</td>
<td>21, M</td>
<td>solitary</td>
<td>lt proximal radius</td>
<td>radial</td>
<td>no symptoms 5 yrs</td>
</tr>
<tr>
<td>9</td>
<td>21, M</td>
<td>solitary</td>
<td>rt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>10</td>
<td>18, M</td>
<td>MHE</td>
<td>rt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>recurrence at 3 yrs postop; no symptoms 4 yrs after 2nd op</td>
</tr>
<tr>
<td>11</td>
<td>21, M</td>
<td>MHE</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>12</td>
<td>20, M</td>
<td>solitary</td>
<td>rt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>13</td>
<td>22, M</td>
<td>solitary</td>
<td>lt fibula head</td>
<td>peroneal</td>
<td>no symptoms 3 yrs</td>
</tr>
<tr>
<td>14</td>
<td>22, M</td>
<td>solitary</td>
<td>lt proximal humerus</td>
<td>radial</td>
<td>no symptoms 4 yrs</td>
</tr>
<tr>
<td>15</td>
<td>21, M</td>
<td>solitary</td>
<td>lt proximal humerus</td>
<td>radial</td>
<td>no symptoms 3 yrs</td>
</tr>
<tr>
<td>16</td>
<td>20, M</td>
<td>solitary</td>
<td>lt distal fibula</td>
<td>peroneal</td>
<td>no symptoms 5 yrs</td>
</tr>
<tr>
<td>17</td>
<td>20, M</td>
<td>solitary</td>
<td>rt fibula head</td>
<td>peroneal</td>
<td>no symptoms 3 yrs</td>
</tr>
<tr>
<td>18</td>
<td>18, F</td>
<td>MHE</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 2 yrs</td>
</tr>
<tr>
<td>19</td>
<td>24, F</td>
<td>solitary</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 3 yrs</td>
</tr>
<tr>
<td>20</td>
<td>22, M</td>
<td>solitary</td>
<td>lt distal femur</td>
<td>peroneal/posterior tibial</td>
<td>no symptoms 3 yrs</td>
</tr>
</tbody>
</table>
Nerve injuries due to osteochondromas

In total, all patients (100%) improved to modified MRC Grade M4 or M5 motor function during the postoperative period. Several patients recovered motor function within hours or days following surgery. The majority of patients recovered in several months. The results of the sensory improvement were similar to that of motor dysfunctions. Nineteen of 20 patients had fair sensory functions (modified MRC Grade S2 or S3). Only 1 patient had no sensation (modified MRC Grade S0). After surgery, all patients (100%) had good sensory recovery (modified MRC Grade S4 or S5).

Electromyography Data

The electromyography (EMG) studies were repeated after surgery for the patients with impaired EMG findings, consisting of slow conduction velocities and reduced motor and sensory nerve action potential in the preoperative periods. Sixteen of the 20 patients exhibited an incomplete axonal loss pattern, 3 had a mixed pattern, and 1 had a pure conduction block pattern. Electromyography performed after resection of the exostoses suggested nerve recovery and remyelination.

In our series, the majority of the lesions were located in the distal femur (45%), followed by the fibula (20%), proximal humerus (15%), proximal tibia (5%), proximal femur (5%), clavicle (5%), and radius (5%; Table 3, Figs. 2–6). The peroneal and posterior tibial nerves were the most commonly affected nerve structures (Fig. 7). Patients with osteocartilaginous exostoses of the proximal humerus and radius had palsies of the radial nerves. The majority of the peripheral nerve injuries due to osteochondromas (50%) were located in the left lower extremities.

Patients With MHE

Two (66.7%) of 3 patients with MHE had a painful mass and weakness as the initial complaint. All patients with MHE had symptoms or findings on physical examination consistent with neural structure compression. All the lesions in these patients were modified MRC M3 levels before the operation (Table 2, Fig. 8). The motor scores of all the patients were M5 levels after the operation. One patient who experienced tumor recurrence 3 years after surgery reported pain at follow-up evaluation. This patient underwent repeat excision of the lesion by the orthopedic surgeons. There was no tumor recurrence after the second procedure during his 4-year follow-up. Two of 3 patients had no complications, no tumor recurrence, and had complete resolution of symptoms after a mean follow-up of 3 years (range 2–4 years).

Patients With Solitary Lesions

Eight (47.1%) of 17 patients with solitary lesions had a painful mass and weakness, whereas 6 (35.3%) had only a mass and weakness. Three (17.7%) of 17 patients had pain and weakness as their initial complaint. All patients with solitary lesions had symptoms or findings on physical examination consistent with neural structure compression. Nine (53%) of 17 patients had M3-level motor scores and 8 (47.1%) had M2-level motor scores before the operation. These patients were treated surgically with lesional resec-
tion and nerve decompression. There were no complications, no tumor recurrence, and complete resolution of symptoms after a mean follow-up of 3.8 years (range 2–6 years). We observed good recovery (M5) in all of these patients (Table 2).

**Literature Review**

The review of the literature revealed 41 cases of peripheral nerve compression secondary to solitary osteochondromas. The age of the patients in this review ranged from 3 to 69 years, and most patients were less than 25 years old (mean 23.7 years). Most patients were male (male to female ratio of 25:9). Multiple hereditary exostoses were positive in 12 patients (32.4%) in 37 documented cases. The proximal fibula was the most frequently attacked area in 59 patients (36.6%). The peroneal nerve had the largest entrapment rate (46.6%). The proximal humerus was the most frequently afflicted region in the upper extremities (50%); it was detected in 10 cases. Forty-nine of 54 patients who underwent surgery experienced good outcomes. The outcomes of the remaining 3 cases were poor and 2 cases were unknown. Gray et al. reported the first splitting of a nerve by an osteochondroma.

**Discussion**

Osteochondroma, or osteocartilaginous exostosis, is a benign cartilage-forming lesion that comprises 10%–15% of all bone tumors. Osteochondromas are usually asymptomatic. However, several potential tumor-related complications can occur, especially in lesions with marked extent or location in critical anatomical sites. Skeletal complications including deformity, joint dysfunction, fracture, and malignant degeneration are the most common. Non-skeletal extrinsic complications due to mass effect on the adjacent tissues, including soft tissue, vascular, and neurological structures, are relatively rare. Nerve compression is extremely rare, present in less than 1% of all cases. However, the majority of the patients in our series and cases identified in the literature had presenting symptoms consistent with neural structure compression. This study provides the largest clinical series of osteochondromas due to peripheral nerve compression from a single institution.

Solitary osteochondromas have their highest incidence within the 2nd and 3rd decades of life, with a predominance of males affected. The ages and gender distributions of our patients with solitary lesions were consistent with those in the literature. Multiple osteochondromas occur as part of a rare familial syndrome with autosomal dominant inheritance (MHE). Three patients had MHE in our cases.

Osteochondromas may be found in nearly every bone, with the exception of the calvaria. The most frequent sites of involvement include the knees, humerus, hips, scapula and ribs, wrists, ankles, elbows, hands, feet, and pelvis. Osteochondromas of the peripheral skeleton can cause nerve compression with consequent entrapment neuropathies or nerve palsies. The peroneal nerve or radial nerve is the most frequently affected structure. Motor weakness or peroneal nerve palsy can occur as sequelae of chronic neural compression by osteochondromas located.

### TABLE 2: Sensorimotor outcomes after surgery according to the modified MRC scale

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Motor Recovery</th>
<th>Sensory Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>preop findings</td>
<td>M0 8 11</td>
<td>S0 1</td>
</tr>
<tr>
<td>postop findings</td>
<td>9 11</td>
<td>9 10</td>
</tr>
</tbody>
</table>

### TABLE 3: Lesion localizations and nerve compressions

<table>
<thead>
<tr>
<th>Localization</th>
<th>Nerve Entrapment</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>distal femur</td>
<td>peroneal/posterior tibial</td>
<td>9 (45)</td>
</tr>
<tr>
<td>fibula</td>
<td>peroneal</td>
<td>4 (20)</td>
</tr>
<tr>
<td>proximal humerus</td>
<td>radial</td>
<td>3 (15)</td>
</tr>
<tr>
<td>proximal tibia</td>
<td>peroneal</td>
<td>1 (5)</td>
</tr>
<tr>
<td>proximal femur</td>
<td>sciatic</td>
<td>1 (5)</td>
</tr>
<tr>
<td>clavicle</td>
<td>brachial plexus</td>
<td>1 (5)</td>
</tr>
<tr>
<td>radius</td>
<td>radial</td>
<td>1 (5)</td>
</tr>
</tbody>
</table>

**Fig. 2.** Case 5. A: Lateral plain radiograph shows a bone lesion (arrow) before surgery. B: Sagittal MR image shows a bone lesion attached to the proximal tibia by a pedicle (arrow). C: Photograph of excised bone lesion with its pedicle.
Nerve injuries due to osteochondromas

cated at the proximal tibiofibular articulation. Palsies of the axillary and radial nerves have been described in patients with osteocartilaginous exostoses of the proximal humerus. In our series, the majority of the lesions were located in the distal femur (45%), followed by the fibula (20%), proximal humerus (15%), proximal tibia (5%), proximal femur (5%), clavicle (5%), and radius (5%). In our cases the peroneal and posterior tibial nerves were the most frequently afflicted peripheral nerves.

Osteochondromas may impinge on adjacent soft-tissue structures such as tendons, muscles, nerves, and vascular structures. Neurological complications are due to direct impingement upon adjacent nerves by an osteochondroma. Therefore, nerve decompression is performed very carefully. Teamwork is important to plan and perform a complete removal of the exostosis. First, the nerve should be explored and preserved by a neurosurgeon, and then an orthopedist should resect the tumor. If the nerve is not first explored, the patient becomes susceptible to severe and irreversible nerve injury. In the second type of lesion (Fig. 1B), nerve injuries are more common. Not only histological examination, but also electrophysiological studies can provide the definitive diagnosis. However, our experiences and intraoperative observations show that there is not only a direct extrinsic pressure to the nerve, but also circumferential ringlike tumor tissue that surrounds the nerve, resulting from the growth of an osteochondroma.

The shape and size of the exostosis is variable. Some are pedunculated with a globose, “mushroom,” or “cauliflower-like” summit, or (smaller exostoses) with a sharp “thornlike” or “coat-hanger” appearance. Others have a broad sessile implant. The pedunculated exostoses are usually directed toward the diaphysis. Rarely, the exostosis can reach large sizes, which per se do not prove malignancy.

Plain radiography is a very practical tool to determine

---

**Fig. 3.** Case 6. A: An anteroposterior plain radiograph reveals an osteochondroma (arrow) of the right clavicle that was compressing the brachial plexus. B: Axial CT scan identifying the lesion (arrow). C and D: Coronal (C) and axial (D) MR images of the same patient showing the lesion (arrow).

**Fig. 4.** Case 7. A and B: Anteroposterior (A) and lateral (B) plain radiographs show the tumor (arrows) that arose from the proximal fibula, which was found to be an osteochondroma. C: Axial CT scans of the same lesion (arrows).

**Fig. 5.** Case 14. A and B: Anteroposterior plain radiograph (A) and axial CT scan (B) reveal an osteochondroma of the proximal humerus that was compressing the radial nerve. C and D: Intraoperative image of the lesion (C) and the tumor that was removed surgically (D).
the number, location, and morphology of the exostoses, and to document complications such as cosmetic and osseous deformities and fracture. Osteochondromas are best visualized on CT rather than MRI, as the bony nature of the lesions is most clearly delineated. Magnetic resonance imaging is the examination method of choice for detecting complications such as bursa formation, vascular compromise, tendon or nerve compression, and malignant transformation. Magnetic resonance imaging is valuable for verifying peripheral compressive neuropathies caused by osteocartilaginous exostoses. Changes in signal intensity, size, or position of the involved peripheral nerve have been shown to represent suggestive MRI findings of compressive and entrapment neuropathies. On MR images, osteochondromas are observed as an isointense signal with a low-signal rim produced by the cortical bone. Preoperative MR images and CT scans should be examined carefully to provide optimal information about the lesion and aid treatment options.

All the patients in this series underwent electrophysiological examinations. A needle electromyographic study usually reveals a pattern of abnormality consistent with a lesion. Surgical findings determine adhesion of the involved nerves. The final diagnosis has to be made using histopathological investigation.

The general surgical indications for benign bone growths are cosmetic defect, exostosis in a location at risk to repetitive trauma, increased risk of the exostoses to fracture, neurological involvement, impairment of the articular range of motion, and suspicion of malignancy. Total en bloc excision of the tumor is the treatment of choice. Other investigators have similarly reported a higher recurrence rate after curettage and bone grafting (41%) as opposed to resection (7%). After decompression surgery, all of our patients described above reported almost complete recovery neurologically, and electrophysiological tests were normalized thereafter. The surgeon must be cognizant that recurrence is common after incomplete removal of the lesion. Complete functional recovery is the goal, and delays in diagnosis and treatment can result in irreversible neurological impairments. Therefore, a team-based approach consisting of a neurosurgeon first exploring and preserving the nerve, followed by lesion resection by an orthopedic surgeon, offers the safest and optimal strategy. We believe that advanced axonal loss at the time of diagnosis was responsible for the unsatisfactory outcome, which emphasizes the importance of early diagnosis and treatment.

Osteochondromas do not affect patient life expectancy. Malignant transformation is the most feared com-

---

**Fig. 6.** Case 17. A: Anteroposterior plain radiograph showing a proximal fibula osteochondroma. B and C: Sagittal (B) and axial (C) MR images of the lesion.

**Fig. 7.** Case 13. A: Photograph of the operative plan. The lesion, caput fibula (CF), and incision lines are marked. B: The lesion was compressing the bifurcation of a peroneal nerve. The lesion was removed in 2 parts. A small piece of the lesion is noted in the photograph. The white arrow indicates the common peroneal nerve, the thick yellow arrow indicates the superficial peroneal nerve, the thin yellow arrow indicates the deep branch of the peroneal nerve, the red arrow shows the peroneus longus muscle, and the blue arrow shows a small piece of the lesion. C: Photograph of the resected tumor in 2 pieces.
Nerve injuries due to osteochondromas

Fig. 8. Case 10 with MHE. A: Anteroposterior plain radiograph shows bilateral osteochondromas of the distal femur (thin arrows) and left proximal tibia (wide arrow). B: Anteroposterior plain radiograph shows the proximal humerus with the osteochondroma (arrow). C and D: Axial (C) and coronal (D) MR images showing the lesion.

Complication of osteochondroma. Osteochondromas may undergo sarcomatous transformation later in life, usually to a chondrosarcoma. Whereas the prevalence of complications in solitary osteochondromas has been estimated to be approximately 1%, this complication rate is higher with MHE, previously reported to be observed in as many as 25% of patients, although a lower prevalence of 3%–5% has been suggested. Malignant transformation was not observed in our series.

Conclusions

All patients with peripheral nerve compression due to an osteochondroma should undergo surgery. The nerve should always be decompressed and protected as a first step before the resection of the bone lesion. Preoperative radiographic evaluation should consist of MRI and CT to provide optimal information about the lesion and aid treatment options. Teamwork is crucial to plan and perform a complete removal of the exostoses. To avoid complications regarding further nerve injury and provide the optimal and safest strategy of management, we recommend a team-based approach consisting of a neurosurgeon first exploring and preserving the nerve, followed by lesion resection by an orthopedic surgeon.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Göçmen, Topuz, Atabey, Şimşek. Acquisition of data: Göçmen, Topuz. Analysis and interpretation of data: Göçmen. Drafting the article: Göçmen, Şimşek. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Göçmen. Administrative/technical/material support: Göçmen. Study supervision: Topuz, Atabey, Şimşek, Keklikçi, Rodop.

References

11. Goudarzi YM, Khodadadyan C, Leuenberger D: Bilateral lesion of the peroneal nerve with lesion of the left-sided median and ulnar nerves in multiple osteocartilaginous exostoses. Chirurg 66:1158–1161, 1995 (Ger)