Osteochondroma are the most common benign primary bone tumor. They are bony outgrowths surrounded by a characteristic cartilaginous cap, most commonly arising from the long bones. They are most often asymptomatic, usually discovered as incidental findings before the third or fourth decade of life. Although the exact pathogenesis is not fully established, there have been reports of these tumors arising after incidents such as fractures, trauma, radiation, and stem cell transplants. There have been only a few cases describing the development of osteochondroma after traumatic events. This report presents a documented case of an osteochondroma arising at the site of a previous femoral fracture, 10 years after the initial trauma.

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A follow-up MRI of the extremity was performed 1 month after the orthopedics department visit to correlate with the CT examination performed during the initial trauma. This MRI revealed a 1.1 × 1.4 cm osseous protuberance arising from the region of the prior trauma, specifically the posterior medial aspect of the distal femoral metaphysis near the insertion of the adductor magnus tendon. This lesion showed marrow continuity with the adjacent metaphysis, a finding compatible with osteochondroma (Fig. 5A-D).

The patient was managed conservatively with physical therapy and serial follow-ups. Over the course of 6 months, the patient reported improvement in pain with physical therapy.

**Discussion**

Osteochondromas are the most common benign bone tumor. They are bony outgrowths surrounded by a cartilaginous cap and arise on the external surface of bones [1]. They can occur...
Solitary osteochondromas most commonly affect the long bones such as the femur and tibia, but any bone of the body can be affected [1,2]. Multiple osteochondromas present as a part of an autosomal dominant condition known as hereditary multiple osteochondromas [1]. The exact pathogenesis of osteochondromas is still not determined, although there have been multiple theories to explain their development. The Virchow theory is one of the earliest proposed theories, which states that osteochondromas may arise from cartilage that separates from the growth plate [3]. An addition to this theory was made by Keith who suggested that the separation of the cartilage from the growth plate may be caused by some sort of defect in the periosteal cuff of bone that normally surrounds the vacuolating zone of the physis during early life [3]. There have also been studies showing the possible role of genetic mutations such as those in the exostosin

Fig. 4 – (A and B) Radiographs of the right knee status post fixation in 2006.

Fig. 5 – T1-weighted magnetic resonance imaging (MRI) images of the same anatomic region in sagittal (A) and axial (B). Cortical and medullary continuity of the lesion is clearly demonstrated, most consistent with an osteochondroma. (C and D) Adductor magnus tendon and medial gastrocnemius tendons, respectively, in close proximity to but with no clear attachment to lesion.
gene, causing accumulation of heparan sulfate proteoglycans within the cytoplasm, which prevent them from participating in the normal diffusion of Indian hedgehog ligands in the extracellular space. This results in loss of normal polarity, causing chondrocytes in the growth plate to grow in the wrong direction [1,4].

Diagnosis of osteochondromas typically begins with radiography. On plain film, the lesion is seen as a bony mass consisting of medulla and cortex [4]. The cortex is continuous with the bone from which it arises [3,4]. The marrow of the source bone can also be seen blending into the spongy portion of the outgrowth [3]. Furthermore, over time, the lesion may appear to be within the metaphysis, separate from the epiphyseal plate [3]. In addition, a common finding is areas of calcification seen within the cartilaginous component [1]. CT and MRI may also be used if the lesion is in areas with more complex anatomy such as the pelvis or shoulder girdle [4]. In addition, these imaging modalities can be used to assess the thickness of the cartilage cap and for planning biopsies [3]. MRI is preferred for imaging of complications arising from osteochondromas [4]. Treatment for osteochondromas is generally surgery if the lesion is symptomatic [1,3].

Osteochondromas most often come to attention before the third or fourth decade of life [2,3]. They usually are asymptomatic and are found incidentally [1]. The most common presentation is a nontender, insidiously growing lump on the bone [4]. Pain may be the presenting symptom, commonly caused by tendonitis or bursitis [3]. They may also result in fractures, deformities of bone, joint problems, as well as compressions of adjacent nerves and blood vessels, resulting in neurovascular symptoms such as numbness, weakness, and decreased pulses [1]. It is reported that osteochondromas affect 1%-2% of the general population, with most cases being asymptomatic. Symptomatic cases tend to be more common in younger patients, with 75% of such cases presenting before age 20. Approximately, 50% of osteochondromas involve the lower limb, with the femur being the most commonly affected bone, comprising 30% of all cases. The humerus is involved in 10%-20% of all cases, and less commonly reported cases in other areas such as the bones of the hands, feet, scapula, and pelvis [4].

Although the majority of these lesions are found incidentally without specific inciting event, there have been reported cases of osteochondromas arising after fractures, trauma, radiation, and hematopoietic stem cell transplants [4]. Specifically, the post-traumatic development of this lesion is presented in only a handful of case reports. The availability of documented images showing the evolution of the injured osseous structure into osteochondroma is exceedingly rare. Only 2 cases involving the distal femur were found during our literature search [5,6]. Of note, other anatomic locations have also been documented, including within the knee, fibula, ankle, and hallux [7–10]. The case presented here demonstrates an osteochondroma arising at the site of a previous fracture at the distal femoral diaphysis. The continuity of the lesion with the cortex and marrow is strongly suggestive of an osteochondroma vs diagnoses such as heterotopic ossification or post-traumatic cortical thickening. Although osteochondromas have been reported at the site of a previous trauma, there is a scarcity of cases that provide images of lesions, showing progression from an inciting traumatic event to an osteochondroma. As the pathogenesis of osteochondromas is still not fully established, it is important to include this case in the literature to bring more attention to the role of trauma in the development of this tumor.

REFERENCES

[1] Kitsoulis P, Galani V, Stefanaki K, Paraskevas G, Karatzias G, Agnantis N, et al. Osteochondromas: review of the clinical, radiological, and pathological features. In Vivo 2008;5:633–46.
[2] Hakim DN, Pelly T, Kulendran M, Caris JA. Benign tumours of the bone: a review. Journal of Bone Oncology. 2015;4(2):37–41.
[3] Brien E, Mirra J, Luck J. Benign and malignant cartilage tumors of bone and joint: their anatomic and theoretical basis with an emphasis on radiology, pathology and clinical biology. II. Juxtacortical cartilage tumors. Skeletal Radiol 1999;28(1):1–20.
[4] Douis H, Saifuddin A. The imaging of cartilaginous bone tumours. I. Benign lesions. Skeletal Radiol 2012;41(10):1195–212.
[5] Sarban S, Kocabey Y, Isikan U. Post-traumatic osteochondroma formation after femoral plate fixation: a case report. Inj Extra. 2005;36(2):15–8.
[6] Kumar R, dos Reis Teixeira Neto A, Madewell J, Deavers M, Moon B. Posttraumatic intramedullary osteochondroma: report of a case. Skeletal Radiol 2013;42(5):725–8.
[7] Mintzer C, Klein J, Kasser J. Osteochondroma formation after a Salter II fracture. J Orthop Trauma 1994;8(5):437–9.
[8] Cohen A, Giannoudis P, Hinsche A, Smith R, Matthews S. Post-traumatic giant intraarticular synovial osteochondroma of the knee. Injury 2001;32(1):87–9.
[9] An V. An unusual swelling at ankle: an osteochondroma in adult? Indian J Clin Pract 2013;23(10):651–3.
[10] Schnirring-Judge M, Visser J. Resection and reconstruction of an osteochondroma of the hallux: a review of benign bone tumors and a description of an unusual case. J Foot Ankle Surg 2009;4:495.