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Osteochondroma. An Osteological Study

ORIGINAL

Humberto Ferreira-Arquez[1]

1 Professor Human Morphology, Medicine Program, University of Pamplona. Morphology Laboratory Coordinator, University of Pamplona.

Contact information:

Humberto Ferreira-Arquez.

Address: University Campus, Kilometer 1. Via Bucaramanga. Pamplona. Norte de Santander, Colombia, Suramérica.
Tel: 75685667.

humfear@unipamplona.edu.co

Abstract

Background: Osteochondroma is the most common tumor of bone, accounting for approximately one third of benign lesions in the skeleton, is a broad (sessile) or narrow (pedunculated) skeletal protrusion comprised of marrow and cortical bone. Although it is benign, its biological behavior still has a malignant potential. Chondrosarcoma arising in osteochondroma has been recognized for many years. Osteochondromas might occur on any bone preformed in cartilage, they were especially seen on the long bones of the extremities, predominantly around the knee. In fact, the lower limb seemed to be at a higher risk of the tumor than the upper limb on the top two locations: distal part of the femur and proximal part of the tibia, however, the proximal humerus ranked the third place for solitary osteochondroma while the proximal fibula for multiples osteochondromas.

Methods and Findings: A total of 20 skeletons and 18 cadavers of both sex, 16 males and 2 females, with different age groups were used, this study was carried out by routine dissection classes for undergraduate medical student´s in the Morphology Laboratory of the University of Pamplona during the years 2013-2016. In only one sample was found the presence of osteochondroma. The measurement of the osseous mass was of 7x3.5x1.5 cm, attached to the posterolateral aspect of the middle third of the femur.

Conclusions: Osteochondroma is generally asymptomatic or discovered accidentally, but it can cause different symptoms depending on site of occurrence local swelling, bony deformities, fracture, bursa formation, arthritis and impingement on adjacent tendons, vascular or neurologic compromise, and dislocation The importance of correct treatment and follow-up of large osteochondromas to avoid complications such as further damage to neighboring neurovascular structures, and potential malignant degeneration. The present study describe a rare location from an osteochondroma in the femur diaphysis.

Keywords
Anatomical Variations; Osteochondroma; Skeletons; Clinical Implications.

Introduction

Osteochondromas (OC) are hamartomatous proliferations of both bone and cartilage that are thought to arise from trapped growth-plate cartilage, extend through the cortex, and grow via endochondral ossification beneath the periosteum. [1] This process of OC development may explain the tendency of OC to involve pelvis and long bones, such as the distal femur, the proximal tibia, and the proximal humerus. [2] An osteochondroma or exostosis is a benign bone tumor consisting of a bony overgrowth that occurs commonly in the metaphysis of long bones, [3] although any bone can be affected. [4] They are the most common of the benign bone tumors, occurring in approximately one per cent of the population. Osteochondromas can be solitary, as in approximately seventy-five per cent of cases, [5] or multiple, presenting as part of the autosomal dominant condition, hereditary multiple osteochondromas (HMO), studies using cell biology, molecular biology and immunohistochemical methods analyzed the mechanisms involved in the pathogenesis of osteochondroma. [2] It has been shown that HMO are caused by mutations in either of two genes: exostosis (multiple)-1 (*EXT1*), which is located on chromosome 8q24.11–q24.13 or exostosis (multiple)-2 (*EXT2*), which is located on chromosome 11p11–12. Recently, biallelic inactivation of the *EXT1* locus was described in nonhereditary osteochondromas. [6] Solitary osteochondromas show a predilection for the metaphyses of the long tubular bones, especially the femur (30%), humerus (26%) and tibia (43%). Lesions are rare in the carpal and tarsal bones, patella, sternum, skull and spine. [7] Complications are commonly associated with these exophytic masses and include cosmetic and osseous deformity, fracture, vascular compromise, neurologic sequelae, overlying bursa formation, and malignant transformation. Variants of osteochondroma include subungual exostosis, dysplasia epiphysealis hemimelica, turret exostosis, traction exostosis, bizarre parosteal osteochondromatous proliferation, and florid reactive periostitis. [8] The purpose of the present study was to document the prevalence of osteochondromas and describe a rare location in the femur diaphysis.

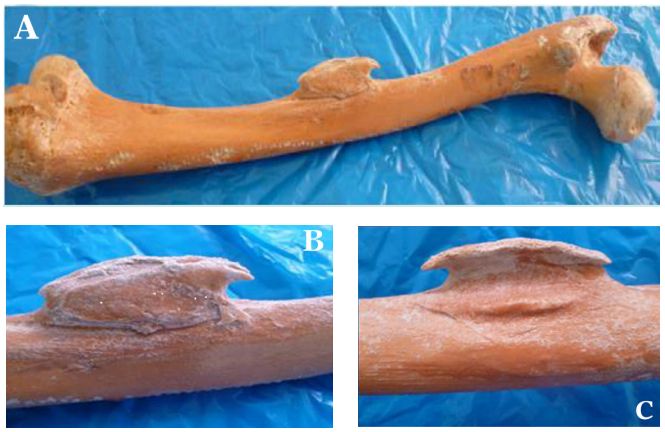
Methods

This work was previously approved by the Ethics Committee in Research and Environmental Impact of the University of Pamplona, conformed by resolution 030 of January 16 of 2014 and Resolution No. 008430 of 1993 of October 4 of the Ministry of Health of Republic of Colombia by which regulates the scientific, technical and administrative norms for health research. This descriptive cross-over study was designed to estimate prevalence of osteochondromas. The skeletons and cadavers were evaluated by direct visual examination to ensure they showed deformities, tumors or significant volume loss with a confirmed diagnosis of body OC involving extremity bones and non-extremity bones (e.g. clavicle, scapula, rib, spine, etc.). A total of 20 skeletons of the osteological collection of the Morphology Laboratory of the University of Pamplona and 18 cadavers of both sex, 16 males and 2 females, with different age groups were used, this study was carried out by routine dissection classes for undergraduate medical student´s in the Morphology Laboratory of the University of Pamplona during the years 2013-2016. Criteria for inclusion included location on the metadiaphyseal side of the growth plate, direction of growth away from the growth plate and the shape of the ossification. Criteria for exclusion included florid reactive ossifications, which were identified as large disorganized growths of osseous material, most often around joints; traction exostoses. Digital Vernier Calipers was used to measure the size of osteochondroma. The prevalence of the same were observed and the topographic details examined and photographed.

Results

Out of 20 skeletons and 18 cadavers examined, in only one sample (2.63%) was found the presence of osteochondroma (solitary and sessile). The measurement of the osseous mass was of x3.5x1.5 cm, attached to the posterolateral aspect of the middle third of the femur. **Figure 1**.

Figure 1.



A: Posterior view of the left femur. B: Medial side. C: Lateral side.

Discussions

Osteochondromas more frequently affect the appendicular skeleton (upper and lower limbs). The long bones of the lower limbs are the bones most commonly affected. [9] The knee is the region most affected (40% of the cases). After the knee, the proximal portions of the femur and the humerus are the sites preferentially affected. [10] After osteochondromas appear in the long bones, they usually become located in the metaphysis and only rarely in the diaphysis. [8] Flat bones like the scapula and hip may also be involved .Despite the slight predominance of the male gender over the female gender that has been reported by some authors, it seems that there is no effective predilection according to sex. [11]

Osteochondroma is usually symptomless and, therefore, the only clinical symptom is a painless slow-growing mass on the involved bone. [12] However, significant symptoms may occur as a result of complications such as fracture, bony deformity or mechanical joint problems. An osteochondroma can occur near a nerve or blood vessel, the commonest being the popliteal nerve and artery. The affected limb can exhibit numbness, weakness, loss of pulse or changes in colour. [13] Although rare, periodic changes in blood flow can also occur. Vascular compression, arterial thrombosis, aneurysm, pseudoaneurysm formation and venous thrombosis are common complications and lead to claudication, pain, acute ischemia, and signs of phlebitis, while nerve compression occurs in about 20% of patients. [14, 15] The tumor can be found under a tendon, resulting in pain during relevant movement and thus causing restriction of joint motion. Pain is also present as a result of bursal inflammation or swelling, or even due to a fracture of the basis of the tumor's stalk. [16] Generally, the normal function and movement can be limited and asymmetry may be also noted in a slowly and inwardly growing osteochondroma. If there is a tumor at the spinal column, there may be kyphosis, or spondylolisthesis if it is close to the intervertebral space. [17] The clinical signs of malignant transformation are pain, swelling and an enlargement of the mass. Rapidly increasing lesion size and local pain processes suggest that sarcomatous transformation is occurring in individuals with osteochondroma that was previously asymptomatic. Continuing growth of the lesion after skeletal maturity is reached should also awaken such suspicions. Other clinical findings that are occasionally reported include slight increases in soft tissues, elevation of temperature and local erythema. [11]

Osteochondromas are slow growing lesions with rare malignant transformation but can raise cosmetic concerns and impinge on local structures, including nerves, vessels and tendons, leading to symptomatology. [8, 18, 19] The majority of lesions are solitary, but they can occur as multiple lesions as part of the syndrome hereditary multiple exostosis (HME), which affects approximately 15% of patients

with osteochondromas and is an autosomal dominant inherited disorder. [2, 16, 20] The hereditary multiple exostosis (HME) syndrome usually presents during the first decade of life or even in newborns. The manifestations include limb undergrowth with normal height, ankle valgus, genu valgum and anomalies of the radio and ulnar deviation. Patients may present with metacarpal, metatarsal and phalangeal shortening, anisomelia, coxa valga, scoliosis and asymmetry of the pectoral and pelvic girdles. Subluxation of the talus or the hip are common symptoms. Tibiofibular synostosis can also take place. Spinal compression syndrome may also be seen. [21] Lesions that arise in the head and neck may be associated with facial asymmetry and dysfunction of the masseters. [22, 23] An inwardly growing osteochondroma can cause injuries of the viscera such as hemothorax, obstruction of the intestine or the urinary tract and dysphagia. [24, 25]

The osteochondromas exerted a direct mass effect on the vein. Scott et al [26] and Lizama et al [27] have reported a case of popliteal vein thrombosis that was associated with popliteal pseudoaneurysm. In that case, the perforation of the popliteal artery by the exostoses produced a false aneurysm, which compressed the popliteal vein that resulted in thrombosis. Kharia and Parnell [28] reported a thrombosis of both popliteal vein and artery as the result of femoral osteochondroma. Vascular diseases are rare in young patients. Intermittent claudication is uncommon and unlikely to be of atherosclerotic origin. Different causes of vascular diseases should be explored in this population. Peripheral thromboembolism may result in acute auricular fibrillation, aneurysm of interauricular septum, or coagulation abnormalities such as antithrombin III deficiency or hemopathy. Arterial insufficiency could be the consequence of popliteal artery entrapment syndrome, popliteal cyst, and Buerger disease. In the case of ischemia or phlebitis, blood investigations are necessary to exclude coagulation disorders that could predispose to thrombosis. Plain radiographs must be systematically performed to eliminate osteochondromas. It is necessary to perform radiography of the four limbs and of the chest to exclude any other locations of exostoses. In the case of known multiple hereditary exostosis pathologic condition, the occurrence of swelling, pain, or ischemia should be a warning sign, and vascular complications of exostosis should be evoked. [29]

Some authors have used Computed Tomography (CT) to diagnose the condition, [2, 30] whilst others have used plain x-ray [2, 3] and Magnetic Resonance Imaging (MRI). [3, 4] Duplex ultrasongraphy and angiograms may also be worth considering to exclude vascular injury. [2, 3, 29] With regards treatment options, the majority will settle with conservative and supportive measures. [8] If symptoms are unresponsive to conservative treatment, then surgical removal of the osteochondroma remains an option. [29] Some authors have undertaken surgical removal using an endoscopic approach, particularly within the distal femoral region. [31] Fitzgerald et al. [32] present a case report of how a patient with multiple osteochondromas got symptomatic relief from hip impingement secondary to hip joint exostosis, with surgical removal of the offending osteochondromas. Some multiple osteochondromas have also been symptomatic to the extent that they have required total hip and/or knee arthroplasty although the authors remind the surgeons that the anatomy is often distorted and therefore the surgery is more technically demanding. [33] Surgical options are generally postponed to after skeletal maturity [2, 3] and patients need to be counselled pre-operatively regarding the two per cent recurrence rate following surgical removal of the lesion. [5, 8]

Dysplasia Epiphysealis Hemimelica (DEH, Trevor's disease, tarso-epiphysial aclasis) and metachondromatosis (MC) are considered in the differential diagnosis of solitary and hereditary osteochondromas. Despite their similarities, they were shown to

be separate entities [34] and the EXT downstream pathway is not involved. [35] DEH is a developmental disorder with cartilaginous overgrowth of a portion of one or more epiphyses. [8] It predominantly affects the lower extremity on one side of the body. It is usually restricted to either the medial (most frequent) or lateral side of the limb (hemimelic). Similar to osteochondroma, DEH is usually diagnosed prior to the age of 15 years, more often in boys than in girls, and growth of these lesions end at puberty as the growth plates close. [8, 36] In contrast to multiple osteochondromatosis (MO), malignant transformation has not been reported so far [8] and there does not appear to be any genetic transmission. [36-38] Metachondromatosis is a rare disorder exhibiting, synchronous, both multiple osteochondromas and enchondromas in children. It has an autosomal dominant mode of inheritance [39-41] but the disorder has not been mapped in the human genome so far. MC related osteochondromas characteristically occur in the hands and feet, predominantly the digits and toes, and point toward the adjacent growth plate, while in MO the osteochondromas are mainly located in the long or other tubular bones and point away from the epiphysis. [39] Differentiation from MO is of great clinical significance because in patients with MC the lesions do not result in shortening or deformity of affected bones as in MO, and may spontaneously decrease in size or resolve completely, both clinically and radiologically. [39-42]

Conclusion

Understanding and recognizing the spectrum of appearances of osteochondroma is important because it represents the most frequent pseudotumoral bone lesion. Osteochondromas are only removed when they cause pain, when they give functional complaints for instance due to compression on nerves or vessels, or for cosmetic reasons. 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. Although it is benign, its biological behavior still has a malignant potential. Chondrosarcoma arising in osteochondroma has been recognized for many years. Depending on the site of occurrence, osteochondromas can give rise to different local symptoms. Possibility of osteochondroma should be kept in mind during differential diagnosis of bony swelling, not only in long bones, but also in flat bones as well as small bones.

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Conflict of interest

The author declare no conflicts of interest.

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References

1. Rains HA, Mann CV. Tumours of bones and joints. In: Baily H, Rains AJH, Mann CV, McNeill Love RJ, editors. Bailey and Love's short practice of surgery. 20th ed. London: HK Lewis; 1988. p. 372-9.
2. Kitsoulis P, et al. Osteochondromas: review of the clinical, radiological and pathological features. In Vivo. 2008; (5):633-46. Available from: http://iv.iiarjournals.org/content/22/5/633.long

3. Wang D, DeRubertis BG. Popliteal artery occlusion secondary to exostosis of the femur. Perspect Vasc Surg Endovasc Ther. 2012; 24(4):217-20. Available from http://journals.sagepub.com/doi/abs/10.1177/1531003513491984
4. Vanhoenacker FM, et al. Hereditary multiple exostoses: from genetics to clinical syndrome and complications. Eur J Radiol. 2001; 40(3):208-17. Available from: http://www.ejradiology.com/article/S0720-048X(01)00401-6/pdf
5. Heron N. Femoral exostosis causing vastus medialis pain in an active young lady: a case report. BMC Res Notes. 2015 Apr 2; 8:119. Available from: https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-015-1077-0
6. Hameetman L, et al. The role of EXT1 in nonhereditary osteochondroma: Identification of homozygous deletions. J Natl Cancer Inst. 2007; 99: 396-406. Available from: https://academic.oup.com/jnci/article-lookup/doi/10.1093/jnci/djk067
7. Solomon L. Hereditary multiple exostosis. Am J Hum Genet. 1964 Sep; 16(3): 351-63. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1932480/pdf/ajhg00549-0101.pdf
8. Murphey MD, Choi JJ, Kransdorf MJ, Flemming DJ, Gannon FH. Imaging of osteochondroma: variants and complications with radiologic-pathologic correlation. Radiographics. 2000; 20 (5): 1407-34. Available from: http://pubs.rsna.org/doi/full/10.1148/radiographics.20.5.g00se171407
9. Dorfman HD, Czerniak B. Osteochondroma. Bone tumors. St. Louis: Mosby; 1998. p. 331-46.
10. Resnick D, Kyriakos M, Greenway GD. Osteochondroma. In: Resnick D, editor. Diagnosis of bone and joint disorders. 3rd ed. Philadelphia: Saunders; 1995. p. 3725-46.
11. De Souza AMG, Bispo Júnior RZ. Osteochondroma: ignore or investigate? Revista Brasileira de Ortopedia. 2014; 49(6):555-564. doi:10.1016/j.rboe.2013.10.002. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4487501/
12. Chrisman OD, Goldenberg RR. Untreated solitary osteochondroma. Report of two cases. J Bone Joint Surg Am. 1968; 50: 508-12. Available from: https://insights.ovid.com/pubmed?pmid=5644867
13. Van Oost J, Feyen J, Opheide J. Compartment syndrome associated with an osteocartilaginous exostosis. Acta Orthop Belg.1996; 62: 233-5. Available from: http://www.actaorthopaedica.be/acta/download/1996-4/9008968.pdf
14. Cardelia JM, et al. Proximal fibular osteochondroma with associated peroneal nerve palsy: a review of six cases. J Pediatr Orthop. 1995; 15: 574-577. Available from: https://www.ncbi.nlm.nih.gov/pubmed/7593564
15. Vallance R, Hamblen DL, Kelly IG. Vascular complications of osteochondroma. Clin Radiol. 1985; 36: 639-42. Available from: https://www.ncbi.nlm.nih.gov/pubmed/4064551
16. Bovée JVMG, Hogendoorn PCW. Multiple Osteochondromas. In: World Health Organization Classification of Tumours. Pathology and Genetics of Tumours of Soft Tissue and Bone. Fletcher CDM, Unni KK and Mertens F (eds.). Lyon, France: IARC; 2002. p. 360-2.
17. Quirini GE, Meyer JR, Herman M, Russell EJ. Osteochondroma of the thoracic spine: an unusual cause of spinal cord compression. Am J Neuradiol. 1996; 17: 961-4. Available from: http://www.ajnr.org/content/17/5/961.long
18. Saglik Y, Altay M, Unai VS, Basari K, Yildiz Y. Manifestations and management of osteochondromas: a retrospective analysis of 382 patients. Acta Orthop Belg. 2006; 72: 748-55. Available from: https://pdfs.semanticscholar.org/3957/bffa7103ed328722cab4c8dea05658df265.pdf?_ga=2.24847738.1343818818.1509068484-1426685699.1509068484
19. Lee K, Davies A, Cassar-Pullicino V. Imaging the Complications of Osteocondromas. Clinical Radiology. 2002; 57: 18-28. Available from: http://www.clinicalradiologyonline.net/article/S0009-9260(01)90719-6/pdf
20. Stieber JR, Dormans JP. Manifestations of hereditary multiple exostoses. J Am Acad Orthop Surg. 2005; 13(2):110-120. Available from: https://insights.ovid.com/pubmed?pmid=15850368
21. Pandya NK, et al. Spinal cord compression in a patient with multiple hereditary exostoses caused by breast adenocarcinoma metastatic to osteochondromas of the spine: case report. Spine. 2006; 31: 920-4. Available from: https://insights.ovid.com/pubmed?pmid=17108823
22. Koga M, et al. Osteochondroma in the mandibular condyle that caused facial asymmetry: a case report. Cranio. 2006; 24: 67-70. Available from: http://www.tandfonline.com/doi/abs/10.1179/crn.2006.011
23. Koehl GL, Tilson HB. Osteochondromas associated with facial asymmetry and masticatory dysfunction: report of two cases. J Oral Surg. 1977; 35: 934-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/269942
24. Huang HR, Lin TY, Wong KS. Costal exostosis presenting with hemothorax: report of one case. Eur J Pediatr. 2006; 165: 342-3. Available from: https://link.springer.com/article/10.1007%2Fs00431-005-0060-5
25. Castells L, et al. Case report: haemothorax in hereditary multiple exostosis. Br J Radiol.1993; 66: 269-70. Available from: http://www.birpublications.org/doi/pdf/10.1259/0007-1285-66-783-269
26. Scott EM, White FJ, Jennings PE. Popliteal vein thrombosis associated with femoral osteochondroma and popliteal artery pseudoaneurysm. Postgrad Med J. 1995; 71:441-2. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2397980/pdf/postmedj00031-0059.pdf

27. Lizama VA, Zerbini MA, Gagliardi RA, Howell L. Popliteal vein thrombosis and popliteal artery pseudoaneurysm complicating osteochondroma of the femur. AJR Am J Roentgenol. 1987; 148:783-4. Available from: http://www.ajronline.org/doi/pdfplus/10.2214/ajr.148.4.783
28. Khaira HS, Parnell A, Crowson MC. Femoral exostosis presenting with deep vein and arterial thrombosis. Br J Surg. 1995; 82:911. Available from: http://onlinelibrary.wiley.com/doi/10.1002/bjs.1800820717/pdf
29. Vasseur MA, Fabre O. Vascular complications of osteochondromas. J Vasc Surg. 2000 Mar; 31(3):532-8. Available from: http://www.jvascsurg.org/article/S0741-5214(00)90315-X/fulltext
30. Tenenbaum S, Arzi H, Shabshin N, Liberman B, Caspi I. Selective computed tomography-guided perisciatic injection as a diagnostic tool in multiple hereditary exostoses. Orthopedics. 2012; 35(9):e1446-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22955418
31. Ayerza M, Abalo E, Aponte-Tinao L, Muscolo D. Endoscopic resection of symptomatic osteochondroma of the distal femur. Clin Orthop Relat Res. 2007; 459:150-3. Available from: https://pdfs.semanticscholar.org/6375/cb2b028d1cb2dd5be7c9523dab95a99a35f0.pdf
32. Fitzgerald CWR, Rowan FE, O'Neill SC, Mulhall KJ. A mountain among molehills: removing an impinging large femoral neck osteochondroma in a man with hereditary multiple exostoses. BMJ Case Reports. 2014; 09:2014. Available from: http://casereports.bmj.com/content/2014/bcr-2013-202317.abstract
33. Mesfin A, Goddard M, Tuakli-Wosornu Y, Khanuja H. Total hip and knee arthroplasty in patients with hereditary multiple exostoses. Orthopedics. 2012; 35(12):e1807-10. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23218641
34. Glick R, Khaldi L, Ptaszynski K, Steiner GC. Dysplasia epiphysealis hemimelica (Trevor disease): a rare developmental disorder of bone mimicking osteochondroma of long bones. Hum Pathol. 2007; 38:1265-72. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0046-8177(07)00063-9
35. Bovée JVMG, Hameetman L, Kroon HM, Aigner T, Hogendoorn PCW. EXT-related pathways are not involved in pathogenesis of Dysplasia Epiphysealis Hemimelica and Metachondromatosis. J Pathol. 2006; 209:411-9. Available from: http://onlinelibrary.wiley.com/doi/10.1002/path.1985/abstract
36. Silverman FN. Dysplasia epiphysealis hemimelica. Semin Roentgenol. 1989; 24:246-58. Available from: http://www.sciencedirect.com/science/article/pii/0037198X89900229
37. Ippolito E, Tudisco C. Dysplasia epiphysealis hemimelica. Clinical, histological and histochemical features. Ital J Orthop Traumatol. 1983: 9:101-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/6411654
38. Kuo RS, Bellemore MC, Monsell FP, Frawley K, Kozlowski K. Dysplasia epiphysealis hemimelica: clinical features and management. J Pediatr Orthop. 1998; 18:543-8. Available from: https://insights.ovid.com/pubmed?pmid=9661870
39. Bassett GS, Cowell HR. Metachondromatosis. Report of four cases. J Bone Joint Surg Am. 1985; 67:811-14. Available from: https://insights.ovid.com/pubmed?pmid=3873457
40. Herman TE, et al. Metachondromatosis: report of a family with facial features mildly resembling trichorhinophalangeal syndrome. Pediatr Radiol. 1997; 27:436-41. Available from: https://link.springer.com/article/10.1007/s002470050164
41. Kennedy LA. Metachondromatosis. Radiology. 1983; 148:117-18. Available from: http://pubs.rsna.org/doi/pdf/10.1148/radiology.148.1.6602353
42. Bovée JV. Multiple osteochondromas. Orphanet J Rare Dis. 2008 Feb 13; 3:3. doi: 10.1186/1750-1172-3-3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2276198/