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Original Article *Özgün Araştırma*

IMAGING FINDINGS OF OSTEOID OSTEOMAS IN CHILDREN AND ADOLESCENTS, CT VERSUS MRI: A SINGLE CENTER EXPERIENCE

Çocuk ve Adölesanlarda Osteoid Osteomaların Görüntüleme Bulguları, Tanıda BT ve MRG'nin Yeri: Tek Merkez Deneyimi

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ABSTRACT

Objective: To analyze osteoid osteomas of the pediatric age group, assess the distribution of lesions, and radiological findings, and compare the ability of Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) in detecting the tumor.

Material and Methods: Forty-four lesions of osteoid osteoma in children and adolescents were retrospectively analyzed using hospital files and institutional picture archiving and communication systems. Age, gender, treatment choices, modality used for diagnosis, tumor site, location within the bone, presence of calcified nidus, perilesional reactive sclerosis, cortical thickening, perilesional bone marrow edema, and joint effusion were documented.

Results: Twenty-nine males and 15 females with a median age of 15.00 (range: 4-18 years) were included in the study. All of the lesions were located in the appendicular skeleton. No axial skeletal involvement was found. Forty out of 44 lesions were located in the long bones. One was localized in the patella, 2 of them in the talus and 1 in the calcaneus. Thirty-four out of forty long bone involvement were in lower extremities. Six cases were located intraarticularly and joint effusion was seen in the involved joint. CT was available in all patients and MRI was available in 18 patients. CT was the first choice of cross-sectional imaging modality in 35 patients, and MRI was the first choice in 9 patients. MRI was successful in only 56% of the cases in characterizing osteoid osteomas. CT was accurate to characterize all osteoid osteoma lesions.

Conclusion: CT is more successful than MRI in detecting and characterizing osteoid osteomas. Intraarticular osteoid osteoma must be kept in mind in differential diagnosis, evaluating joint synovitis in children and adolescents.

***Keywords**: Osteoid osteoma, child, radiology, imaging*

ÖZ

Amaç: Pediatrik yaş grubundaki osteoid osteomaları analize ederek, olguların demografik özellikleri, lezyonların radyolojik bulgularını tespit etmek, Bilgisayarlı Tomografi ve Manyetik Rezonans Görüntüleme (MRG)'nin tanıdaki yerini belirlemektir.

Gereç ve Yöntemler: Kurumsal hasta bilgi sistemi ve görüntüleme arşiv sistemi kullanılarak 44 çocuk ve adolesanda tespit edilen osteoid osteoma lezyonu retrospektif olarak analiz edilmiştir. Yaş, cinsiyet dağılımı, tercih edilen tedavi seçeneği, tanıda tercih edilen kesitsel görüntüleme modalitesi (MRG, BT), tümör yeri, tümörün kemikteki lokalizasyonu, kalsifiye nidus varlığı, perilezyonal reaktif skleroz, kortikal kalınlaşma, perilezyonal kemik iliği ödemi ve eklem effüzyonu varlığı araştırılmıştır.

Bulgular: 4-18 yaş aralığında 29 erkek, 15 kız hasta çalışmaya dahil edildi. Lezyonların tümü apendiküler iskelet yerleşimli olup aksial iskelet tutulumu saptanmadı. Kırkdört lezyondan 40'ı uzun kemiklerde yerleşmişti. Bir lezyon patella, iki lezyon talus, bir lezyon kalkaneus yerleşimli idi. Kırk uzun kemik tutulumunun 34'ü alt ekstremiteleri tutmuştu. Altı olgu intraartiküler yerleşimli olup etkilenen eklemde effüzyon artmı vardı. Tüm olgularda BT ile değerlendirme yapılırken 18 olguda MRG ile de değerlendirme yapılmıştı. Öncelikli tercih edilen kesitsel görüntüleme modalitesi 35 olguda, BT iken 9 olguda MRG idi. BT tüm osteoid osteoma lezyonlarını doğru olarak tanırken, MRG'nin lezyonları tanımadaki başarısı %56 idi.

Sonuç: Osteoid osteomayı tespit etmede ve lezyonu karakterize etmede BT, MRG'den daha başarılı bulunmuştur. Çocuk ve adolesanlarda eklem effüzyonu varlığında ayırıcı tanıda intraartiküler osteoid osteoma da akılda bulundurulmalıdır.

***Anahtar Kelimeler**: Osteoid osteoma, çocuk, radyoloji, görüntüleme*

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INTRODUCTION

Osteoid osteoma is a benign neoplasm that was first described in 1930 by Bergstrand (1). It accounts for 10-12% of all benign osseous neoplasms. It is a bone-forming lesion presenting with a nidus of vascular osteoid tissue surrounded by the extensive formation of sclerotic bone. The osteoid within the nidus may go through variable calcification. Osteoid osteomas occur most frequently in boys, between 7-25 years old (2).

Night pain that relieves by the administration of salicylates and other nonsteroidal anti-inflammatory drugs is the most frequent complaint (3). The location of the lesion governs the clinical course. For example, spinal osteoid osteomas may present with scoliosis, whereas intraarticular lesions may cause synovitis and joint restriction (4,5).

The exact pathogenesis of osteoid osteoma is not clear. An increased concentration of prostaglandin E2 and prostacyclin within the nidus of the lesion have been identified in immunohistochemical studies. Prostaglandin E2 (PGE2) is a bioactive lipid that has many biological effects including inflammation which is the cause of the pain in osteoid osteoma (6).

Open surgery is the classic treatment of osteoid osteoma. However, computerized tomography (CT) guided percutaneous radiofrequency ablation (RFA) or laser ablation and percutaneous CT-guided trephine resection of the nidus has become the choice of treatment in recent decades (3,7).

A small radiolucent nidus measuring as large as 1.0-2.0 cm with variable mineralization, surrounding bone sclerosis, and cortical thickening are the classic features of osteoid osteoma on X-rays. Identifying some types of osteoid osteomas such as intramedullary and intraarticular lesions is difficult on X-rays, due to the less marked corticoperiosteal reactions. Also, identifying spinal osteoid osteomas is harder on X-rays because of the complex anatomy and overlapping structures. When conventional radiographs are not sufficient, sectional imaging methods should be used. Even when there is a high suspicion of osteoid osteoma, based on clinical and radiographic features, sectional imaging methods are still needed to better demonstrate the lesion and confirm the diagnosis (8). There is not an exact consensus about the appropriate sectional imaging modality (CT or MRI) to accurately diagnose osteoid osteomas. It is reported that compared to CT, magnetic resonance imaging (MRI) has a limited role in delineating the nidus (9). On the other hand, MRI has the advantage of the lack of radiation exposure.

The goal of this study is to analyze osteoid osteomas in the pediatric age group, assess the distribution of lesions, and radiological findings, and compare the ability of CT and MRI in detecting the tumor.

MATERIALS AND METHODS

This is a retrospective, single-center study evaluating 44 children and adolescents with osteoid osteoma who were diagnosed at Erciyes University Medical School between 2013-2021. Ten out of the 44 patients had histologically proven osteoid osteomas following open surgery. The remaining 34 patients had lesions with characteristic appearances of osteoid osteoma on imaging modalities and 27 were successfully treated by CT guided percutaneous RFA without histological confirmation. The radiological findings of the individuals were evaluated by a pediatric radiologist with 20 years of experience in musculoskeletal radiology. The patient's age, gender, and treatment choices were noted from the hospital files. The sectional imaging modality chosen for diagnosis (CT, MRI), tumor site, location within the bone (cortical, medullar, endosteal, periosteal), presence of calcified nidus, perilesional sclerosis-cortical thickening, perilesional bone marrow edema and presence of intraarticular effusion (for juxta-articular lesions) were evaluated from the institutional picture archiving and communication systems (PACS).

Statistical Analysis: Statistical analysis was conducted with SPSS IBM Statistics Version 22.0. Descriptive

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statistics were provided where appropriate. Median (range), frequency, and percentile were used for the description of the data.

RESULTS

Twenty-nine males and 15 females with a median age of 15.00 (range: 4-18 years) were included in the study. X-ray and CT were available in all patients and MRI was available in 18 patients.

In one out of 44 patients the initial examination was far away from the lesion location because of the reflected pain. With a delay of two months, the lesion location and characterization were truly determined.

All of the lesions were located in the appendicular skeleton. No axial skeletal involvement was encountered.

Forty out of 44 lesions were located in the long bones. One was localized in the patella, 2 of them in the talus and 1 in the calcaneus. Thirty-four of the long bone involvement were in the lower extremities. Seventeen lesions were located in the proximal femur. The sites of lesions in long bones are shown in Table 1.

There were 35 cortical, 5 subperiosteal, 2 endosteal, and 2 medullary lesions. Calcification of the nidus was noticed in 38 out of 44 lesions. Perilesional sclerosis-cortical thickening was seen in 41 out of 44 lesions. The remaining three lesions were located in the talus, calcaneus, and tibial epiphysis (Figure 1).

Perilesional edema was seen in all MRI examinations. Six cases were located intraarticularly and joint effusion was seen in the involved joint (Figure 2). Five out of 6 intraarticular lesions and joint effusions were located in the femoral neck and 1 in the calcaneus.

CT was the first choice of cross-sectional imaging modality in 35 patients, and MRI was the first choice in 9 patients. In 8 patients contrast-enhanced MRI was performed after CT examination to confirm the diagnosis. When CT was performed as the first choice of cross-sectional imaging modality it was seen that in all patients the modality was sufficient to characterize osteoid osteoma. When MRI was performed as the first choice modality, lesions were accurately characterized in 5 out of 9 patients. Four of these 5 examinations were contrast-enhanced. In the remaining 4, the lesions were misdiagnosed. Two of these 4 examinations were contrast-enhanced (Figure 3). Accurate diagnosis in these patients was made by CT after a delay following MRI. Clinico-radiological details of the osteoid osteomas not seen in MR imaging was given in Table 2.

Table 1: The sites of osteoid osteomas in long bones

Site	(%)	Bone
Diaphysis	57.5	Femur 10, tibia 10, humerus 3
Metaphysis	37.5	Femur 12, tibia 3
Epiphysis	2.5	Tibia 1
Apophysis	2.5	Femur (trochanter major) 1

Table 2: Clinico-radiological details of the osteoid osteomas misdiagnosed at MRI

Age (years)	Site	Location in bone	MRI Contrast
12	femoral neck	cortical	+
16	femoral neck	endosteal	-
15	talus	subperiosteal	-
17	patella	medullar	+

MRI: magnetic resonance imaging

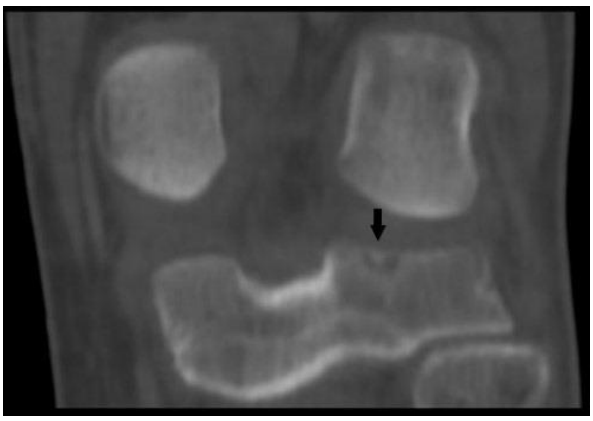

Figure 1: Tibial epiphyseal osteoid osteoma. 17 years old boy. Coronal reformatted CT. Osteoid osteoma located in lateral tibial epiphysis (arrow). No prominent perilesional sclerosis-cortical thickening.

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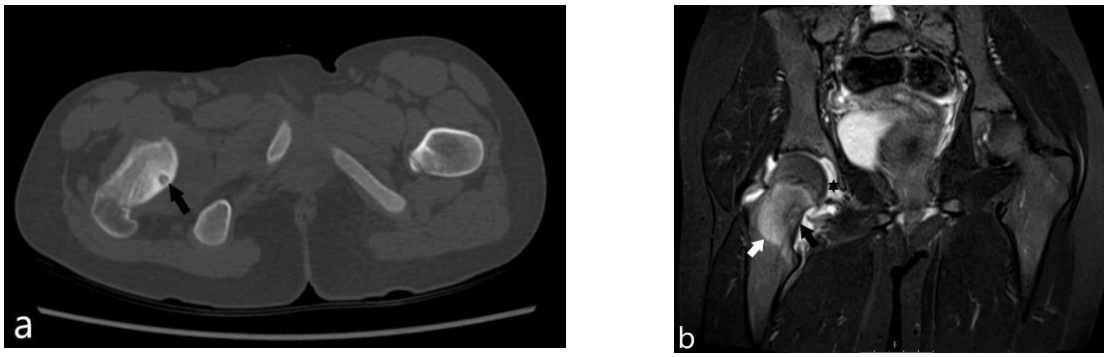

Figure 2: Intraarticular osteoid osteoma. 11 years old girl. CT (a). Calcified nidus located in the right femoral neck (arrow). Coronal T2 weighted suppressed MRI (b). The tumor nidus (arrow) is seen on MR imaging only as a subtle abnormality. Bone marrow edema (white arrow) and joint effusion (asterisk).

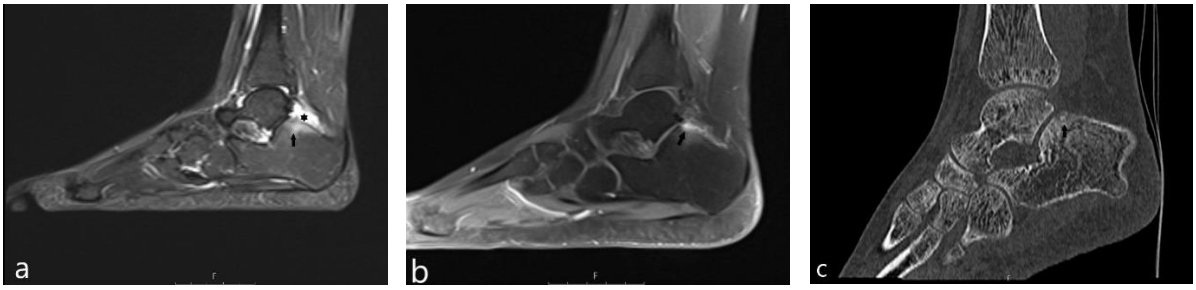

Figure 3: Calcaneal osteoid osteoma. 16 years old girl. Sagittal T2 weighted suppressed MRI (a). Bone marrow edema at the superior part of the calcaneus (arrow). Effusion in talocalcaneal joint (asterisk). Sagittal contrast-enhanced T1weighted MRI (b). Minimal contrast enhancement at the superior surface of the calcaneus (arrow). Sagittal reformatted CT (c). Osteoid osteoma is visualized with calcified nidus (arrow).

Thirty-seven of the patients were treated at our institution. In 10 patients, the treatment was performed with surgical resection and in 26 with CT-guided percutaneous RFA. In 1 patient the treatment was performed by CT-guided percutaneous RFA after insufficient surgical resection.

DISCUSSION

Osteoid osteomas are frequently seen in adolescents and young adults (4). However, patients with an age range of 7 months to 65 years old have been reported (10,11). In our case series, the median age was 15. The smallest child was 4 years old with a lesion located in the femur subtrochanteric region which was treated by CT-guided percutaneous RF ablation. There is a male prevalence, ranging from 1.6/1 to 4/1, in studies (12). This ratio was 2/1 in the current study.

Pain is the almost invariable complaint in osteoid osteomas (4). Although pain is often referred to as a nearby joint, it may be so distant from the lesion that radiographic examinations are misdirected (4). In one patient in this study, we noticed this point too. Although the lesion was located in the femoral intertrochanteric region, the pain was in the ankle. So the initial examination was performed to examine the ankle. The imaging findings were normal for the ankle. After 2 months after the first examination, the lesion location and characterization were truly determined.

The role of radiological imaging in osteoid osteoma is to identify the lesion and to determine the exact location before surgical resection or percutaneous treatment. Osteoid osteomas can locate in any bone in the appendicular and axial skeleton. It is very rare in the skull or face (13). It is reported that more than half of the osteoid osteomas locate in the long bones of lower extremities. The proximal femur is known as the most common localization (8). In our case series, no axial skeletal involvement was found, all of the lesions were located in the appendicular skeleton. Thirty-four out of 44 lesions were located in long bones of lower extremities and 17 of them were located in the proximal femur in contribution to the literature. Osteoid osteoma most commonly involves the diaphysis, followed by the metaphysis of the long bones. The incidence of diaphyseal and metaphyseal involvement is reported as 50% and 40% (8). In the current study, the most common site in long bones was diaphysis, followed by metaphysis (55% and 40%, respectively) compatible with the literature (Table 1).

Osteoid osteomas are classified as intracortical, subperiosteal, medullary, and endosteal according to the location in the bone. It is believed that osteoid osteomas have a subperiosteal origin and in time appear as endosteal, intracortical, and medullary lesions. Inward migration of osteoid osteomas is explained by continuing bone remodeling (14). The most common location is reported as the cortex. Medulla is reported as the next most common location. Subperiosteal location is reported as the least commonly involved (4). In this study, cortex was most frequently involved in contribution to literature. Differently, subperiosteal location was the second most common location, and medulla and endosteal location were least commonly involved.

Calcification is reported to be 25-50% in nidus (8). In the current study, calcification was quite high with a frequency of 86%. Perilesional sclerosis-cortical thickening was the common finding in CT, in the current study. Only three lesions located in the talus, calcaneus, and tibial epiphysis did not show perilesional sclerosis-cortical thickening.

Intraarticular location of osteoid osteomas is rare. Rimondi et al. in their broad case series reported an incidence of 12% of articular involvement (15). Hip involvement was most common This incidence was 13.6 % (six cases) in the current study and the hip was the most common joint in contribution with them. Synovitis and joint effusion were the main findings in all 6 intraarticular lesions, in this case series. The diagnosis of intraarticular osteoid osteoma is difficult because of its atypical radiologic findings. In intraarticular osteoid osteomas, prostaglandin triggers synovitis, causing arthritis and joint effusion. These findings may misguide the radiologist leading to the diagnosis of inflammatory arthritis (15). In the current study, the diagnosis was missed as inflammation and the correct diagnosis was delayed for several months, in one intraarticular lesion. Intraarticular osteoid osteoma must be kept in mind when evaluating joint synovitis in children and adolescents.

The role of CT and MRI, as primary diagnostic modalities for diagnosing osteoid osteomas, has been controversial. CT has a disadvantage of radiation exposure that is especially avoided in children. However, it has the advantage of being the basis for planning CT-guided interventional treatment techniques (16). MRI has the advantage of the lack of radiation exposure. Some studies recommend using non-ionizing imaging modalities in children, advocating the utility of MRI for the diagnosis of osteoid osteomas (17-19). On the other hand, several studies have stated the superiority of CT over MRI in diagnosing osteoid osteomas (20-23). Davies et al. stated that there exists a 35% potential for misdiagnosing osteoid osteomas if MRI was used alone (20). Assoun et al. reported that CT,

more accurately detected tumor nidus compared with MRI (21). Hosalkar et al., in their study, asked radiologists who were blinded to the histologic diagnosis to classify the osteoid osteoma lesions as benign-latent, benign-aggressive, or malignant depending on features seen on MRI (23). Sixty-nine percent of the MRI examinations were reported as benign aggressive and 11% were reported as malignant demonstrating that osteoid osteomas may have an aggressive appearance leading to misdiagnosis. In the current study, in all osteoid osteomas, CT examinations were sufficient to detect and characterize the lesions. In 9 patients, MRI was chosen as the primary diagnostic tool. It was found that MRI recognized only 56% of the osteoid osteomas. The presence of bone marrow edema in MRI may help to detect the nidus, acting as a red flag and recommending a more detailed evaluation in the area of the edema (8). On the other hand, perilesional bone marrow edema may obscure the nidus on MRI scans. Also, MRI helps demonstrate joint effusion and synovitis. But these findings may be misinterpreted as inflammatory arthritis (24). Also, one of the misdiagnosing potentials of MRI may be related to the difficulty of identification of small lesions due to the similarity of the nidus to the surrounding cortex (9).

In some studies, it is reported that dynamic MRI increases the nidus conspicuity, by enhancement of tumor or peri-lesional reactive changes allowing confident diagnosis (25,26). In the current study, MRI contrast was used in 4 out of 5 (80%) correctly diagnosed lesions. MRI contrast was used in 2 out of the remaining 4 (50%) incorrectly diagnosed lesions. According to these results, it can be generalized that MRI contrast helped to diagnose osteoid osteomas but was not sufficient to demonstrate all of them. The results of the current study are contributing that, MRI examinations have the potential for misleading the diagnosis of osteoid osteoma.

A limitation of the current study is the relatively small number of MRI examinations compared with CT. However, as the study was retrospective we could not have an opportunity to increase the number. Another limitation was that most of the lesions did not have a histopathologic diagnosis. However, no histological confirmation before RFA is needed when the clinical and imaging features are suggestive of osteoid osteoma (16).

CT is more successful than MRI in detecting and characterizing osteoid osteomas. Intraarticular osteoid osteoma must be kept in mind in the differential diagnosis when evaluating joint synovitis in children and adolescents.

Conflict of Interest: The author declares that there is no conflict of interest.

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REFERENCES

1. Bergstrand H. Über eine eigenartige, wahrscheinlich bisher nicht beschriebene osteoblastische krankheit in den langen knochen der hand und des fusses. Acta Radiol. 1930;11(6):596-613.
2. Laurence N, Epelman M, Markowitz RI, Jaimes C, Jaramillo D, Chauvin NA. Osteoid osteomas: a pain in the night diagnosis. Pediatr Radiol. 2012;42(12):1490-501; quiz 1540-2.
3. Somma F, Stoia V, D'Angelo R, Fiore F. Imaging-guided radiofrequency ablation of osteoid osteoma in typical and atypical sites:

Long term follow up. PLoS One. 2021;16(3):e0248589.

4. Iyer RS, Chapman T, Chew FS. Pediatric bone imaging: diagnostic imaging of osteoid osteoma. AJR Am J Roentgenol. 2012;198(5):1039-52.
5. Graham GN, Browne H. Primary bony tumors of the pediatric spine. Yale J Biol Med. 2001;74(1):1-8.
6. Nakanishi M, Rosenberg DW. Multifaceted roles of PGE2 in inflammation and cancer. Semin Immunopathol. 2013;35(2):123-37.
7. Reverte-Vinaixa MM, Velez R, Alvarez S, Rivas A, Perez M. Percutaneous computed tomography-guided resection of non-spinal osteoid osteomas in 54 patients and review of the literature. Arch Orthop Trauma Surg. 2013;133(4):449-55.
8. Carneiro BC, Da Cruz IAN, Ormond Filho AG, Silva IP, Guimarães JB, Silva FD et al. Osteoid osteoma: the great mimicker. Insights Imaging. 2021;12(1):32.
9. Chai JW, Hong SH, Choi JY, Koh YH, Lee JW, Choi JA et al. Radiologic diagnosis of osteoid osteoma: from simple to challenging findings. Radiographics. 2010;30(3):737-49.
10. Virayavanich W, Singh R, O'Donnell RJ, Horvai AE, Goldsby RE, Link TM. Osteoid osteoma of the femur in a 7-month-old infant treated with radiofrequency ablation. Skeletal Radiol. 2010;39(11):1145-9.
11. Hart FD, Smyth JM. Osteoid osteoma in an elderly patient. Rheumatol Rehabil. 1981;20(2):106-7.
12. Kransdorf MJ, Stull MA, Gilkey FW, Moser RP Jr. Osteoid osteoma. Radiographics. 1991;11(4):671-96.
13. Ciftdemir M, Tuncel SA, Usta U. Atypical osteoid osteomas. Eur J Orthop Surg Traumatol. 2015;25(1):17-27.
14. Kayser F, Resnick D, Haghighi P, Pereira Edo R, Greenway G, Schweitzer M et al. Evidence of the subperiosteal origin of osteoid osteomas in tubular bones: analysis by CT and MR imaging. AJR Am J Roentgenol. 1998;170(3):609-14.
15. Rimondi E, Mavrogenis AF, Rossi G, Ciminari R, Malaguti C, Tranfaglia C et al. Radiofrequency ablation for non-spinal osteoid osteomas in 557 patients. Eur Radiol. 2012;22(1):181-8.
16. Rehnitz C, Sprengel SD, Lehner B, Ludwig K, Omlor G, Merle C et al. CT-guided radiofrequency ablation of osteoid osteoma: correlation of clinical outcome and imaging features. Diagn Interv Radiol. 2013;19(4):330-9.
17. Spouge AR, Thain LM. Osteoid osteoma: MR imaging revisited. Clin Imaging. 2000;24(1):19-27.
18. Liu PT, Chivers FS, Roberts CC, Schultz CJ, Beauchamp CP. Imaging of osteoid osteoma with dynamic gadolinium-enhanced MR imaging. Radiology. 2003;227(3):691-700.
19. Gaeta M, Minutoli F, Pandolfo I, Vinci S, D'Andrea L, Blandino A. Magnetic resonance imaging findings of osteoid osteoma of the proximal femur. Eur Radiol. 2004;14(9):1582-9.
20. Davies M, Cassar-Pullicino VN, Davies AM, McCall IW, Tyrrell PN. The diagnostic accuracy of MR imaging in osteoid osteoma. Skeletal Radiol. 2002;31(10):559-69.
21. Assoun J, Richardi G, Railhac JJ, Baunin C, Fajadet P, Giron J et al. Osteoid osteoma: MR imaging versus CT. Radiology. 1994;191(1):217-23.
22. Zanetti M, Eberhard SM, Exner GU, von Hochstetter A, Hodler J. Magnetic resonance tomography in osteoid osteoma: more confusion than benefit? Praxis (Bern 1994). 1997;86(11):432-6.

23. Hosalkar HS, Garg S, Moroz L, Pollack A, Dormans JP. The diagnostic accuracy of MRI versus CT imaging for osteoid osteoma in children. Clin Orthop Relat Res. 2005;433:171-7.
24. Seniaray N, Jain A. Osteoid Osteoma Mimicking Inflammatory Synovitis. Indian J Nucl Med. 2017;32(3):194-7.
25. Liu PT, Chivers FS, Roberts CC, Schultz CJ, Beauchamp CP. Imaging of osteoid osteoma with dynamic gadolinium-enhanced MR imaging. Radiology. 2003;227(3):691-700.
26. Zampa V, Bargellini I, Ortori S, Faggioni L, Cioni R, Bartolozzi C. Osteoid osteoma in atypical locations: the added value of dynamic gadolinium-enhanced MR imaging. Eur J Radiol. 2009;71(3):527-35.