RESEARCH ARTICLE

Clinical Outcome of Proximal Femoral Osteoid Osteoma: Radiofrequency (RF) and Ablation Surgical Resection

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Abstract

Objectives: Osteoid osteoma (OO) is one of the most common benign bone tumors and can occur in various skeletal structures. It often presents with symptoms, such as nocturnal pain, which may mimic constitutional conditions, and it is characterized by a distinct radiological appearance that allows for easy differentiation from other lesions. Over the past decade, numerous studies have evaluated the efficacy of both surgical and radiological interventions for treating OO. While several treatment methods are available, each carries distinct advantages and disadvantages. This study aims to report the outcomes of surgical resection for ocular (OO) lesions.

Methods: A total of 29 patients were enrolled in this study. Of these, 14 patients chose surgical resection as their primary treatment, while 15 patients opted for radiofrequency (RF) ablation. Three patients who exhibited a lack of response to RF ablation subsequently underwent surgical resection, bringing the total number of patients in the surgery group to 17. This study specifically focused on lesions located in the peritrochanteric region. For lesions that recurred at the same site, whether due to recurrence or lack of response to initial treatment, the same treatment modality used in the first instance was applied.

Results: Among the 17 individuals who initially underwent surgical resection, 11 had extracapsular lesions, and 6 had intracapsular lesions. All patients who underwent surgical resection became symptom-free, and no complications were observed during the procedure. Furthermore, all cases that received surgical resection were confirmed through pathological assessment. Additionally, three patients with extracapsular lesions had previously been treated with RF thermoablation but had not fully recovered from their symptoms, necessitating surgical resection.

Conclusion: Based on the results, although RF is the first choice of treatment for OO, surgical resection could be a vital and safe option for peritrochanteric OO.

Level of evidence: IV

Keywords: Bone neoplasm, Cancer of bone, Osteoid, Osteoma, Radiofrequency ablation

Introduction

Osteoid osteomas (OOs) account for approximately 10% of all primary benign bone tumors in both children and adults, representing 10-12% of benign tumors and 2-3% of all primary bone tumors.[1] These tumors are typically located in the long tubular bones, including the head and neck regions of the femur. In more than 50% of cases, they are found on the cortical surface of the diaphysis of the tibia or femur.[2] OOs are most commonly observed in the proximal femur in children.[3] Less frequently, they occur in the axial skeleton and have even been reported in the cortical bone of the external auditory meatus.[4] The most common symptom of OO is

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nocturnal pain, which often improves with anti-inflammatory medications. The intense pain associated with tumor progression typically intensifies at night.

Histologically, patients with OO exhibit a small nidus of osteoblasts and osteoid, positioned over several millimeters, and surrounded by a peripheral arterial and neural supply.[5,6]

This tumor, which follows a specific progression pattern, predominantly occurs in young adults and adolescents. OO is most commonly seen in individuals under the age of 50, with a higher incidence in men than women. Diagnosis typically occurs during the second decade of life.[7]

Many patients with OO can manage pain with analgesics. However, as pain intensifies due to disease progression, accompanied by insomnia, many seek definitive treatment through surgical resection. While radiofrequency (RF) is considered the optimal treatment for OO, surgery may be required in some cases. Indications for open surgery include lack of response to RF, proximity to the joint or articular surface, involvement of small bones such as those in the hands and feet, involvement of the axial skeleton, and patient preference.[8,9]

Several challenges are associated with lesion localization during surgery, which can limit surgical success and have led to the development of various imaging-guided, minimally invasive treatments and interventions. In surgical resection, distinguishing normal bone from the tumor area is difficult, necessitating accurate methods for tumor localization. While computed tomography (CT) is the preferred diagnostic modality, it is not always available intraoperatively. Therefore, the tumor should either be visualized with fluoroscopy using a C-arm during surgery or marked preoperatively with CT.

In general, the most recommended treatments for OO include complete tumor removal through surgical resection, percutaneous excisional techniques with or without ethanol instillation, and radiofrequency (RF) ablation. However, some studies have reported the spontaneous healing of tumors following medical treatment with anti-inflammatory drugs and nonsteroidal anti-inflammatory drugs (NSAIDs).[10-12]

In this study, we aimed to review the children with peritrochanteric osteonecrosis (OO) whom we treated, as well as assess the effectiveness of our surgical method in patients without prior radiofrequency (RF) ablation, to gain further insights into its efficacy. We hypothesize that surgery may serve as a viable alternative to RF under certain conditions, such as financial constraints, patient preference, or the presence of intracapsular lesions.

Materials and Methods

This study was designed as a case series, presenting information about the included patients. A total of 29 patients were referred to our clinic with suspicious OO lesions, of whom 14 opted for surgical intervention over the RF treatment course. The remaining 15 patients chose RF as their therapeutic approach, and three patients who had an inadequate response to RF were treated with surgical resection. Thus, the total number of patients in the surgery group was 17.

Herein, we describe 17 children with OO located in the head and neck regions of the femur. Based on the precise tumor location, 11 cases were extracapsular at the level of the lesser trochanter, just below the insertion of the iliopsoas tendon. At the same time, the remaining patients had intracapsular tumors just above the lesser trochanteric zone [Table 1].

Table 1. Gender distribution of the patients

	Extracapsular lesion	Intracapsular lesion
Boy	6	4
Girl	5	2

Clinical cases were selected from 2012 to 2019, with patients ranging in age from 4 to 11 years and a minimum follow-up of 2 years, extending up to 8 years. The age distribution of the children, along with details of each patient's sex and the specific location of the osteoid lesion, is shown in [Table 2].

Table 2. Age distribution of cases by years

	Extracapsular Lesion	Intracapsular Lesion
Boy	5,6,7,8.5,9,11	5,6,8,9
Girl	4,5.5,6,8,9	6,8

We recommended either surgical intervention or RF ablation therapy. For patients with intracapsular lesions, we proposed surgical intervention from the outset Figures 1 and 2, while those with extracapsular lesions were given the choice between surgery and radiofrequency (RF) ablation [Figures 1 and 2]. Of the 11 cases with extracapsular involvement, three underwent RF ablation therapy. One patient did not experience complete recovery after RF ablation, as symptoms persisted despite treatment. Consequently, we performed surgical intervention but did not initially confirm the OO diagnosis. Pathological assessment revealed the lesion to be infectious, necessitating a wider surgical resection followed by a broad-spectrum antibiotic therapy protocol for osteomyelitis, which ultimately alleviated the patient's clinical symptoms [Figure 3]. The other two patients did not recover following one or two RF ablation treatments, respectively, but showed full recovery after surgical resection.

Among the patients with extracapsular lesions, two were marked with Kirschner wires before surgical resection under local anesthesia and fluoroscopic guidance from the lateral approach at the nidus area. However, due to imaging challenges with radiology and C-arm, the approach was switched to a medial one to ensure complete resection of the tumoral bed [Figure 4]. Additionally, RF ablation was not performed on the six patients with intracapsular lesions, as it may cause synovitis and cartilage loss. For patients who were less cooperative or younger than six years old, a spica or broomstick cast was applied for three to four weeks to minimize the risk of fractures. Postoperatively, no NSAIDs were prescribed, and there were no incidents of recurrence, fractures, or avascular necrosis in any of the cases.

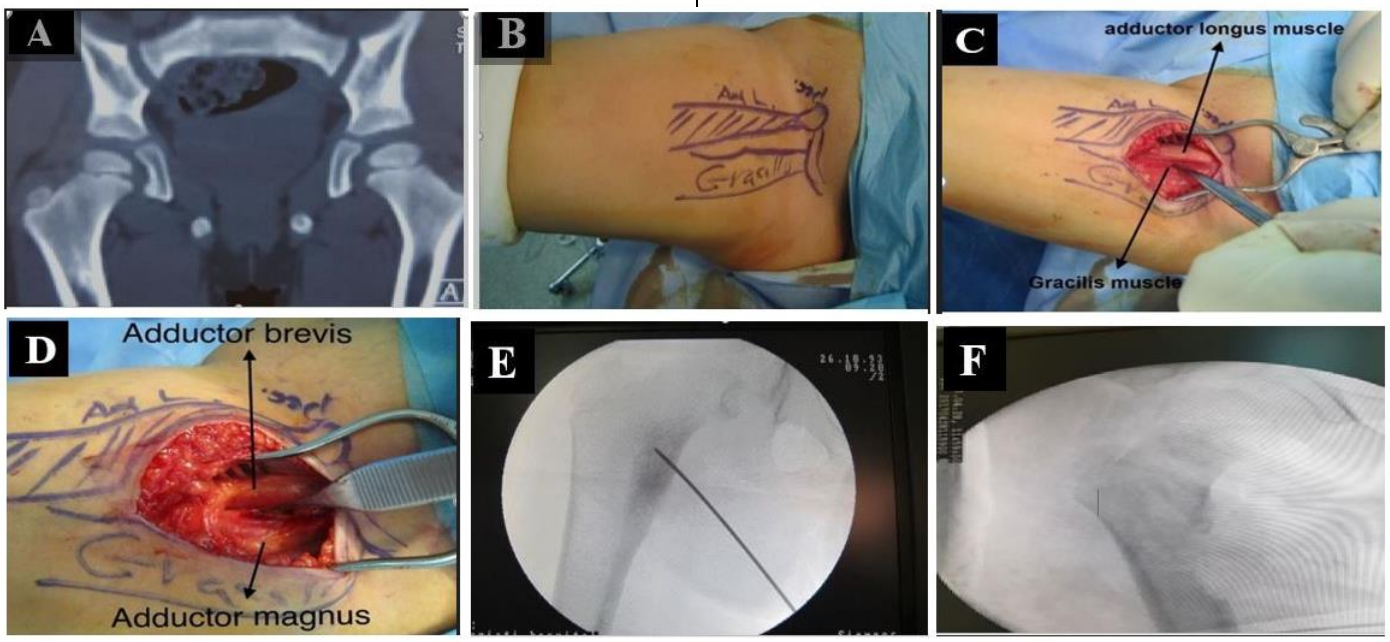

Figure1. A seven-year-old boy with an extracapsular proximal femoral osteoid osteoma underwent resection through a medial approach between the adductor longus muscle and the gracilis muscle. A) Preoperative CT scan of the pelvis demonstrating the pathology in the medial proximal cortex. B) Patient's right thigh in the surgical field. The Adductor Longus and Gracilis muscles are marked on the skin. C) Superficial approach between the Adductor Longus and Gracilis muscles. D) Deeper approach between the Adductor Brevis and Adductor Magnus muscles. E) Intraoperative fluoroscopy for evaluation of the surgical approach. F) Postoperative fluoroscopy

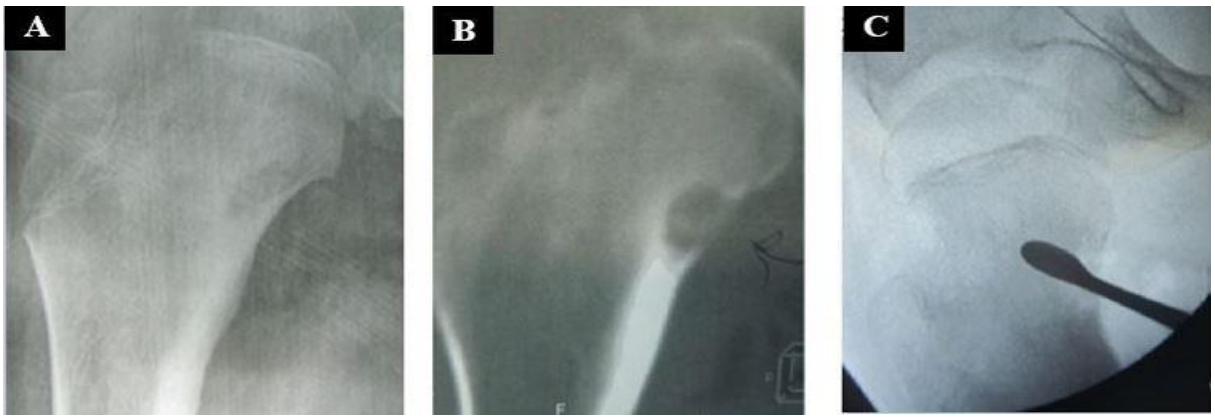

Figure 2. A nine-year-old girl who underwent resection without any prior marking. A) Preoperative X-ray of the left proximal femur. B) Preoperative CT scan of the left proximal femur. C) Intraoperative fluoroscopy

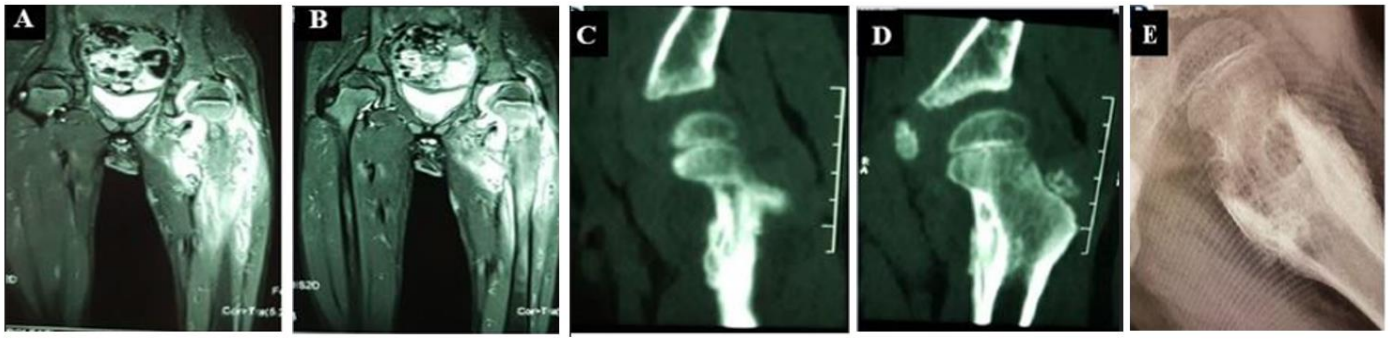

Figure 3. A patient who was first misdiagnosed with osteomyelitis. CT-scan guided biopsy approved Osteoid Osteoma, and multiple failures of radiofrequency ablations made us do the surgical resection. A and B) Preoperative MRI of the pelvis. C and D) Preoperative CT scan. E) X-ray of the proximal femur two months postoperatively

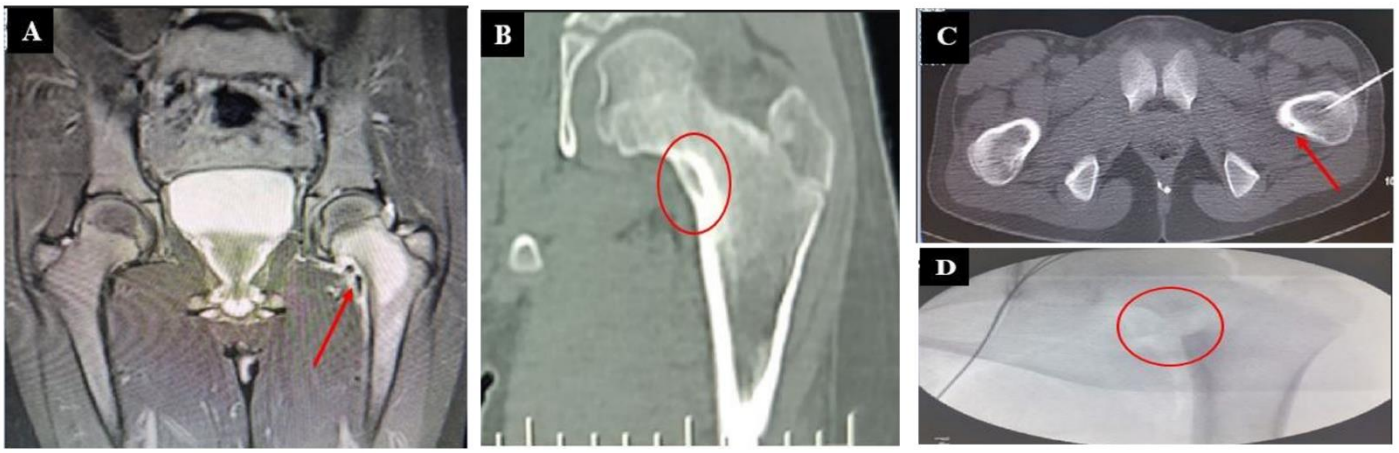

Figure 4. An eight-year-old boy with an intracapsular lesion in the proximal femur underwent resection, and CT-guided marking was performed to facilitate the procedure. A) Preoperative pelvis MRI demonstrating the intracapsular lesion in the medial proximal femur of the left side. B) Preoperative CT scan of the left hip. C) CT-guided marking before the operation. D) Postoperative fluoroscopy

Medial Surgical Approach Description

The patient lies in a supine position on a radiolucent table. In the first step, the affected limb is placed in a figure-of-four position to facilitate the medial approach. A 4 cm incision is made on the medial proximal aspect of the thigh, and the skin and percutaneous tissues are dissected. In the superficial layers, the approach is performed between the adductor longus and gracilis muscle intervals, and in the deeper layers, between the adductor brevis and adductor magnus muscle intervals. Caution is necessary around the superficial and deep branches of the obturator artery. As the approach progresses, the medial aspect of the proximal femur is reached. If the lesion is located beneath the iliopsoas tendon insertion, as in extracapsular lesions, we excise the lesion using a subperiosteal approach under C-arm guidance [Figure 1]. Suppose the lesion is intracapsular within the supra-lesser trochanteric region. In that case, we first shave the iliopsoas tendon insertion from the lesser trochanter and then proceed with a longitudinal incision over the capsule to expose the lesion under C-arm guidance. Care must be taken to avoid damaging the medial circumflex artery, which passes just medial to the capsular incision. At the end of the procedure, the iliopsoas tendon is reattached at its insertion site. Long-term follow-up results showed that this procedure did not affect the function of the iliopsoas muscle, which serves as the hip flexor.

Inclusion Criteria

In this study, we included all patients with diagnostic evidence of osteoid osteoma. This evidence included nocturnal pain, a dramatic reduction in pain after taking NSAIDs, and the presence of a visible nidus lesion (<1 cm) on CT scans.

In all cases, pain was localized to the anterior portion of the thigh or the prearticular knee joint, except for one patient with an extracapsular lesion who reported unspecified leg pain. All patients exhibited some degree of limping.

Exclusion Criteria

Patients with OO lesions located outside the proximal femur, as well as those in whom clinical symptoms or imaging suggested alternative diagnoses, were excluded from this study. Additionally, patients who did not consent to participate were also excluded from the study.

Ethics

The Institutional Review Board (IRB) at our university reviewed and approved our study protocol, confirming that it raised no ethical concerns. Additionally, an informed consent form was designed to collect data from each patient, which was signed by the parent(s).

Results

We enrolled 17 patients in this study. Among them, 11 had extracapsular OO lesions in the peritrochanteric region, while six presented with intracapsular lesions in the same zone. Patients were divided into two groups based on their preference, the location of the lesion, and any prior treatments they had received to address the tumor. All patients with intracapsular lesions underwent surgical resection and experienced full recovery postoperatively. Surprisingly, three patients who underwent RF ablation therapy experienced a recurrence of nocturnal pain in the same region. Further evaluation revealed remnants of the osteoid lesion and failure of RF ablation in two of these patients, who then underwent another round of RF ablation but did not fully recover. They were ultimately relieved of their symptoms following surgical resection. One of these patients, however, did not recover despite multiple courses of RF ablation. Open biopsy and pathological assessment revealed an infectious source in this case. Based on the microbiologic antibiogram, the patient received a course of broad-spectrum antibiotic therapy and has remained symptom-free to date.

Discussion

Osteoid osteomas (OOs) frequently occur in the proximal femur. Campanacci reported a prevalence of 25.4% for this phenomenon[3], which underscores the need for the present study. The advantage of our research lies in its specific focus on the proximal femur. Many previous studies in this field, whether using drilling, thermoablation, or other surgical methods, have not differentiated between lesions in the proximal femur and those in different locations.

The primary goal in treating osteoid osteoma (OO) is to identify and completely remove the nidus. Once the nidus is entirely excised, the patient will experience immediate relief from pain. Therefore, surgical intervention is preferred over conservative treatment, which may require NSAID use for a period ranging from six months to three years.[13] There is no need to remove all the surrounding thickened bone, as minimal bone resection ensures there is no significant bone defect or subsequent instability. In some cases, particularly based on the patient's age or the size of the nidus, we immobilize the patient with a cast for a short period.[14]

There are alternative percutaneous methods for treating patients with osteoid osteoma (OO). The outcomes of RF thermoablation have been reported as acceptable, with recovery rates of 97% and 92% as reported by Neumann et al.[15] and Hoffman et al.,[16] respectively. Rosenthal et al.[17] reported a recurrence of the nidus in seven out of 74 cases of femoral OO, while Hoffman et al. did not report any cases of recurrence.[16] Although RF ablation has a remarkable success rate, recurrence is not uncommon, and several patients in this study experienced recurrence or a lack of response to RF ablation.

Results of laser ablation have also been promising, with Gangi et al.[18] and Roqueplan et al.[19] reporting total recovery rates of 99% and 96%, respectively. However, these studies noted several minor complications. Etienne et al. identified broken RF instruments and skin burns as the most common complications of RF therapy,[20,21] while Roqueplan et al. reported nerve injury and tendinitis.[19] In addition to cutaneous damage induced by RF, some cases of cellulitis developed within two weeks after RF treatment at the probe application site, which resolved spontaneously with a routine course of oral antibiotics. Despite these potential adverse effects, RF's non-invasive nature, lack of need for anesthesia, and absence of surgical scars have contributed to its increasing popularity. Studies by Rosenthal et al.[22]and Cribb et al.,[23] with sample sizes of 45 and 117 patients undergoing RF ablation of OO lesions, demonstrated that RF yielded better outcomes in primary OO compared to recurrent OO, particularly in extra-vertebral lesions.[22,23] Notably, none of our cases experienced recurrence or complications.

Another approach to treating osteoid osteoma (OO) is CT-guided excision. Wang et al. reported successful outcomes in 100% of cases in a series of 26 patients with OO in various locations.[24] One significant disadvantage of CT-guided excision is the lack of perioperative CT guidance, which is necessary for confirming complete tumor excision. Rajasekaran et al. emphasized the use of this technique, particularly for the proximal femur, and suggested that confirmation of complete resection can be achieved through 3D reconstructions.[25,26]

In our country, RF ablation therapy is not covered by insurance due to financial policies regarding specific medications. Additionally, RF ablation, being a contemporary and advanced technique, is not available in all clinics and is primarily limited to referral institutions. Therefore, surgical resection appears to be a more favorable approach, given its wider availability and insurance coverage for the associated costs.

During the study, we observed that two patients did not respond to RF therapy; none of their symptoms were completely alleviated, even after repeating the RF course. In contrast, all patients who underwent surgical resection achieved 100% symptom resolution. Unlike RF therapy, surgical resection allows for confirmation of the diagnosis through pathological assessment.

Surgery was performed with a minimal medial approach incision, resulting in very low morbidity and no additional complications.

It is essential to note that RF therapy can lead to synovitis and cartilage loss in intracapsular lesions. Therefore, we recommend performing surgical resection at the outset of treatment for such cases to minimize the risk of iatrogenic complications.

Limitation

The primary limitation of this study was the relatively small sample size compared to similar studies in the literature. Additionally, we may not have had sufficient data to thoroughly compare the two methods based on previous studies; however, we made efforts to obtain accurate results with the available data. Lastly, patients were not randomly assigned to surgery or RF groups, and their preference was the determining factor, which introduces potential selection bias.

Conclusion

RF ablation therapy is increasingly chosen as an alternative treatment for osteoid osteoma (OO), depending on the patient's preferences and medical condition, alongside surgical resection. It is important to note that the findings of this study do not claim surgery is superior to RF ablation. However, our study demonstrates that, despite RF ablation being proposed as a new method for treating such lesions, it has a higher failure rate in patients with peritrochanteric lesions compared to conventional surgical resection. This is evident in terms of eventual outcomes, recurrence rates, and the ability to obtain diagnostic tissue pathology during surgical resection.

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References

1. DC D. General aspects and data on 8542 cases: Giant cell tumor. Bone tumors. 1986:119-40. doi: 10.1016/S0025-6196(12)61914-4.
2. May CJ, Bixby SD, Anderson ME, et al. Osteoid osteoma about the hip in children and adolescents. J Bone Joint Surg Am. 2019;101(6):486-493. doi: 10.2106/JBJS.18.00888.
3. Campanacci M, eds. Bone and soft tissue tumors: clinical features, imaging, pathology and treatment. 2nd ed. Springer Science & Business Media; 2013.
4. Rinzler ES, Shivaram GM, Shaw DW, Monroe EJ, Koo KS. Microwave ablation of osteoid osteoma: initial experience and efficacy. Pediatr Radiol. 2019;49(4):566-570. doi: 10.1007/s00247-018-4327-1.
5. Matthies L, Rolvien T, Pakusa TJ, et al. Osteoid osteoma of the mandible–clinical and histological findings. Anticancer Res. 2019;39(1):291-296. doi: 10.21873/anticanres.13110.
6. Harirchian MH, Mohammadpour Z, Fatehi F, Firoozeh N, Bitarafan S. A systematic review and meta-analysis of randomized controlled trials to evaluating the trend of cytokines to vitamin A supplementation in autoimmune diseases. Clin Nutr. 2019;38(5):2038-2044. doi: 10.1016/j.clnu.2018.10.026.
7. Canella C. Osteoid osteoma: diagnosis and treatment. Radiol Bras. 2015;48(4):v. doi: 10.1590/0100-3984.2015.48.4e1.
8. Lin N, Ye Zm, Qu H, et al. Open surgery for osteoid osteoma with three dimensional C-arm scan under the guidance of computer navigation. Orthop Surg. 2016;8(2):205-11. doi: 10.1111/os.12233.
9. Shariatzadeh H, Bahrabadi M, Amiri S, Jahanshahi F, Joudi S, Bahrabadi M. Intra-articular osteoid osteoma of the capitulum: A diagnostic challenge. Clin Case Rep. 2022;10(5):e05796. doi: 10.1002/ccr3.5796.
10. Bahrami S, Baheiraei N, Shahrezaee M. Biomimetic reduced graphene oxide coated collagen scaffold for in situ bone regeneration. Sci Rep. 2021;11(1):16783. doi: 10.1038/s41598-021-96271-1.
11. Mansoori B, Kosaraju V, Yoon J, et al. Incidental osseous lesions on chest CT: an algorithmic approach for radiologists. Clin Imaging. 2022:91:69-96. doi: 10.1016/j.clinimag.2022.08.015.
12. Spiker AM, Rotter B-Z, Chang B, Mintz DN, Kelly BT. Clinical presentation of intra-articular osteoid osteoma of the hip and preliminary outcomes after arthroscopic resection: a case series. J Hip Preserv Surg. 2017;5(1):88-99. doi: 10.1093/jhps/hnx042.
13. Kneisl J, Simon M. Medical management compared with operative treatment for osteoid-osteoma. J Bone Joint Surg Am. 1992;74(2):179-85.
14. Yildiz Y, Bayrakci K, Altay M, Saglik Y. Osteoid osteoma: the results of surgical treatment. Int Orthop. 2001;25(2):119-22. doi: 10.1007/s002640100231.
15. Neumann D, Berka H, Dorn U, Neureiter D, Thaler C. Follow-up of thirty-three computed-tomography-guided percutaneous radiofrequency thermoablations of osteoid osteoma. Int Orthop. 2012;36(4):811-5. doi: 10.1007/s00264-011-1402-8.
16. Hoffmann R-T, Jakobs TF, Kubisch CH, et al. Radiofrequency ablation in the treatment of osteoid osteoma—5-year experience. Eur J Radiol. 2010;73(2):374-9. doi: 10.1016/j.ejrad.2008.11.018.
17. Rosenthal DI, Hornicek FJ, Wolfe MW, Jennings LC, Gebhardt MC, Mankin HJ. Percutaneous radiofrequency coagulation of osteoid osteoma compared with operative treatment. J Bone Joint Surg Am. 1998;80(6):815-21. doi: 10.2106/00004623-199806000-00005.
18. Gangi A, Alizadeh H, Wong L, Buy X, Dietemann J-L, Roy C. Osteoid osteoma: percutaneous laser ablation and follow-up in 114 patients. Radiology. 2007;242(1):293-301. doi: 10.1148/radiol.2421041404.
19. Roqueplan F, Porcher R, Hamzé B, et al. Long-term results of percutaneous resection and interstitial laser ablation of osteoid osteomas. Eur Radiol. 2010;20(1):209-17. doi: 10.1007/s00330-009-1537-9.
20. Etienne A, Waynberger É, Druon J. Interstitial laser photocoagulation for the treatment of osteoid osteoma: retrospective study on 35 cases. Diagn Interv Imaging. 2013;94(3):300-10. doi: 10.1016/j.diii.2012.11.002.
21. Oc Y, Kilinc BE, Cennet S, Boyacioglu MM, Ertugrul R, Varol A.

Complications of computer tomography-assisted radiofrequency ablation in the treatment of osteoid osteoma. Biomed Res Int. 2019:2019:4376851. doi: 10.1155/2019/4376851.

22. Rosenthal DI, Hornicek FJ, Torriani M, Gebhardt MC, Mankin HJ. Osteoid osteoma: percutaneous treatment with radiofrequency energy. Radiology. 2003;229(1):171-5. doi: 10.1148/radiol.2291021053.
23. Cribb G, Goude W, Cool P, Tins B, Cassar-Pullicino V, Mangham D. Percutaneous radiofrequency thermocoagulation of osteoid osteomas: factors affecting therapeutic outcome. Skeletal Radiol. 2005;34(11):702-6. doi: 10.1007/s00256-005-0947-2.
24. Wang B, Han SB, Jiang L, et al. Percutaneous radiofrequency ablation for spinal osteoid osteoma and osteoblastoma. Eur Spine J. 2017;26(7):1884-1892. doi: 10.1007/s00586-017-5080-0.
25. Haghighizadeh E, Shahrezaee M, Sharifzadeh SR, Momeni M. Transforming growth factor-β3 relation with osteoporosis and osteoporotic fractures. J Res Med Sci. 2019:24:46. doi: 10.4103/jrms.JRMS_1062_18.
26. Rajasekaran S, Karthik K, Chandra VR, Rajkumar N, Dheenadhayalan J. Role of intraoperative 3D C-arm-based navigation in percutaneous excision of osteoid osteoma of long bones in children. J Pediatr Orthop B. 2010;19(2):195-200. doi: 10.1097/BPB.0b013e328333997a.