Osteoid osteoma is a benign bone tumor with a male predominance occurring mainly in children and young adults. The most common symptom is intermittent pain that worsens at night and is at least partially relieved by nonsteroidal anti-inflammatory drugs.

The purpose of this study was to assess the long-term effectiveness of computed tomography–guided percutaneous radiofrequency thermoablation in patients with a minimum follow-up of 2 years. Twenty patients with osteoid osteoma (15 men and 5 women) with a mean age of 20.7 years (range, 4-61 years; 12 patients aged 20 years or younger) underwent computed tomography–guided percutaneous radiofrequency thermoablation. Lesion sites were the femur (n = 9), tibia (n = 7), pelvis (n = 1), talus (n = 1), cuneiform bone (n = 1), and humerus (n = 1). Mean follow-up was 44 months (range, 3-106 months). Pain relief was significant in 95% of patients; it disappeared within 24 hours in 14 patients, within 3 days in 4, and within 7 days in 1. The patient with persistent symptoms underwent another percutaneous radiofrequency thermoablation procedure that was successful. The difference between pre- and postoperative pain was significant (P < .01). No recurrences occurred.

Computed tomography–guided percutaneous radiofrequency thermoablation is a safe, minimally invasive, and economical procedure with high technical and clinical success rates, and it effectively and durably enhances quality of life.
Osteoid osteoma, a ubiquitous benign bone tumor with a male predominance, primarily occurs in children and young adults. It accounts for approximately 10% of benign bone tumors and mainly affects the long bones (femur and tibia). On histology, it exhibits a small nidus of osteoblasts endowed with nerve and blood supplies. Lesions are typically single and small (less than 2 cm in size). The most common symptom is bone pain, initially discontinuous and later constant; it is not related to physical exercise, gets worse with rest, and considerably affects quality of life. The pain may initially be a dull ache but often progresses to severe localized pain over the lesion site. The characteristic nocturnal exacerbations may cause sleep deprivation. Less common manifestations include growth disturbance, bone deformity, and painful scoliosis.

Osteoid osteoma is generally managed with pain medications, such as acetylsalicylic acid or other nonsteroidal anti-inflammatory drugs (NSAIDs). The pain might be due to prostaglandin release, which would help explain the relief provided by prostaglandin inhibitors. However, long-term pain management is unacceptable for most patients because relief is often inadequate and gastrointestinal complications can occur. The standard treatment is surgical resection. Percutaneous radiofrequency thermoablation is an effective and economical alternative that is associated with fewer complications and a shorter length of hospital stay. The purpose of this study was to assess the long-term outcomes of percutaneous radiofrequency thermoablation in patients with a follow-up of at least 2 years.

**Materials and Methods**

**Patients**

Between July 2002 and February 2011, twenty patients with osteoid osteoma (15 men and 5 women) underwent CT-guided percutaneous radiofrequency thermoablation at the authors’ institution. Mean age...
was 20.7 years (range, 4-61 years), and 12 patients were aged 20 years or younger. Mean follow-up was 44 months (range, 3-106 months), and mean symptom duration was 12 months. All patients had histories of diurnal and nocturnal pain that was managed with NSAIDs (range, once weekly 3 times daily). Patients reported variable responses to NSAIDs. No patient took opioid analgesics. Patients sought a long-term solution due to quality of life deterioration due to nocturnal pain, the need for pain drugs, and interference with job, education, and physical activity.

The clinical and radiological workup included standard radiographs, radionuclide scintigraphy, and CT to confirm the diagnosis of osteoid osteoma, establish the lesion site, and plan the operation. Magnetic resonance imaging was performed in only 2 patients due to its low specificity for these lesions. The diagnosis of osteoid osteoma was based on the following criteria: pain with or without nocturnal exacerbation responsive to NSAIDs, a radiolucent lesion (ie, the nidus) in the medial aspect of the bone surrounded by bone sclerosis and cortical thickening on radiographs, and a bone lesion with a small nidus surrounded by a zone of reactive sclerosis on CT.7,9 Lesion sites were the femur (n=9), tibia (n=7), pelvis (n=1), talus (n=1), cuneiform bone (n=1), and humerus (n=1). No patient had undergone previous surgical treatment. The lesion size was calculated from axial CT scans. Mean nidus size was 5.3 mm (range, 3-10 mm), and the distance between the center of the nidus and the overlying skin ranged from 14 to 74 mm.

Patients completed a questionnaire that the authors translated from English to Italian for use in this study. The questionnaire rated pre- and postoperative pain separately.10

**Surgical Technique**

The procedure was performed in the CT room in aseptic conditions by an interventional radiologist (E.P.) and an orthopedic surgeon (M.G.) in the presence of an anesthetist. Patients received local epidural anesthesia, and general anesthesia was given to children due to the pain caused by percutaneous radiofrequency thermoablation. Patients were discharged the following day.

The percutaneous approach and the needle’s route were preliminarily assessed by consensus evaluation of the imaging data by the orthopedic surgeon and the interventional radiologist and depended on the lesion’s position with regard to the neurovascular structures. The first CT scan was obtained after placing an adhesive marker plate with...
radiopaque coordinates (Beekley Medical’s GuideLines, Bristol, Connecticut) to determine the exact location of the nidus and the needle’s route from the entry point on the skin to the center of the nidus (Figure 1). Local anesthesia was administered after skin preparation and sterilization.

A fine needle was introduced through the soft tissue above the lesion at a right angle to the bone to prevent slipping during perforation of the cortical bone. Another CT scan was then obtained to monitor the needle’s direction (Figure 2). The needle was then replaced with a Kirschner guidewire, and another CT scan was obtained (Figure 3). Another CT scan was obtained after reaching the nidus. After collecting a bone specimen with a bone biopsy needle (Laurane Perforating Biopsy Kit, Westbrook, Connecticut; Trapdrill-Bone Access set HS Hospital Services, Aprilia, Latina, Italy) for histological examination (Figure 4), the trocar was removed, and a straight electrode that was connected to the radiofrequency generator (Covidien Cool-tip RF Ablation System; ValleyLab, Boulder, Colorado) was inserted (Figure 5). Tip temperature was set to 90°C. Percutaneous radiofrequency thermoablation was performed at 90°C for 6 minutes, and a final CT scan was obtained to reveal possible complications (Figure 6). The skin wound was sutured. Mean operative time was 70 minutes (range, 55-100 minutes).

Preoperative Assessment

Clinical evaluation was performed according to the questionnaire by Barei et al., which consists of 3 parts. The first part asks about the diagnostic workup, number and type of specialists involved, diagnostic hypotheses advanced (especially the wrong ones), treatments undertaken, and comorbid diseases. The second part asks about the preoperative period, time between symptom onset and treatment, use of NSAIDs, diurnal and nocturnal pain intensity, and need for one to modify their lifestyle. Diurnal and nocturnal pain was rated separately on a scale from 0 to 10, where 0 represents no pain and 10 represents the most severe pain imaginable. Most patients reported having greater pain during the night than during the day. Mean nocturnal and diurnal pain intensity were 8.25 and 5.95, respectively. The last part addressed the postoperative period and asked when the pain disappeared and about the pain intensity, diurnal and nocturnal pain, need for NSAIDs, and return to activities of daily living.

Patients were followed up 1 week and 1 and 6 months postoperatively. Follow-up data were available for a mean of 44 months (range, 3-106 months), which represented more than 2 years for 16 patients. Patients reporting pain more than 30 days postoperatively underwent a further radiological workup. Otherwise, follow-up was exclusively clinical.

Results were evaluated in terms of pain reduction or absence. The difference between pre- and postoperative pain was evaluated with Student’s t test. Significance was set at a P value less than or equal to .05.
RESULTS

No complications occurred intraoperatively or immediately postoperatively. Diurnal and nocturnal pain reduction was significant and generalized. Mean nocturnal pain intensity was 8.25 preoperatively and 0.5 postoperatively (P<.01), whereas mean diurnal pain was 5.95 preoperatively and 0.9 postoperatively (P<.01) (Figures 7-9). Most patients distinguished the pain related to the lesion from that induced by the procedure (mean value of the latter, 2.25 on a scale of 0 to 10).

Postoperative Evaluation

The pain disappeared within 24 hours after treatment in 14 patients, within 3 days in 4, and within 7 days in 1. The patient with symptom persistence for more than 30 days underwent another percutaneous radiofrequency thermoablation procedure after a radiological workup and achieved complete pain remission 24 hours postoperatively. Histopathological confirmation of the diagnosis was obtained in 1 patient due to insufficient biopsy tissue collection.

All patients returned to their jobs or school activities directly. Patients who engaged in sports who had reduced or given up exercise were allowed unrestricted activity after 2 months postoperatively. At 2-year follow-up, no lesion or pain had recurred.

DISCUSSION

Osteoid osteoma is a small, benign bone tumor that usually presents at an early age. It causes initially inconstant then continuous pain that often gets worse at night and is at least partially relieved by NSAIDs. Its diagnosis mainly relies on history and radiological findings.\(^\text{11}\) However, such data are not always conclusive and may delay diagnosis.\(^\text{10,12-16}\) Early diagnosis enables timely treatment, avoids unnecessary pain and treatments, and minimizes morbidity, including bone deformity.\(^\text{16}\)

Some bone lesions are reported to mimic osteoid osteoma.\(^\text{17}\) Various differential diagnoses should be considered for small radiolucent bone lesions surrounded by a sclerotic rim. The most frequent differential diagnoses are bone infarct, chronic osteomyelitis, and chondroblastoma. Additional imaging techniques, such as radionuclide bone images and magnetic resonance imaging, can help diagnose equivocal cases.\(^\text{17}\) The diagnosis of osteoid osteoma is based on a combination of history, clinical examination, and radiological data.\(^\text{18}\)

Characteristic radiograph findings include a nidus of vascular osteoid tissue in the bone cortex surrounded by reactive sclerotic bone. However, CT is the modality of choice for detecting this tumor and providing the best characterization of the nidus and the surrounding sclerotic bone.\(^\text{9}\) Magnetic resonance imaging is not as specific as CT.\(^\text{10,15,19-21}\) Radionuclide scintigraphy discloses intense activity at the nidus and decreased activity in the surrounding reactive zone.\(^\text{7}\) Although endowed with low specificity, it may be useful for lesion localization due to its high sensitivity, particularly when radiographs
are normal or nearly normal. In the current study, radionuclide scintigraphy was positive in all patients.

Complete surgical excision of the nidus is curative and provides symptom relief. Open surgery is the treatment of choice despite its drawbacks, such as difficulty locating the lesion intraoperatively, the need for prolonged length of hospital stay, and the possibility of postoperative complications that range from an unsatisfactory cosmetic result to bone fracture because lesion resection may leave a defect that is vulnerable to fracture. Some patients require internal fixation and bone grafts. Precise intraoperative localization of the lesion is difficult even with intraoperative scintigraphy or needle- or wire-based methods. Furthermore, a second procedure may be required when resection is incomplete. Lesions may be located at sites that prevent surgical excision due to the risk of damaging the adjacent structures. The excision of articular and epiphyseal lesions may involve arthroscopy and impair bone growth or joint mobility in these often young patients. Average postoperative length of hospital stay is 3 to 5 days, and activity is often restricted for 1 to 6 months.22,23

Computed tomography–guided percutaneous radiofrequency thermoablation, which induces lesion necrosis, is minimally invasive, safe, effective, and repeatable, with reported success rates ranging from 80% to 100%,5,10,24 Its cost is significantly lower than that of traditional open surgery due to reduced hospital costs.25 The potential complications of percutaneous radiofrequency thermoablation are cellulitis,13 bleeding and infection at the skin entry site, intraoperative vasomotor instability,20 and clubfoot due to temporary muscle contraction.11 Extreme caution must be exercised when operating on lesions less than 1 cm from structures such as nerves and vessels11,15 or on superficial lesions that are at risk for soft tissue damage and burns from thermal necrosis.7,13,21,22,26 The percutaneous radiofrequency thermoablation settings reported in previous reports are 4 minutes at 90°C10,13,20,24 or 6 minutes at 80°C.25 The current authors applied a prolonged ablation time of 6 minutes at 90°C.

The number of patients enrolled in the current study and the mean follow-up are similar to those of other studies.2,4,27 The current findings compare favorably with those of previous studies.2,21,22 Postoperatively, 19 of 20 patients reported pain relief within 1 week. The patient with symptom persistence underwent another procedure that was successful. No complications occurred intraoperatively or immediately postoperatively. No patient reported pain recurrence 2 years postoperatively.

In the literature, follow-up CT scans and magnetic resonance imaging showed decreased nidus size and periosteal edema with a periosteal reaction. However, no radiological changes were observed in some patients despite the clinical remission. Therefore, radiological healing does not coincide with a favorable clinical outcome. Imaging follow-ups do not determine the success or failure of radiofrequency treatment. The main disadvantage of percutaneous radiofrequency thermoablation is the frequent absence of histological confirmation of the diagnosis due to insufficient biopsy tissue; however, tissue obtained during open surgery does not always allow a definitive diagnosis to be made.

However, in a previous study, osteoid osteoma was confirmed in 36% to 100% of bone biopsies before percutaneous radiofrequency thermoablation was performed.28 Some authors reported that the diagnosis of osteoid osteoma is mainly clinical and radiological and do not regularly perform biopsies before percutaneous radiofrequency thermoablation.18 Others perform tissue sampling preoperatively.18 Histopathological confirmation of the diagnosis may help, especially when the treatment failed or the disease recurred.18 The current authors had inconclusive findings in 95% of the patients with clinically and morphologically unequivocal osteoma osteoid. However, the diagnosis of osteoid osteoma is considered to be based on clinical and radiological features and postoperative symptom regression.18

CONCLUSION

Despite its benign nature, osteoid osteoma can result in disability secondary to unrelenting pain. Percutaneous radiofrequency thermoablation is a viable therapeutic option with high technical and clinical success rates whose advantages include minimal invasiveness and cost-effectiveness. Various technical options are available for percutaneous treatment. This article focused on treatment standardization so this procedure may be spread.

REFERENCES


