Original article

Percutaneous CT-guided radiofrequency thermocoagulation in the treatment of osteoid osteoma: A 87 patient series

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Introduction: Osteoid osteoma is a painful, benign bone tumor that mainly affects young people. Thermocoagulation is one of the recommended percutaneous treatment methods. This study sought to assess its efficacy and identify risk factors for osteoma recurrence.

Methods: Results were analyzed retrospectively for a group of 87 patients treated by thermocoagulation between 2002 and 2011. The recurrence rate was calculated and analyzed relative to patient and tumor characteristics. The treatment efficacy was determined and methods to prevent complications were analyzed.

Results: The mean follow-up time was 34 months. The average patient age was 23 years. There were seven complications including three patients with delayed wound healing, mainly at tibial sites. The recurrence rate was 10.4%. The success rate for first-line treatment was 89.6% and it was 97.5% for second-line treatment. Analysis of patient characteristics and tumor locations revealed no risk factors for recurrence.

Conclusion: Percutaneous thermocoagulation is a reliable and effective technique that provides fast, long-lasting pain relief. However, recurrence can occur even after the nidus is completely resected. These recurrences can be effectively managed by repeat treatment. Recent technical improvements have reduced the risk of thermocoagulation-related complications.

Level of evidence: IV.

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1. Introduction

Osteoid osteoma (OO) is the most common bone-derived benign tumor. It makes up 10–12% of benign bone tumors, and 2–3% of primary bone tumors [1]. OO was first described in 1935 by Jaffe [2,3]. It has an unusual structure and is generally less than 1 cm in diameter. Histologically, 85% of osteoid osteoma cases have a nidus [4], which is described as a central hypervascular area surrounded by a hard shell of bone [5]. OO mostly occurs in young people. Patients typically present with disabling pain in the area of the tumor. Imaging is the key to diagnosis, especially computed tomography (CT) [6]. In most cases, CT can identify the nidus and peripheral sclerotic area. There is currently no evidence that magnetic resonance image (MRI) is better than CT in this application [7,8]. However, dynamic gadolinium-enhanced MRI slightly improves the precision of the diagnosis relative to CT scan, but not significantly [9]. At the time that Jaffe discovered OO, the gold standard treatment was one-piece resection of the nidus [1]. This treatment is now being performed percutaneously.

Percutaneous drill resection (PDR) is an effective technique with a reported 85–95% success rate. [10]. PDR was used as the first-line treatment for OO at our facility until 2002. At that point, we purchased a thermocoagulation device, which had become the gold standard for OO treatment [11]. Through a radiofrequency (RF) generator, an alternative current heats the tissue and destroys it. The target temperature is between 60 and 100 °C [12]. We chose to use radiofrequency to limit recurrences and complications that we had observed with PDR, such as skin necrosis. In particular, one patient experienced skin necrosis at the tibia and required a secondary sural flap. We also observed secondary cartilage damage in cases of OO near the joint.

This retrospective study was performed in the Radiology and Orthopedics Departments of the Lille University Hospital (CHRU) to evaluate the efficacy and failure rate of thermocoagulation treatment and explore its limitations and complications. We also evaluated risk factors for recurrence and the causes of failure in this cohort.
2. Patients and methods

This was a single-center, single-radiologist, retrospective study. Every patient \((n = 109)\) with osteoid osteoma who had been treated at the Lille CHRU between January 2002 and April 2011 was eligible for the study. The diagnosis was made by surgeons in the Orthopedics, Neurosurgery and Pediatric Orthopedics Surgery Departments after a full clinical examination and imaging assessment, which consisted at least of a CT scan, bone scan and MRI in some cases. Each patient’s record was reviewed in a multidisciplinary setting with at least one senior radiologist from the Musculoskeletal Imaging Department present.

Six patients who underwent first-line PDR treatment were excluded from the study. Sixteen patients could not be contacted despite multiple attempts. In all, 87 patients were included in the study.

Patients were admitted to the hospital on the day before the procedure. They were released either the day of the procedure or the day after, following a clinical examination by the surgeon and an assessment of pain levels. The treatment was performed by radiologist at the Lille CHRU Interventional Radiology Unit with an orthopedic surgeon and anesthetist present. The procedure was performed under strict aseptic conditions in a sterile manner by the referring surgeon. All procedures were performed under general anesthesia. Depending on the size of the nidus, one of two probes was used (5 or 10 mm activity radius). In 2009, we changed to a COSMANT generator (same manufacturer as the original generator, but newer model). The heating time was lengthened from 6 to 8 minutes based on the manufacturer’s recommendations and the radiologist’s experience.

After the lesion was located on CT scan (Fig. 1A), a skin marker was used to mark the entry point for the guide wire, then the skin incision (a few millimeters long) was performed with a no 11 scalpel. The ground plate was placed on the patient’s limb and connected to the RF generator. A sterile field was placed over the surgical area. Using the most appropriate approach, a threaded K-wire was inserted towards the nidus until it contacted bone. After a new CT scan, the K-wire was repositioned as needed (Fig. 2A), and imaged again to ensure that it was perfectly centered within the nidus (Fig. 1B). A cannulated drill bit was inserted over with K-wire to breach the bone cortex. This drilling step was essential in bone locations with thick cortex (femur, tibia, periosteal thickening) but it was not always performed if the tumor was located in cancellous bone or under a thin cortex. In the latter cases, the trocar was manually placed directly over the K-wire. Once the cortex had been breached, the drill bit and guide wire were removed and the trocar pushed into the nidus, with continued CT scan verification. A plug was removed with the biopsy needle in all patients. This sample was intended to histologically confirm the diagnosis.

![Fig. 1. A. Osteoid osteoma at the femoral head. B. Positioning of the guide wire. C. Introduction of the probe into the nidus.](image1.png)

![Fig. 2. Thermocoagulation instrumentation. A. Guide wire. B. Thermocoagulation probe.](image2.png)

The thermocoagulation probe (Fig. 2B) was inserted into the trocar until it came into contact with the nidus (Fig. 1C) and then connected to the console (Fig. 3). The device was programmed to heat the tissue to 85 °C for eight minutes. In cases where neighboring tissues could get burned, injections of cold, 5% glucose solution was used to protect the heated area by thermal isolation. At the end of the procedure, one final CT scan was performed to ensure the nidus has been removed.

The 87 patients included in our study were contacted by telephone or mail and asked to answer a questionnaire. This questionnaire took into account the duration of symptoms before the diagnosis, effectiveness of NSAIDs and aspirin, time before the pain disappeared after the treatment (in days), time before work-related and sport-related activities could be resumed (in weeks), recurrence rate (pain recurs after a pain-free period), treatment-related complications, and type of revision performed in cases of failure. The patient’s demographics, pathology data, duration of hospitalization and tumor location were taken from the patient’s electronic medical records.

The mean follow-up time was 34 months (range 6–96). The study cohort consisted of 24 women and 63 men. The average patient age was 23 years (range 5–59). Twenty-five percent of patients were under 15 years of age, and 75% were under 30 years of age. The most common tumor locations were the femur in 27 cases (31%), tibia in 18 (20.7%), femoral neck in 18 (20.7%) and talus in six cases (6.9%). Less common locations included the greater trochanter in 3 cases (2.5%), the elbow, knee, humerus and scapula in two patients each (2.3%) and then the spine, fibula, lateral cuneiform, metatarsal, cuboid, calcaneus and pelvis in one patient each.

The OO was located in the lower limb in 78 patients, the upper limb in seven patients, and in the pelvis or spine in one patient each. The tumor was located in the diaphysis in 41 cases (49%), the epiphysis in 11 cases (13%) and the metaphysis in 31 cases (38%). The tumor was located in long bones in 41 cases (82%), short bones in 15 cases (17%) and vertebrae in one case (1%). An average of 12.3 months (range 2–48) elapsed between the appearance of pain and the osteoid osteoma diagnosis. The NSAIDs and aspirin prescribed before the thermocoagulation procedure were effective in 52.7% of patients. The median duration of hospitalization was 48 hours (range 24–72).

Of the 53 reviewed pathology summaries, 40 confirmed the diagnosis of OO. The other 13 samples were described as containing normal bone. Pathology information was not available in every patient because not enough bone was collected in some cases to provide useful histology information, especially when the tumor was located in cancellous bone.

Descriptive statistics were calculated for the above-mentioned variables. A Kaplan-Meier survival analysis was performed to evaluate the main outcome, time to recurrence. Recurrence was defined as the recurrence of pain after a pain-free period. Risk factors for recurrence were evaluated through log-rank analysis. The following risk factors were evaluated: age, gender, type of bone, NSAIDs efficacy and pathology findings.

Some of the patients underwent additional CT scans during the study period. In all, 24 CT scans were performed at various time points between 6 and 48 months postoperative. These scans were used to assess the tumor site healing (Fig. 4) and to eliminate the possibility of recurrence in cases where the pain returned. No statistical analysis was performed on these data since CT scans were not performed systematically during the study and the time points were heterogeneous. The CT scan images revealed that the nidus had completely disappeared and the treated area had become sclerotic in 15 cases, while the nidus had reappeared in nine cases. These nine patients were all asymptomatic at the time the CT scan had been performed.

3. Results

There were nine recurrences in our 87 patients. This amounts to a 10.4% recurrence rate and a first-line treatment efficacy rate of 89.6%. All of the recurrences occurred within the first two years after the procedure (Fig. 5).

Of the nine patients with recurrence, four were treated by a second thermocoagulation session and five by PDR. The second-line treatment was selected based on the size and location of the tumor (Table 1). Only one patient still had pain after the secondary treatment; she was subsequently lost to follow-up. The second-line treatment efficacy rate was 97.5%.

There were seven complications: three cases of delayed wound healing treated with local wound care only; one case of injury to the lateral cutaneous femoral nerve, which regressed spontaneously; one case of secondary talonavicular osteoarthritis; one case of extension deficit in the fifth finger that required rehabilitation.
Table 1
Summary of the various recurrences and how they were treated.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Patient Location</th>
<th>TTR (months)</th>
<th>Treatment</th>
<th>Indication</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scapula</td>
<td>18</td>
<td>Thermocoagulation</td>
<td>Recurrence: nidus &lt;1 cm on CT scan</td>
<td>Successful</td>
</tr>
<tr>
<td>2</td>
<td>Femur</td>
<td>1</td>
<td>Thermocoagulation</td>
<td>Recurrence: nidus &lt;1 cm on CT scan</td>
<td>Successful</td>
</tr>
<tr>
<td>3</td>
<td>Distal humerus</td>
<td>2</td>
<td>PDR</td>
<td>Near joint</td>
<td>Failed, 2nd PDR effective</td>
</tr>
<tr>
<td>4</td>
<td>Femur</td>
<td>4</td>
<td>PDR</td>
<td>Nidus size &gt;1 cm</td>
<td>Successful</td>
</tr>
<tr>
<td>5</td>
<td>Femoral neck</td>
<td>24</td>
<td>PDR</td>
<td>Delayed recurrence</td>
<td>Failed, no other treatment, patient not seen again</td>
</tr>
<tr>
<td>6</td>
<td>Humerus</td>
<td>4</td>
<td>PDR</td>
<td>Physician’s decision</td>
<td>Successful</td>
</tr>
<tr>
<td>7</td>
<td>Femur</td>
<td>8</td>
<td>Thermocoagulation</td>
<td>Recurrence: Nidus &lt;1 cm on CT scan</td>
<td>Successful</td>
</tr>
<tr>
<td>8</td>
<td>Femoral neck</td>
<td>4</td>
<td>Thermocoagulation</td>
<td>Recurrence: Nidus &lt;1 cm on CT scan</td>
<td>Successful</td>
</tr>
<tr>
<td>9</td>
<td>Lesser trochanter</td>
<td>6</td>
<td>PDR</td>
<td>Size &gt;1 cm</td>
<td>Successful</td>
</tr>
</tbody>
</table>

TTR: time to recurrence.

4. Discussion

The current study is one of the largest published series of OO treatment by radiofrequency ablation. Only Rosenthal et al. [13] and Vanderschueren et al. [14] reported on a larger number of patients (126 and 97, respectively). Since the Lille CHRU is the only regional hospital where percutaneous thermocoagulation is performed, our sample was not selective.

CT-guided percutaneous radiofrequency or laser thermocoagulation is approved by the French Health Authority (HAS) as a treatment for osteoid osteoma. The treatment success rate ranges from 76–94% [15–21]. The relevance and efficacy of laser ablation for OO treatment has also been demonstrated [22,23]. Other studies have evaluated the relevance of percutaneous laser photocoagulation [24] and reported similar results to RF ablation in terms of pain relief and complication rate. We have not used this technique since the laser device is located at another facility and used to treat other types of diseases. Our success rate was comparable to published studies and the cohort in the current study was one of the largest. We decided to look at a sub-group of patients treated after 2009, when a new thermocoagulation console was used. At that time, the practitioner was having technical problems with the first console, which forced him to stop the procedure and use another technique, namely PDR. The recurrence rate in this sub-group dropped from 12% to 7% once the new console was used and the heating parameters were adjusted. Based on manufacturer recommendations and the radiologist’s experience, the heating time was also increased from six to eight minutes.

Recurrence continues to be a problem and various studies have tried to identify risk factors. Vanderschueren et al. [25] explored the efficacy criteria for thermocoagulation in a retrospective series of 110 patients. The treatment was deemed effective if pain had completely disappeared within 15 days of the session. Success was more likely in older patients and when the probe was placed in multiple positions. Cribb et al. [26] found a significantly higher recurrence rate in non-diaphysis locations in their 45 patient series. This finding was not confirmed in the current study, as there were no specific factors that increased the risk of recurrence (Table 1). However, it was difficult for us to statistically identify risk factors because fewer than 10 cases of recurrence were available for analysis. Vanderschueren et al. [25] showed that if the tumor was in a hard to access position (intra-articular or deep), it is better to place multiple guide wires in different directions to effectively treat the nidus. This technique is not used by the referring physician at our facility. The activity area of the probe used in our study was 5 or 10 mm in diameter, depending on the volume being treated and tumor location. Cool-tip probes have been developed that have an 18 mm activity area. Martel et al. [27] used these probes and reported a primary success rate of 97% and secondary success rate of 100%. However, patients were only followed for 3–24 months.
Vanderschueren et al. [25] found that treatment duration affected the recurrence rate. The treatment time used in our study (8 minutes at 85 °C) is twice as long as in most other studies. This treatment time was chosen by the radiologist based on published data, the manufacturer's advice, the console's features and personal experience. The complication rate reported here was not any higher than in other published studies and our success rate was about the same.

In the current study, eight of the nine patients who had a recurrence had an average pain-free period after the first procedure of 8 days (range 1–30). Every case of recurrence was reassessed using CT and bone scans to confirm the nidus had reappeared. The ninth patient did not experience any pain-free period and never experienced any pain relief, despite the second treatment. One of the limitations of the current study is that different techniques were used to treat the recurrences. Of our nine patients with recurrences, four were treated with a second thermocoagulation session and five were treated by PDR (Table 1). The pain completely disappeared in eight of the nine patients within one day to six months. There were no complications with either technique. Our team prefers using PDR for cases of long-term recurrence and large OO lesions because it is reliable and effective, but it is never used as the first-line treatment.

Based on our experience, tissue burns near the tumor are the main complication of thermocoagulation. Preoperative imaging assessment is crucial for analyzing the exact position of the tumor and selecting a surgical approach that will minimize the risk of injuring adjacent tissues. Finstein et al. [28] reported a case of skin burn with 1 cm diameter necrosis after thermocoagulation of a tibial OO. This is the most common complication reported. Several studies have demonstrated that thermocoagulation has a lower risk of complications and a lower morbidity rate than PDR or surgical removal, along with requiring shorter hospital stays [29,30].

In our practice, pouring cold saline over the skin during the heating period helps to limit the risk of skin burns for superficial OO locations. Despite taking these precautions, there were still three cases of skin burns in the current study, which did not require surgical revision, only local wound care. Martel et al. [27] used a cool-tip probe to reduce the risk of burns in adjacent tissues. Because of the risk of osteoarthritis when the OO is near the joint, we use a smaller diameter probe with a smaller activity radius. Another alternative is to protect the tissues with carbon dioxide. This is currently being done with liver or kidney tumors treated by RF ablation [31]. This method creates a protected area around the nidus and limits damage to adjacent tissues (cartilage, nerves or blood vessels).

5. Conclusion

Thermocoagulation is now our gold standard treatment for osteoid osteoma treatment. The indications are well-defined. The survival rate without recurrence in the current study was 89.6% after the first thermocoagulation session. Thermocoagulation can be used as a second-line treatment in cases of radiologically-confirmed recurrence. One of the goals of this study was to explore which factors contribute to recurrence. But none of the variables evaluated were significantly related to recurrence. Skin burns are still the main complication, especially for tibial OO cases. However, newer preventative techniques should considerably reduce the occurrence of this type of complication.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References
