Percutaneous radiofrequency ablation in osteoid osteoma

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We treated 58 patients with osteoid osteoma by CT-guided radiofrequency ablation (RF). In 16 it followed one or two unsuccessful open procedures. It was performed under general anaesthesia in 48, and spinal anaesthesia in ten. The nidus was first located by thin-cut CT (2 to 3 mm) sections. In hard bony areas a 2 mm coaxial drill system was applied. In softer areas an 11-gauge Jamshidi needle was inserted to allow the passage of a 1 mm RF probe into the centre of the nidus. RF ablation was administered at 90°C for a period of four to five minutes.

Three patients had recurrence of pain three, five and seven months after treatment, respectively, and a second percutaneous procedure was successful. Thus, the primary rate of success for all patients was 95% and the secondary rate was 100%. One minor complication was encountered.

CT-guided RF ablation is a safe, simple and effective method of treatment for osteoid osteoma.

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Osteoid osteoma is a relatively common benign bone tumour, always small in size (less than 2 cm) and painful. It occurs mainly in children and young adults. It was first described by Bergstrand in 1930, but Jaffe was the first to recognise it as a separate entity in 1935. The basic radiological element is a distinctive small rounded area of osteolysis, the ‘nidus’, which consists of osteoid tissue surrounded by a halo of hyperostosis on radiographs or signal intensity on MRI. Radio-isotope bone scanning always reveals a rounded area of intense increased uptake and dynamic-contrast CT can distinguish it from osteomyelitis. The clinical feature of the lesion is local pain, typically more severe at night and often promptly responding to aspirin and other non-steroidal anti-inflammatory drugs. Other possible symptoms include growth disturbances, bony deformity, painful scoliosis, and if located within the capsule of a joint, swelling, synovitis, restricted movement, and contracture.

In the past several methods have been recommended as the ‘treatment of choice’. These have included medical management with non-steroidal anti-inflammatory drugs, open surgical resection with intralesional, marginal, or wide surgical margins, CT-guided burr ablation and, most recently, CT-guided radiofrequency (RF) needle ablation. There is general agreement that in open procedures complete removal of the nidus is needed for cure and resolution of symptoms. Failure to do so is usually associated with incomplete relief of symptoms, and an increased risk of local recurrence. Since intraoperative localisation of these small lesions can be very difficult, open surgical removal often necessitates considerable resection of bone, and consequently internal fixation and/or bone grafting may be required. Although various localisation techniques have been developed to ensure complete removal, the nidus may even be missed at surgery.

Regardless of the method of treatment chosen, success is highly dependent on preprocedural localisation of the nidus. CT-guided procedures may reduce morbidity and complications when compared with traditional open surgical resection.

In recent years, several CT-guided percutaneous techniques have been used in order to achieve removal or destruction of the nidus with minimal tissue invasion, including percutaneous trephine resection, drill resection with or without the subsequent injection of ethanol, thermal destruction by means of laser photocoagulation or RF ablation. The last is a new technique using CT-guidance and was first described in 1995. We have used it since 1997 and in this prospective study we evaluate CT-guided percutaneous RF ablation as minimally invasive treatment for osteoid osteoma.
Patients and Methods

Between March 1997 and July 2000, 58 patients (16 women and 42 men) with osteoid osteoma were treated by percutaneous RF ablation. Their mean age was 20.1 years (3 to 41). All were symptomatic. The duration of pain before RF ablation varied from several months to four years. The decision concerning appropriate treatment was made at a referral centre for bone tumours by orthopaedic surgeons and radiologists on the basis of clinical and radiological criteria. Clinical criteria included pain, worse at night and rest, and relief after administration of non-steroidal anti-inflammatory drugs. Radiological criteria included typical findings on radiographs and CT and/or MRI with a clear depiction of a nidus of less than 1.5 cm in maximum diameter. In those with epiphyseal and/or medullary localisation of the nidus, dynamic contrast-enhanced CT was additionally carried out to differentiate osteoid osteoma from chronic osteomyelitis (Fig. 1). If doubts persisted about the diagnosis, RF ablation was rejected and patients underwent open resection. In 16 patients previous unsuccessful open resection had been undertaken, once in 11 and twice in five. In all these cases, CT also showed a typical nidus. There were 33 lesions in the femur (femoral shaft 14, femoral neck 10, lesser trochanter 4, distal femur 5), 16 in the tibia (tibial shaft 13, distal metaphysis 2, tibial tuberosity 1), two in the pelvis (acetabulum 1, posterior iliac spine 1), two in the calcaneus, one in the humerus, two in the ulna, one in the talus and one in the body of the twelfth thoracic vertebra. The lesions were intra-articular in 12 patients.

All the procedures were carried out in the CT radiology room after the administration of general (n = 48) or spinal anaesthesia (n = 10) by a team consisting of an orthopaedic surgeon, radiologists, and anaesthetists. After the patient had been positioned securely on the moving table contiguous CT scans with a section thickness of 1 to 3 mm (Tosmoscan LX; Philips, Eindhoven, The Netherlands) were obtained for the precise localisation of the nidus. Under CT-guidance a crossed laser beam was adjusted according to the desired angle and location. A 20-gauge needle was then inserted for periosteal anaesthesia with 2 to 5 ml of 0.5% bupivacaine hydrochloride. With the needle in place a single CT cut confirmed the correct approach.

A skin incision was made at the puncture site and access to the nidus was established either using a 11-gauge Jamshidi hollow biopsy needle or a 2 mm coaxial drill system (Richards Surgical Products, Kalamazoo, Michigan), depending on the hardness of the adjacent bone (Figs 2 to 4). The position of the inserted instrument was imaged by additional CT.

A straight rigid electrode with an outer diameter of 1 mm, having an effective length of 5 mm and an internal flexible temperature probe for simultaneous temperature measurement, was introduced through the Jamshidi needle, or through a hollow needle, which was exchanged for the drill over a Kirschner wire in a coaxial fashion. The non-insulated portion of the electrode was then exposed and positioned within the centre of the nidus (Figs 2 to 4). After connection of the electrode to an RF generator (Radionics RFG-3B, Burlington, Vermont) and grounding with an intramuscular or subcutaneous needle, RF ablation was undertaken by heating the tip of the electrode to 90° for a period of 4 to 5 minutes. After thermocoagulation and removal of the electrode approximately 2 to 5 ml of 0.5% bupivacaine hydrochloride was injected directly into the nidus to reduce postoperative pain. Postprocedural CT scans were obtained to confirm the lack of soft-tissue damage.
Fig. 2
CT scans of an 18-year-old man with an osteoid osteoma of the distal femur showing reactive bone formation. 1. A subcortical nidus below the suprapatellar pouch. 2. Planning an anterior approach on CT. 3. A transarticular approach with a 20-gauge needle. 4. After drilling through the reactive bone the RF electrode is in place.

Fig. 3
CT scans of a 14-year-old girl with an osteoid osteoma in the lesser trochanter. 1. Marked reactive bone formation around the nidus, and a needle for local anaesthesia in place. 2. A Kirschner wire has been exchanged for the needle. 3. Drilling into the nidus in a coaxial fashion. 4. The RF electrode in the centre of the nidus.
swelling or haematoma. In lesions larger than 1 cm in diameter a second approach completely cauterised the tissue within the nidus. In 11 patients, a core biopsy was taken before RF ablation; four were positive for osteoid osteoma.

All patients were discharged 24 hours after the procedure and immediately resumed full weight-bearing and normal activities. Follow-up was undertaken six months later by CT in the first 15 patients to monitor changes within the nidus. All later patients were followed by standard radiological and clinical examination.

**Results**

Percutaneous treatment was technically successful in all patients and only one complication was encountered during or following the procedures. This was a mild skin burn induced by heat caused by drilling in the anterior tibia. It responded to conservative treatment. Mild to moderate postoperative pain, within the first 48 hours, was controlled by oral analgesics. All patients were free from pain within one week. They were followed up for a mean of 23 months (6 to 41). In 44 patients, the follow-up period was longer than 12 months. A total of 55 patients (95%) remained free from symptoms; three had recurrence of local pain three, five and seven months after treatment. Two of these had a relatively large nidus with a maximum diameter of 1.0 and 1.5 cm, respectively, to which only one approach had been used. All recurrences were treated successfully with a second ablation and the patients were relieved of pain for the remainder of the follow-up (4 to 41 months). There were no late complications.

Follow-up CT in 15 patients at six months showed complete ossification of the nidus in eight, partial ossification in three and no changes in four. Lesions of the cortical bone with intense reactive bone surrounding the nidus showed a greater tendency to ossify than those in subperiosteal or intramedullary locations. No biomechanical weakening caused by resorption of heated bone was seen.

**Discussion**

To our knowledge this study represents the largest series of percutaneously-treated osteoid osteomas. Treatment was primarily successful in 95% of patients, and in all after a second ablation. These results are comparable to those...
described by other authors, who reported RF ablation of osteoid osteoma in a limited number of cases (3 to 18 patients), and who achieved rates of 83% to 94% for primary and of 89% to 100% for secondary success.7,25-27 Laser photocoagulation was reported to have a primary rate of success of 93% and a secondary rate of success of 96% in a series of 28 patients.28 Curative treatment by means of percutaneous resection in 96% and 88%, respectively, has been reported in series of 2429 and 32 patients.25 Percutaneous resection with a trephine or drill requires relatively large-calibre instruments to ensure complete removal.16,25-27,29 Subsequent structural weakness of the affected bone can lead to fracture with limitation of activity and impaired weight-bearing for up to three months after the procedure.25 In a series of 38 patients treated by percutaneous resection25 two fractures occurred, one in the femoral neck and one in the shaft of the femur. Further complications of this technique include skin burns and necrosis due to the high rotation speed of the instrument, which may also cause muscle haematoma, irritation of adjacent nerves with transient paresis, and osteomyelitis.26 In the study of Sans et al25 the overall rate of complications was 24%. The advantages of percutaneous resection are immediate verification of complete removal of the nidus with histological confirmation of the diagnosis.25,26 Thermocoagulation of osteoid osteoma using RF ablation requires only small osseous access to allow insertion of the electrode. Loss of bone substance therefore is minimal and does not cause significant structural weakening. Experimental RF treatment causes necrosis of bone in a spherical area approximately 1 cm in diameter.24 Bone resorption during the repair process may lead to some mechanical weakness requiring restriction of sports activities for a period of three months, if the lesion is located at a vulnerable site such as the proximal femur.3 None of our 15 patients showed evidence of this weakness in follow-up CT. No previous studies of RF ablation of osteoid osteoma have reported early or late complications.21,24,30 In 28 patients treated by laser photocoagulation, the one post-interventional complication was mild reflex sympathetic dystrophy of the wrist in a patient with an osteoid osteoma of the lunate.28 In our series of 58 patients only one minor complication was encountered and all patients returned to normal activity immediately, with no restriction of sports. Based on our experience RF ablation therefore can be regarded as minimally invasive and safe.

The main disadvantage in patients with suspected osteoid osteoma is the lack of histological verification. Although biopsy can easily be accomplished during the initial puncture process we did not routinely remove a biopsy specimen before ablation for various reasons; histological diagnosis is therefore delayed and a frozen section of hard osteoid tissue is virtually impossible to obtain. Percutaneous biopsy of osteoid osteoma has been reported as yielding reliable results in only 50% of cases,16,29,31 which corresponds to our experience of four positive results in 11 biopsies. We believe that the main challenge in CT-guided RF ablation, as in other percutaneous techniques with a lack of histological verification, is not the procedure itself, but the correct selection of patients on the basis of imaging findings and symptoms. Although the morphology of the lesion can vary according to its location, most osteoid osteomas can be reliably diagnosed by means of radiographs and standard CT and MRI.31 Dynamic CT can aid in the differential diagnosis between osteoid osteoma and chronic osteomyelitis.3 If there is uncertainty about the diagnosis open surgical or percutaneous resection should be considered.

Our cases included only one spinal lesion which could be treated safely, since the nidus was located in the vertebral body. Most spinal osteoid osteomas are located within the posterior elements5,3 and have a close anatomical relationship to dural and/or neural structures.8,28 We agree that spinal osteoid osteomas should only be treated by RF ablation if the nidus is located at least 1 cm away from vital structures, in order to prevent neurological complications.

In our view CT-guided percutaneous RF ablation is a simple minimally invasive, safe and effective technique for the treatment of osteoid osteomas and can be regarded as the treatment of choice for most cases. Our results also suggest that RF ablation represents a promising method for treating patients with persistent or recurrent pain after unsuccessful surgical treatment. Open surgery should be reserved for cases of diagnostic uncertainty, as well as for spinal lesions into which heat cannot be introduced without the risk of neurological damage.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


