What makes CT guided radiofrequency ablation for osteoid osteoma superior to open surgery in terms of pain control and patient’s quality of life?

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Abstract Purpose: To demonstrate our experience in percutaneous radiofrequency ablation (RFA) as a minimally invasive therapy for patients with osteoid osteoma. Patients and methods: We will highlight cases of osteoid osteoma treated by minimally invasive therapy (RFA) and the role of image guidance in making the procedure rapid outpatient service instead of hospitalization and morbidity of open surgery. This will include 15 patients (10 males & 5-females) aged 12–35 years, (mean 20), their clinical and radiological diagnosis was osteoid osteoma. All patients were treated by CT guided percutaneous RFA under spinal and epidural anesthesia. Results: 14 (93.3%) of the 15-patients had prompt improvement of clinical symptoms and pain relief, one patient underwent second session of re-ablation. The mean follow-up period was 12 months and no patient had pain recurrence. Conclusion: Percutaneous RFA is a safe and effective minimally invasive outpatient treatment for osteoid osteoma with low cost, low morbidity, better quality of life when compared with open surgery.

1. Introduction

Osteoid osteoma is a small, benign painful bone forming lesion with specific clinical and imaging characteristics. Ninety percent of cases arise before the age of 30 years, with male predominance. The proximal femur and tibia are the most common sites to be affected (1).

In Mayo Clinic a review of 11087 primary bone tumors that were subjected to either biopsy or complete surgical resection, osteoid osteoma accounted for 13.5% of all benign tumors (2).
The most common symptom is bone pain, which often worsens at night and is usually dramatically relieved by aspirin or other non-steroidal anti-inflammatory drugs. Pain initially may be described as a dull aching pain which may progress to severe localized pain over the site of the tumor. It may cause arousal from sleep, with resultant sleep deprivation. Less common manifestations of osteoid osteoma include growth disturbance, bone deformity, and painful scoliosis in spinal lesions. If the lesion is located within a joint capsule, it may cause joint swelling, synovitis, effusion and restricted mobility. Despite medical therapy, many patients have residual discomfort related to their osteoid osteoma (3).

Radiologically, the lesion is consisted of a small rounded radiolucency called nidus, which is surrounded by dense, reactive new bone. The nidus is often obscured on radiographs by reactive bone. Computed tomography (CT) is the best modality to delineate the bony architecture of osteoid osteoma. The nidus is characteristically less than 10 mm in diameter. Technetium-99M HDP bone scintigraphy typically reveals intense focal radiotracer uptake in the lesion. MDCT and magnetic resonance imaging help differentiate between osteoid osteoma and infection (4).

In the past several methods have been used to treat osteoid osteoma, these included medical management with non-steroidal anti-inflammatory drugs (5) and open surgical resection with wide surgical margins. Precise intraoperative localization of the nidus is the most crucial point and is considered the surgical difficulty, which often requires wide bone resection to ensure adequate treatment. This has resulted in significant surgical morbidity, intraoperative and early post-operative pathological fracture in many cases. Percutaneous radiofrequency ablation (RFA) for osteoid osteoma was first reported by Rosenthal et al. in 1992 (6), and has been practiced in many centers around the world (7). RF generator supplies RF power to the tissue through the electrode and producing RF voltage that producing electrical field within the patient’s body, this electric field oscillates with alternating RF current which cause oscillatory movements of ions in the tissue in proportion to the field intensity. The mechanism of tissue heating for RF ablation is frictional, or resistive energy loss caused by the motion from the ionic current (8).

Regardless of the method of treatment chosen, success is highly dependent on pre-procedural localization of the nidus. CT-guided RF procedure dramatically reduced morbidity and complications compared with traditional open surgical resection. Moreover it is usually carried out as an outpatient procedure with less cost, medications and hospital stay (9).

In this study, we will highlight our work on 15 patients referred to our institute, to treat them in a minimally invasive outpatient fashion using CT guided RFA with much less morbidity and no mortality compared to open surgical resection. We will also describe in details our technique of performing this procedure and the 12 months follow up post procedure.

### Table 1
Shows clinical manifestations in patients with osteoid osteoma.

<table>
<thead>
<tr>
<th>Pain and medications</th>
<th>Responding</th>
<th>Not responding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement limitation</td>
<td>Limited in</td>
<td>Not limited in</td>
</tr>
<tr>
<td>Muscle wasting</td>
<td>Present in</td>
<td>Not evident in</td>
</tr>
</tbody>
</table>

### Table 2
Shows location and architecture of the nidus (size, sclerosis, and cortical reaction).

<table>
<thead>
<tr>
<th>Lesion location</th>
<th>Proximal femur</th>
<th>Proximal tibia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nidus</td>
<td>Visible in radiograph</td>
<td>Size</td>
</tr>
<tr>
<td>Sclerosis</td>
<td>Dense sclerosis in</td>
<td>Scanty sclerosis in</td>
</tr>
<tr>
<td>Cortical reaction</td>
<td>Marked in</td>
<td>Mild in</td>
</tr>
</tbody>
</table>

### Table 3
Shows clinical and radiological improvement in patient post RF ablation of osteoid osteoma.

<table>
<thead>
<tr>
<th>One month</th>
<th>6 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>14 improve</td>
<td>15 improve</td>
</tr>
<tr>
<td>Cavity</td>
<td>Persist</td>
<td>Partial filling</td>
</tr>
<tr>
<td>Sclerosis</td>
<td>Persist</td>
<td>Reduced</td>
</tr>
<tr>
<td>Fractures</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
consisted of an orthopedic surgeon, interventional Radiologist and anesthesiologist. All patients rated their satisfaction with the procedure after signing a written consent. All patients were discharged within hours after the procedure and resumed full weight-bearing. Follow-up was done every six months both clinically for pain and by CT to monitor changes within the ablated nidus. The next 6 months for architectural changes of the lesion.

2.2. RF ablation procedure

Localization of the lesion was performed by immediate preprocedure multiple thin-section CT images at the level of the osteoid osteoma. Reformatted images were helpful for preprocedural planning. A single skin entry point was planned for the lesion by putting Radiopaque marker on the skin overlying the lesion. Most of the lesions were approached from anterior and lateral aspect to avoid medial vascular structures. Spinal or epidural anesthesia was administered to all patients during the procedure.

The patient lie supine on the CT couch (Bright speed 16 slice; GE medical system), ground bards are usually put at the posterior aspect of the thigh. The skin then prepared and draped with sterile technique. One gram of 3rd generation cephalosporin was administered intravenously immediately before the procedure.

A thin long Sheba needle was used to locate the lesion passing from the site of radiopaque skin marker reaching the outer cortex of the osteoid osteoma guided by CT fluoroscopy. Small skin snip using scalpel was done then the Co-axial Bone biopsy set was used to do percutaneous access to the lesion and guide the RF electrode for ablation. Manual bone Drilling of the cortex overlying the nidus was done, then CT images were obtained many times during drilling to verify the depth and direction of the bone drilling sheath in the nidus, when the drill tip traversing the nidus reaching the contra lateral sclerosed edge of the nidus, it was considered a satisfactory position for placement of RF electrode.

The RF electrode was then inserted through the sheath of the co axial system, with its tip directed toward the center of the nidus reaching its contra lateral edge. CT images were obtained again to confirm appropriate position of the electrode. Prior to ablation, the electrode hosting sheath was partially withdrawn over the electrode out to the level of the insulated shaft to prevent electrical conduction and heating of adjacent tissues. The generator (RF 3000 Generator and

Fig. 1  (A and B) coronal CT images showing the nidus and the overlying bone sclerosis at the upper shaft of the femur. (C and D) Axial CT images showing the nidus and the overlying bone sclerosis at the upper shaft of the femur.
Leven electrodes from Boston scientific, MA, USA) is activated with an electrical impedance value of 200–600 Ω (10). Thermal heating is applied with the RF electrode at a targeted temperature of 90–105 °C, with manual adjustment of output controls during the procedure as needed to maintain a stable lesion temperature and accepted tissue impedance. Ablation is typically performed for a total of 5–7 min which may be repeated in cycles as long as impedance was low, repositioning of RF electrode tip in different directions was also performed to insure more heat trapping, more ablation and much less recurrence rate.

2.3. Post-procedural care

After ablation, the electrode is removed and a sterile dressing is applied, no need for skin wound stitches. Discharge usually within 4 h after the procedure. Weight bearing and prolonged activity should be avoided for 1–3 months following the procedure if ablation is performed in a weight-bearing bone (8,11). A follow-up visit is scheduled 1 month after the procedure. RF procedural success is defined as the absence of pain after the procedure during the follow up period. Follow-up CT is only indicated 6 months post procedure.

3. Results

The study was carried out at Radiology Department, El Minia University Hospital, from November 2009 to June 2012. Proximal femur and tibia were the commonest sites involved. The selected group of patients included in the study were symptomatic, presented by distressing pain not responding to medications and seeking for definitive satisfactory treatment option, all patients were diagnosed clinically and radiologically as osteoid osteoma. 4 patients were satisfied by analgesics but seeking for ablation to stop medications and avoiding side effects of analgesics on GIT, 11 patients were not completely responders to medication and developed tolerance to analgesic doses they receive, 8 patients were suffering from limitation of movement and reduced activity, 5 patients develop wasting and reduction of muscle bulk in the affected limb and that what force them for treatment (Table 1).

Treatment strategy was to perform the procedure in an outpatient, complication free fashion with less cost, less hospital stay and less morbidity. We achieved the goal in all patients by following fixed steps in assessment of all patients and their lesions precisely as follow, first step; patient suspected clinically and referred from orthopedic department, then we
performed high quality digital radiographs for all patients, which then confirmed by MDCT (Bright speed 16 slice; GE medical system), reformatted images were obtained for better localization of the nidus and its overlying dense sclerosis and cortical thickness. Location of the nidus was the most crucial point for preoperative planning to perform the procedure safely with less possible complication, MRI was done for patients with suspicious lesions to assess related bone marrow edema and soft tissue involvement in lesions of diagnostic uncertainty (Table 2). Second step; good pre-operative planning by studying each lesion separately, the technique was customized for each lesion based on its location and its relation to the nearby vasculatures, moreover we followed fixed steps of CT guidance to reach the lesion and to achieve good ablation by placing the RF electrode in a proper position within the nidus to get the full benefits of scientific fact “Oven effect” bone act as heat insulator, trapping of heat resulting in more augmentation of heat effect and more tissue destruction beyond what is expected (12). Technical success without intraoperative complications was achieved in 14 patients, in one patient ground bad burn was surprisingly seen by the end of the procedure, it was of first degree burn and treated completely within 10 days after the procedure, no hematoma or fractures seen during the procedures in all patients. Third step; postoperative care and follow up of patients for pain relief, 14 had prompt pain relief within 10 days and were able to return to normal activities within 30-45 days after the procedure. One patient had residual unrelieved pain and underwent radiofrequency ablation within 3 months. By 6 months follow up all patients had complete pain relief with no more medications used. Radiological healing in terms of refilling (partial ossification) of the ablated cavity as well as reduction of bone sclerosis and cortical thickness start to be apparent by the end of first 6 months (Table 3). There was no correlation between pain relief and absence of the signs of radiological healing (ossification).

After a mean follow-up period of 6, 12 months no patient had pain recurrence, more ever by being minimally invasive,
outpatient procedure with less cost, less hospital stay and less morbidity, dramatic pain relief with no recurrence, RF ablation for osteoid osteoma will be superior to open surgery in terms of pain control and better quality of life in a relatively short time when compared to open surgical management (see Figs. 1–3).

4. Discussion

Osteoid osteoma is a benign skeletal tumor, usually less than 1.5 cm in diameter, it is composed of woven bone, osteoid and is more commonly located in the appendicular skeleton, there is a male preponderance, with a male: female ratio of 3:1. It is commonly seen in children and young adults. The disease commonly presents with focal bone pain at the tumor site in a child or a young adult. The pain has a characteristic pattern; it worsens at night, increases with activity, and is relieved by small doses of anti-inflammatory medications (13–15).

The ordinary open surgical treatment of osteoid osteoma consists of en-bloc excision or curettage of the lesion. Several alternative methods have been used recently, among which CT-guided-percutaneous radiofrequency ablation. In the view of our results, CT-guided percutaneous RF ablation is a simple minimally invasive, safe and effective technique for treatment of osteoid osteoma 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 the persistent pain of osteoid osteoma shortly after the procedure apart from pain of incision and the procedure itself which subsides shortly. Open surgery should be reserved for cases of diagnostic uncertainty, as well as for spinal lesions in a critical locations, in which introduction of heat carry high risk of neurological damage. In our series of 15 patients only one minor complication was encountered and all patients returned to normal activity shortly post-operative.

We believe that the main challenge in CT-guided RF ablation, as in other percutaneous techniques with a lack of histological evidence, is not the procedure itself, but the correct selection of patients on the basis of imaging findings and symptoms, and that was avoided by joint consultation and evaluation of all cases by both radiologists and the orthopedic surgeons. Although the morphology of the lesion can vary according to its location, most osteoid osteomas can be reliably diagnosed by means of conventional radiographs, MDCT and MRI (11).

Of the 15 patients, we did RFA twice for only one patient that had recurrence and required a 2nd session of ablation. The rest of patients were treated by single session of RF ablation, we noticed the patient with recurrence had a lesion of 13 mm diameter. In a study done by Tilliston et al., they used RFA in 8 patients with a lesion of 10 mm and more, they noted a high recurrence rate in that group because these lesions were ablated in multiple locations, using overlapping pattern of ablation; it is likely that, in some areas of tumor outside the sphere, ablation was not adequate and a residual viable tumor tissue was the reason of tumor recurrence. Our electrode tip was placed distally within the nidus, at different directions, in different plans; multiple cycles of RF ablation were done to get benefits from ‘oven effect’. Lower thermal conductivity of surrounding background bone (heat insulator) significantly increases temperatures within the nidus by accumulation and entrapment of heat to increase RF ablation efficacy (12,16).

RFA for bony tumors offers several advantages over other treatment modalities, previously, surgical excision has been the treatment of choice (17). Precise intraoperative localization of the nidus is often difficult and en-bloc excision often requires a long incision, extensive dissection and frequently internal fixation as a prophylaxis against fracture through the operative site. Failure to locate the lesion at open excision is a well-recognized complication (17), however with the advances in CT technology precise CT fluoroscopy guided localization of the nidus during RFA reach 100% accuracy and incorrect targeting is much less likely to occur in skilled hands. Another treatment is CT-controlled laser photocoagulation, which has been reported to give good results, but it requires expensive equipment and complicated logistics (10). In our patients we used manual drill by bone biopsy kit. CT-guided percutaneous automatic drilling using a large-bore drill has also been described (18).

Weight-bearing and return to ordinary life activity after operation depend on the location of the lesion. One series reported a complication rate of 24%, including two patients with femoral neck fractures and one with osteomyelitis (18). We have not encountered any major postoperative complications to date, and this result concurs with those of other studies (19).

The interval to being symptom-free after therapy was variable in our group. No patient was symptom-free at 24 h, it took 3 days for our first four patients to be symptom-free. The remainders had complaint up to one 1 week post procedure. This result can be compared with the results of two published series of patients treated with RFA over a 4-min delivery of energy at 90 °C. The first series included-18 patients, 10 of them were symptom-free by 24 h; 14 were symptom-free by 3 days; and, finally, 16 patients were symptom-free by 1 week (20). In the second series (13 patients), the number of symptom-free patients at 24 h was not mentioned. By 3 days, 10 were symptom-free and one further patient was symptom-free at 1 week (21).

5. Conclusion

Based on our experience RF ablation can be regarded as minimally invasive, safe alternative and superior to open surgery in treatment of patients with osteoid osteoma with less morbidity, mortality, cost and hospital stay.

Conflict of interest

No conflict of interest.

References


