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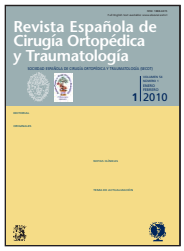

ORIGINAL PAPERS

Treatment of osteoid osteoma by means of CT-guided radiofrequency

J.M. Sarabia Condes[a,*], J. Martínez Martínez[a], P. Villamor Redondo[a], M. Martínez Fernández[b] and A. Blanco Barrio[b]

[a] *Department of Traumatology and Orthopaedic surgery, Morales Meseguer Hospital, Murcia, Spain*
[b] *Radiodiagnosis Department, Morales Meseguer Hospital, Murcia, Spain*

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KEYWORDS
Osteoid osteoma;
Radiofrequency;
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Abstract
Purpose: To present the results obtained in the treatment of osteoid osteoma by percutaneous resection using computerized tomography-guided radiofrequency. We discuss the technique used and report on the economic advantages of the procedure, as compared with the traditional surgical technique.
Patients and methodology: Between October 2001 and July 2007, twenty-one patients were analyzed who presented with an osteoid osteoma located in the femur (11 cases), tibia (7 cases), pelvis (1 case), talus (1 case) and hand (1 case). A CT-guided cool-tip electrode was introduced into the center of the nidus, connecting it to a radiofrequency generator. Patients stayed in hospital for 10 h and immediately afterwards returned to their usual activities. A study was carried out to compare the cost/effectiveness of the CT-guided RF technique as compared with the conventional technique, whereby open surgery is performed to remove the bone fragment contained by the tumor.
Results: The results obtained show complete remission of symptoms in 20 cases; the remaining case improved when the procedure was repeated. The cost/effectiveness study revealed hospital cost savings for the RF procedure.
Conclusions: This is a simple percutaneous technique that can be carried out on an outpatient basis. It is indicated in nearly all locations. No significant complications have been reported and the results obtained have been satisfactory.

*Corresponding author.
E-mail: j_sarabia_condes@hotmail.com (J.M. Sarabia Condes).

PALABRAS CLAVE
Osteoma osteoide;
Radiofrecuencia;
Termocoagulación percutánea guiada por tomografía computarizada

Tratamiento del osteoma osteoide mediante radiofrecuencia guiada por tomografía computarizada

Resumen
Objetivos: Presentar los resultados obtenidos en el tratamiento del osteoma osteoide mediante resección percutánea con radiofrecuencia guiada por tomografía computarizada (TC), exponer la técnica utilizada y mostrar las ventajas económicas del procedimiento, comparado con la técnica quirúrgica tradicional.
Pacientes y metodología: Se estudiaron 21 pacientes que presentaban un osteoma osteoide localizado en el fémur (11 casos), la tibia (7 casos), la pelvis (un caso), el astrágalo (un caso) y la mano (un caso), entre octubre de 2001 y julio de 2007. Se introdujo un electrodo de punta fría guiado por TC en el centro del nidus y se conectó a un generador de radiofrecuencia. Los pacientes permanecieron ingresados 10 h y volvieron a su actividad habitual de forma inmediata. Se realizó un estudio económico comparativo con la técnica convencional que elimina el fragmento óseo que contiene el tumor a cielo abierto y la descrita en este trabajo.
Resultados: Los resultados obtenidos muestran la desaparición completa de la sintomatología en 20 casos y el caso restante mejoró al repetir el procedimiento. El estudio económico revela un ahorro de costes hospitalarios para el procedimiento realizado con radiofrecuencia.
Conclusiones: Es una técnica fácil, percutánea y ambulatoria. Está indicada en casi todas las localizaciones. No se han descrito complicaciones importantes y proporciona buenos resultados.

Introduction

Osteoid osteomas represent 11%of all benign bone tumours. They are localized in the femur and tibia in 50-60%of cases and in the spinal column in 7-10%, although in this location osteoblastomas are more common, which are distinguished by the size of the lesion.[1-4]

The treatment of choice is a complete excision of the nidus. Various cases of spontaneous remission of pain symptoms have been described, as well as others in which pain disappeared within a few years following a prolonged treatment with non-steroid anti-inflammatories,[5,6] a method most often indicated for those who decline surgical treatment.

En bloc resection can pose problems such as difficulty in localizing the lesion, even though various methods are proposed,[7-9] and at times necessitates resection of a large quantity of bone, requiring a bone graft or ostetosynthesis in order to prevent fracture. Another surgical procedure that attempts to avoid the possible complications inherent to en bloc resection is the localization of the nidus and excision using a high-speed cutter.[9,10]

With the goal of localizing and excising or obliterating the nidus with the least invasive surgical procedure possible, various techniques guided by computed tomography (CT) have been proposed, many of which produce satisfactory results. Some examples amply described in the medical literature include resection using trephine or bit drills, alcohol ablation, laser photocoagulation, and radiofrequency thermocoagulation.[11-25] We discuss the technique used in this study and report on the results obtained and the economic advantages of the procedure, as compared with traditional surgical methods.

Material and methods

Between April 2001 and July 2007, 21 patients presenting with osteoid osteomas were treated using CT-guided radiofrequency thermocoagulation. Diagnosis was performed by evaluating medical histories, simple radiographs, bone scans, CT scans, and MRIs. No preoperative biopsies were performed, although a CT-guided percutaneous biopsy using a 17 G bone biopsy needle was required in 2 cases just before the radiofrequency application.

Of the 21 cases treated, 17 were men and 4 were women, with an age range of 11 to 46 years (mean age = 24 years). Fourteen of the 21 patients were under the age of 24. Tumours were located in the femur (11 cases), tibia (7 cases), pelvis (1 case), talus (1 case) and hand (1 case) (fig. 1). In one case the patient had been treated by open surgery for an osteoid osteoma in the femoral neck that had resulted in a failed resection of the nidus, and another case in the tibial plateau had been treated using CT-guided alcohol ablation; the rest received initial treatment using radiofrequency thermocoagulation. Mean follow-up time was 50 months, and in 12 of the 21 cases surpassed 4 years. 20 patients received only local anaesthesia and one received general anaesthesia; all patients were discharged within 10 hours of surgery.

Procedure

Patients were admitted to the hospital on the day of the surgical intervention; outpatient pre-anaesthesia and

preoperative assessments had been carried out in which the patient was explained the details of the procedure and signed the informed consent. The procedure was performed in the scan room by a team made up of an anaesthesiologist, a radiologist and an orthopaedic surgeon. Under local or general anaesthesia, the tumour was localized under CT control using 2mm-thin slices. 40/8mm needles were placed on the skin in the area of the osteoid osteoma (fig. 2A and B) in order to facilitate the orientation of a 100 and 2.4mm (13 G) bone biopsy needle (Ostycut®). Proper planning allowed us to guide the bone biopsy needle percutaneously directly into the centre of the nidus, avoiding damage to tendons and vascular-nervous packages (fig. 2C). The biopsy needle was introduced using CT slices to ensure placement in the centre of the nidus. We then removed the safety from the coaxial system of the biopsy needle and introduced the 15 x 1cm electrode of the Cool-tip RF ablation system® (Tyco Healthcare). We positioned it such that the distal centimetre of the electrode, the active end, filled the greatest diameter of the nidus (fig. 2D) in order to provoke a 1cm burn in the adjacent tissue. In small lesions (less that 6mm in hands and feet) we used a 14.4 × 0.7cm electrode (fig. 3). We removed the coaxial system of the bone biopsy needle to avoid contact with the active end of the radiofrequency electrode.

Once the electrode position was established, it was connected to a radiofrequency generator and 2 heat dispersion plates were placed on the skin of the patient near the point of entry. The optimal energy level was administered according to the impedance of the tissue. Impedance was controlled by hand and without the use of

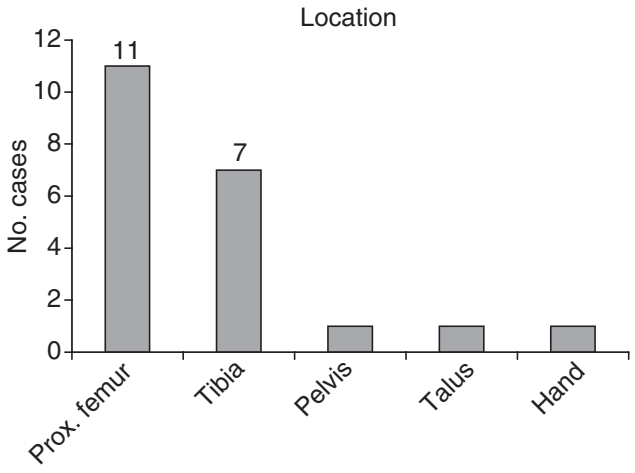

Figure 1 Anatomical distribution of tumour location. The majority were found in the femur and tibia.

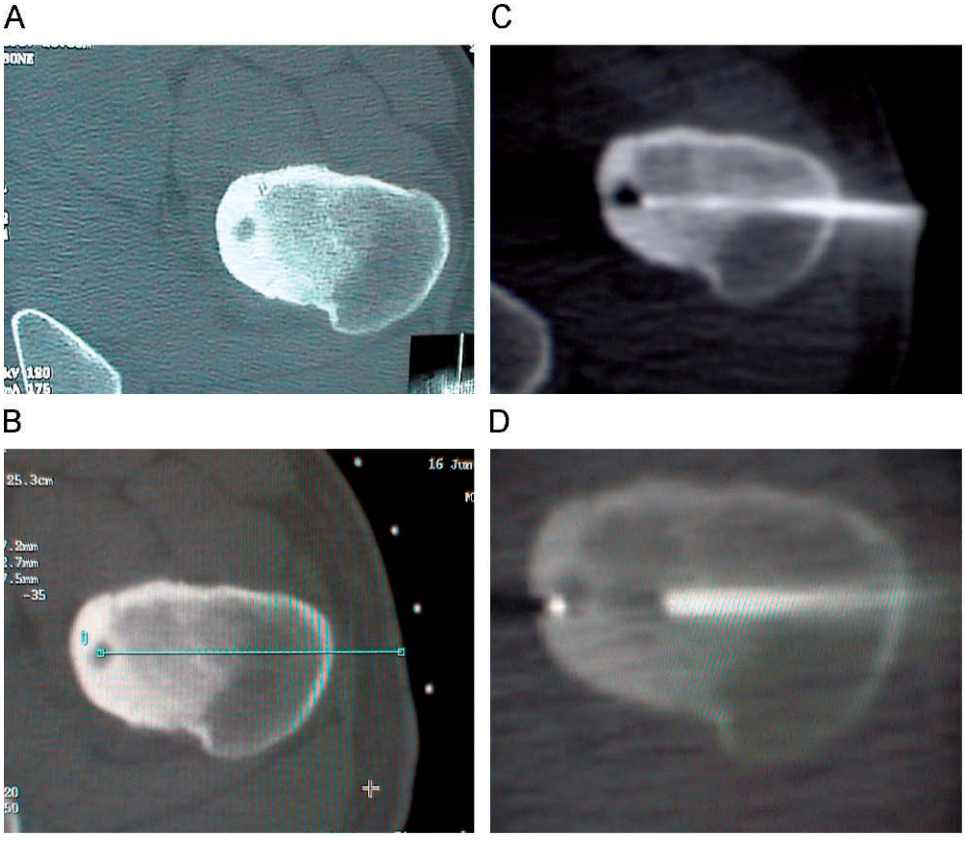

Figure 2 A) Image of an osteoid osteoma in the femur of an 18-year-old male with a strong sclerotic reaction. B) Location of the lesion using computerized tomography with 40/8mm needles on the skin to facilitate insertion of the bone biopsy needle. C) Placement of the coaxial system of the bone biopsy needle in the nidus. D) Verification of the placement of the radiofrequency electrode's active end.

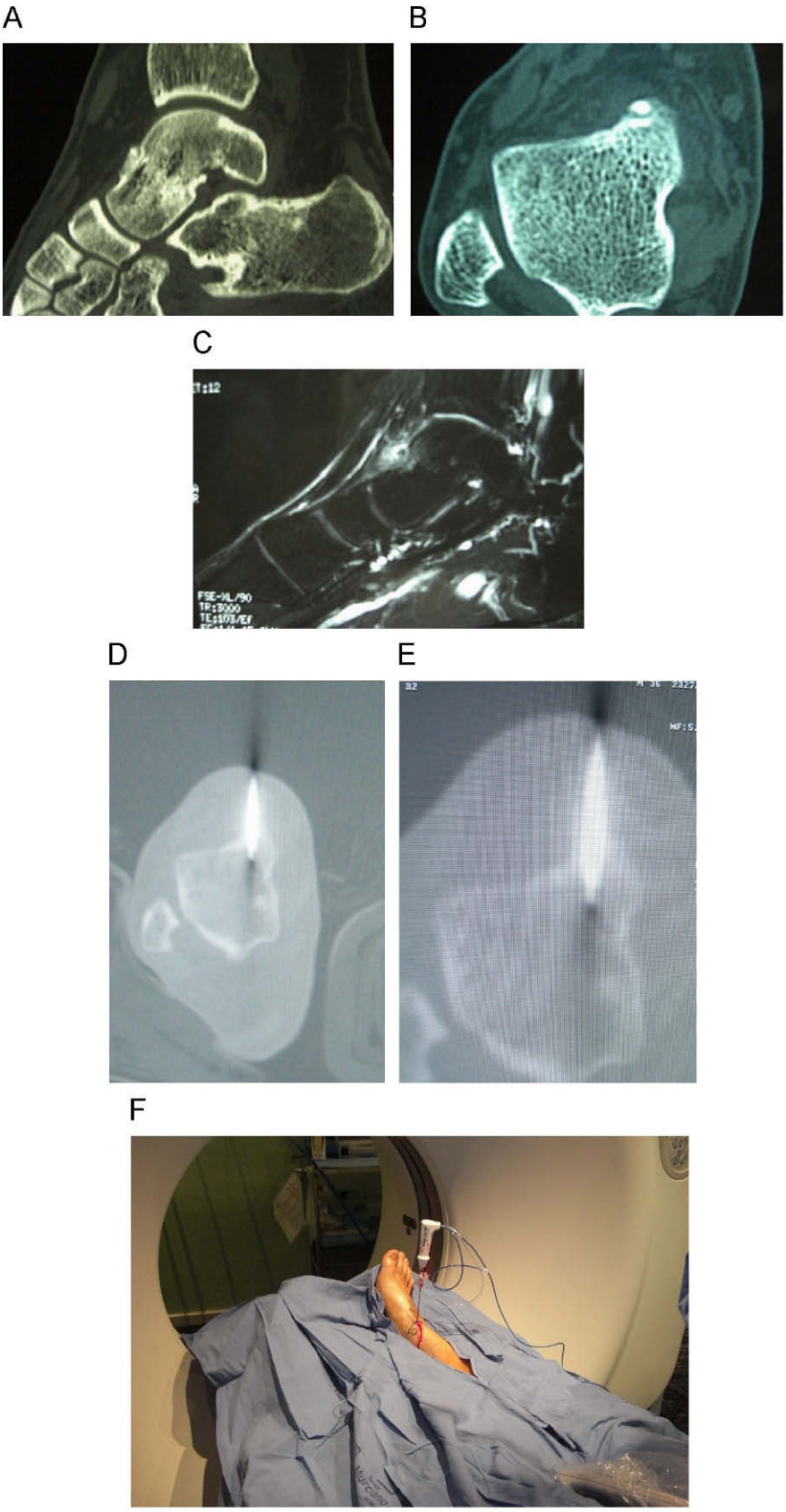

Figure 3 A) Sagittal slice CT image of an osteoid osteoma in the neck of the talus in a 38-year-old male. B) Axial slice of an osteoma. C) Location of the lesion using MRI. D) Insertion of the bone biopsy needle into the centre of the nidus. E) Verification of the radiofrequency needle placement. F) Patient on the CT gantry with the radiofrequency needle situated.

cooling pumps. Treatment cycle lasted 6 minutes, with temperature maintained at 80° C for the duration of the procedure. When optimal temperature was not reached, the procedure was repeated in order to ensure the thermocoagulation of the tumour. Antiseptic and a sterile dressing were then applied.

Patients were discharged 6-12 hrs following the procedure in accordance with the outpatient surgery protocols at our hospital.

We then filled out Barei's questionnaire[15] using the patient's demographic information, preoperative and postoperative evaluation of diurnal/nocturnal pain intensity, analgesic intake, and ability to continue occupation, studies, and physical activities. Clinical follow-up evaluations were performed at 3 days, 1 month, and 6 months following the procedure. In this final assessment we performed MRI and CT scans to evaluate the radiographic situation of the tumour.

In collaboration with the management at our centre, we established the economic cost of the procedure for the hospital and compared it with the open surgical technique, using en bloc resection of the bone. For both procedures, the personnel costs, hospitalization (average 5 days for open surgery), operating room time, laboratory costs, pathology, radiology, anaesthesia, reanimation, radiofrequency needle, osteosynthesis, and CT room use were all taken into account. All monetary costs for both processes were updated for year 2007 according to the Spanish National Institute of Statistics.

Results

Symptoms recurred in only one case, in which the location of the lesion was very superficial on the internal tibial plateau; the active zone of the radiofrequency needle was inserted into the area excessively, requiring new treatment. One treatment cycle was sufficient to attain optimal temperature in all cases. We obtained histological confirmation of the lesion in only 2 cases.

For treatment of osteoid osteomas using open surgery, the economic costs per patient at our hospital reached €4,250 excluding the value of the osteosynthesis material that was used occasionally in some patients. Cost per patient using percutaneous treatment of the osteoid osteoma with radiofrequency was €1,533.71 (table 1).

Table 1 Breakdown of costs for open surgery and radiofrequency procedures in Euros (€)

	Open Surgery	Radiofrequency
Personnel	1,463.43	281.65
Pharmacy	795.67	52.31
Outpatient hospital		69.08
Hospitalization services	341.69	
Laboratory	145.69	45.69
Operating room	510.76	
Pathology	128.58	
Diagnostic radiology	232.97	43
CT use		81.08
Anaesthesia and reanimation	631.21	320.9
Radiofrequency needle		640
	4,250	1,533.71

CT: computerized tomography.

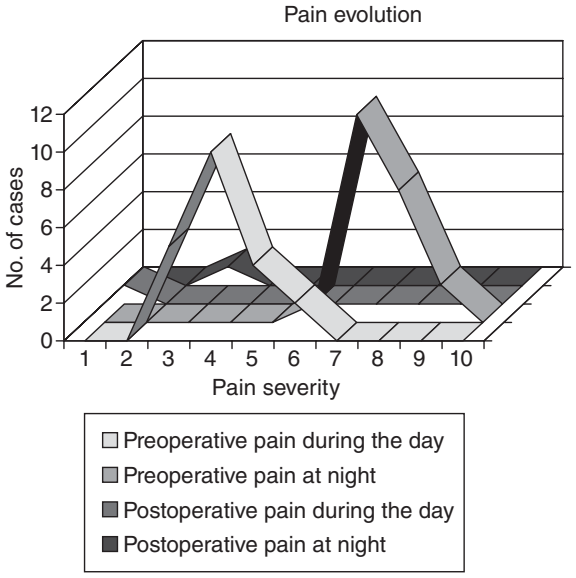

Figure 4 Distribution of diurnal and nocturnal pain severity in patients before (preoperative) and after (postoperative) the procedure.

Preoperative evaluation

Patients presented with pain during a mean time of 15 months. The majority of patients (85%) presented symptoms for over a year, nocturnal pain being more frequent than diurnal pain, with a mean score of 7.47 and 4.14 points out of 10, respectively (fig. 4). Three of the 7 patients who worked had to modify their occupational activity in some way, and 4 of the 14 patients attending school had to modify their academic activity. Pain obliged 10 of the 15 patients that were physically active in sports to adjust their athletic participation.

All patients were prescribed non-steroid anti-inflammatory medication in various doses ranging from three to one tablet per day. No patients required stronger analgesics. Nocturnal pain, the need for medication, and interference with normal occupational or academic activities were the strongest preoperative concerns held by patients, in that order.

Postoperative evaluation

Complete cessation of pain that was present before the surgery was achieved at 7 days post-operation in 14 patients, between 7 and 14 days in 4 cases, and between 14 and 30 days in 2 patients. In one case the pain did not subside and required a second procedure 6 months following the

first in order to obtain complete relief. The majority of patients were able to distinguish the pain felt prior to the procedure from the pain produced by the surgery itself. The mean evaluation of postoperative pain was 2 points out of 10. On a scale of 0 to 10 nocturnal and diurnal pain was rated at 0.28 and 0.14, respectively. (fig. 4).

All patients were able to return to their occupational or academic activities full-time immediately following the procedure, and those that practiced some type of sport or recreational activity were able to resume with no limitations within a month.

MRI follow-up revealed low signal halo and oedema in the bone marrow with zones of bone infarction around the nidus, which continued to diminish a year following the surgery. In exceptional cases we requested MRI evaluation one year post-operation from those patients that sought medical consult for non-related reasons. The CT revealed a progressive reduction of the size of the nidus.

Discussion

Osteoid osteomas are benign bone tumours that provoke continuous pain, predominantly nocturnal, that typically occur within the first few decades of life. Diagnosis is based on evaluation of symptoms and radiography;[23] CT scans are the preferred method for diagnosis, and are even preferred over MRI.[13,15,20,25] It is a difficult diagnosis to make, as evidenced by the delay most patients wait to be treated according to the majority of studies published on the subject.[6,10,15,16,18,25] One case in our study had gone 2 and a half years before being diagnosed (fig. 3). Bone scans are very valuable for presumptive diagnosis, for although they are still an inexact form of examination, they come back positive in almost 100% of cases.

The treatment of choice for this type of tumour has traditionally been en bloc surgical resection. In the last few years, CT-guided percutaneous techniques have been developed in order to avoid the difficulties and complications inherent to the treatment of these lesions through open surgery, with the radiofrequency thermocoagulation methods described by Rosenthal[11] being the most studied and extended. The use of this technique requires a CT room and adequate coordination of a multidisciplinary surgical team (radiologist, anaesthesiologist, and orthopaedic surgeon). Locoregional anaesthesia can be used in adults, although general anaesthesia is preferable in children in order to guarantee a stable position. The key to this procedure lies in the correct localization of the nidus and the precise insertion of the radiofrequency electrode.[14-18,20] The lesions encountered in our study that were greater than 1cm did not require relocating the electrode for more than one thermocoagulation event.[20,25] We used cool-tip electrodes with 6-minute cycles reaching temperatures of 80° C in a 1cm area around the point of the radiofrequency needle. We extended the time of the procedure but minimized the complications presented in other methodologies, which use 4-minute cycles reaching temperatures of 90°.[13,15-17]

This technique is a safe, efficient, and affordable procedure that produces satisfactory results in 80–100% of cases,[12,15,17,22,26] along with fewer complications and a shorter recovery time. It is a safe technique, as long as a series of precautions are taken, such as maintaining a distance of at least 1cm from any important neurovascular structures,[12,21,23,25] a dorsal approach in hands and feet, and special care taken in superficial areas with little coverage of soft tissue, where thermal-induced cutaneous necrosis is a frequent occurrence, especially in the anterointernal face of the tibia.[13,16,20,27] Several authors recommend excluding vertebral osteoid osteomas from this technique for the possible risks to the neural structures that must be at least 1cm from the lesion, and where there must be intact cortex between the lesion and spinal canal or nerve root.[13,15] Other minor complications have been described in the medical literature, such as cellulitis,[14] vasomotor instability[13] and clubfoot due to temporal muscular contraction.[23] We did not register any such complications in our study. However, the higher rates of complications inherent to conventional surgery are apparent, since these techniques require bone removal, which in the majority of cases requires reducing and limiting physical activity in order to prevent fractures. At times, bone grafts and prophylactic fixations are required due to the bone loss from the en bloc resection. Bone loss using radiofrequency thermocoagulation is minimal, and we did not have to limit patients' physical activity in any way: reincorporation into ordinary life is practically immediate.

This is an affordable technique, as shown by the results of our work, in which we found a large economic difference in favour of radiofrequency thermocoagulation compared to open surgery.[10,11,15,17,21,24,25,27-29]

Radiofrequency thermocoagulation is an efficient treatment for osteoid osteomas and obtains a success rate similar to that of open surgery. The vast majority of published studies show high success rates near 95%, as in our case. The efficiency of this technique is not conditioned by the location of the lesion, nor the sex or age of the patient.[13] Clinical success of the procedure is defined as complete disappearance of symptoms. Following surgical intervention, registered clinical improvement is generally fast, and pain dissipates within 24–72 hrs following thermocoagulation in 85% of patients;[15,30] some patients can take 3–4 weeks for a complete recovery.

The adequate follow-up period indicated in various studies in order to evaluate the possible recurrence of the lesion is 2 years.[13,15] Rates of recurrence vary between authors, and figures between 4.5 and 10% are common,[3,14,15,17] although these figures diminish when using CT-guided percutaneous treatment due to the ease of locating the nidus. Rosenthal[13] registered higher persistence values than rates of recurrence; in our study only one case required a second procedure, and disappearance of symptoms was 100%

Follow-up using imaging techniques (CT and MRI) often show that the nidus has reduced in size and growth in the peripheral sclerotic reaction, along with decreased marrow oedema. In some cases, ossification, sclerosis, and remodelling of the osteonecrotic centre that has been created can be identified.[16,21,26,30] In other cases with positive clinical results these changes have not been observed.[24] Imaging follow-ups do not determine the success or failure of radiofrequency treatment.

The lack of histological confirmation is the main inconvenience in all percutaneous techniques, but this is not achieved in all

cases using en bloc resection either. The diagnosis of the osteoid osteoma is obtained using the symptoms presented and complementary explorations. The disappearance of symptoms following radiofrequency treatment aids in confirming the diagnosis.

Radiofrequency thermocoagulation is the treatment of choice for osteoid osteomas for its proven clinical efficiency, minimal trauma, and minimal functional limitations. The cost of this treatment is significantly lower than in traditional open surgery methods due to the reduced hospital costs. The degree of satisfaction is also greater due to the reduced time spent in resuming sport, recreational, and academic activities.

Conflict of interest

The authors affirm that they have no conflicts of interest.

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