Osteoid osteoma: nidus radioguided spine surgery
Osteoma osteóide: detección intra-operatoria
Osteoma osteoide: deteccion intraoperatoria

ABSTRACT
Objective: to describe the clinical value of radio guided surgery of osteoid osteoma lesions. Osteoid osteoma of the spine is usually located in the posterior vertebral arch.
Methods: we reported on four clinical cases of patients with lumbar osteoid osteoma. Patient sample: four adolescent patients suffering from low back pain, caused by lumbar spine and sacrum osteoid osteoma. Outcome measures: a clinical interview was used as the primary method of follow-up for the majority of patients. The main outcome measure in this study was pain resolution. The minimum follow-up was two years. We used a two-phase protocol consisting of: 1) Injection of 99mTechnetium MDP (metyldiphosphonate) prior to surgery; 2) Intraoperative gamma radiation detection; the intravenous injection is carried out four to 12 hours before surgery. One to two hours post-injection, images were acquired using a large field of view gamma camera to locate the lesions. All positive foci (areas of increased tracer uptake) were further confirmed with the gamma probe.
Results: four patients ranking from 14 to 16 years, one of them female, with osteoid osteoma located in articular

RESUMO
Resultados: foram operados quatro pacientes, com idades entre 14 e 16 anos, sendo um do sexo feminino, com osteoma osteóide localizados nos processos articulares de T12, L3, L4 e no osso sacral. Todas as lesões foram identificadas intra-

RESUMEN
Objetivo: describir el valor del procedimiento operatorio guiado por imagen en la resección del osteoma osteoide de la columna vertebral. Métodos: evaluación de 4 casos clínicos de pacientes con osteoma osteoide de la región de la columna lumbosacra. Los pacientes eran adolescentes con dolor lumbar. Para la evaluación de los resultados fue usada entrevista como método primario para el acompañamiento de la mayoría de los pacientes. La principal evaluación fue en relación a la resolución del dolor lumbar. Fue utilizado un protocolo constituido por dos etapas: 1) Inyección de Tecnecio marcado antes de la operación; 2) Detección intraoperatoria por radiación gama. La inyección endovenosa fue realizada en un periodo de dos a cuatro horas antes de la cirugía. Una a dos horas después de la inyección fueron adquiridas imágenes usando una gama cámara de amplio espectro para la localización de la lesión. Los focos positivos fueron a seguir confirmados por la sonda de la gama cámara.
Resultados: fueron operados cuatro pacientes, con edad entre 14 y 16 años, siendo uno del sexo femenino, con osteomas osteoides localizados en los procesos articulares de T12, L3, L4 y en el...
process of T12, L3, L4 and sacrum. All lesions were successfully identified intraoperatively with the gamma probe which proved to be extremely helpful for the surgical resection. After surgery, all patients experienced immediate pain relief. The technique was able to accurately localize the lesion, to facilitate its removal with minimal vertebral destruction. During follow-up (2 to 4 years) there was no evidence of recurrence or spine instability caused by surgery. In two scoliosis patients, this condition disappeared during follow-up. **Conclusion:** the use of radioguided surgery, allowed the surgical removal of the nidus, with minimal bone resection of the posterior spinal structures. This issue was of great relevance for the spine stability.

**KEYWORDS:** Osteoma, osteoid/diagnosis; Osteoma, osteoid/surgery; Osteoma, osteoid/radionuclide imaging; Spinal neoplasms/surgery; Radiosurgery/methods;

**DESCRIPTORES:** Osteoma osteóide/diagnósticos; Osteoma osteóide/cirurgia; Osteoma osteóide/cintilografia; Neoplasias da coluna vertebral/cirurgia; Radiocirurgia/métodos

**INTRODUCTION**

Osteoma osteoid is a benign bone painful lesion consisting of less than 1.5cm of abnormal nidus surrounded by an area of reactive bone. The first description was performed by Jaffé in 1935. Approximately 10% to 20% of the osteoma lesions are located in the spine most of them located at the posterior arch of the vertebra. The main symptom is pain which has special characteristics such as night and exercise worsening, and is relieved with acetylsalicylic acid or non steroidal anti-inflammatory drugs. 90% of cases appear in patients under 30 years of age and in some cases a scoliotic deformity may develop. However, the diagnosis of this disease can be clinically difficult and many patients can experience a significant delay in determining the exact cause of the pain.

Ozaki et al. described an average of 11.6 months from the onset of the pain to the time of surgery. Other authors report this time lag to be 18.4 months. If patients are not diagnosed at early stages, the outcome of certain image studies may produce confusion. Recently, we reported at our center 15 cases of vertebral osteoid osteomas excluding osteoblastomas. With one exception, they were all located in the posterior elements of the lumbar spine and sacrum. The locations included the lamina, articular and transverse processes and the posterior arch. In two cases, the nidus was not adequately resected and the patients had to be re-operated to complete the excision assuring a complete resection. To assure a complete resection, we have used the intra-operative detection of the nidus by means of radioguided surgery. This is a two-phase technique that includes an initial intravenous injection of 99mTecnetium MDP. Secondly, a gamma probe detector is used during surgery to define the area of high radiation uptake that increases the certainty of locating the margins of the nidus.

**METHODS**

This report consists of our experience within four cases of patients with spinal osteoid osteomas, in which gamma probe detection was used to localize the lesion intraoperatively. All tumors were located in the posterior arch of the vertebra. All patients had a nine months to one year history of thoracolumbar pain. Plain radiographs showed a scoliotic deformity of the spine in two patients. Preoperative diagnosis included bone scan and CT scan (Figures 1C and 2A), showing focal high uptake of the radiopharmaceutical and the nidus with sclerotic margin, respectively, in the posterior structures of the spine in all patients. MRI showed unilateral neural arch edema in two cases without clear definition of the nidus (Figures 1A, 1B, 2B).

**DESRIPTORES:** Osteoma osteoide/diagnóstico; Osteoma osteoide/cirurgia; Osteoma osteoide/cintigrafia; Neoplasias de la columna vertebral/cirugía; Radiocirugía/métodos
Osteoma osteoide: detección intraoperatoria

Patients
The general information of the four study cases is synthesized in Table 1, its ages, sex, type of clinical manifestation and imagenologic studies (Rx, bone scan, CT scan, IRM and topography of the lesion).

<table>
<thead>
<tr>
<th>Name</th>
<th>Age/years</th>
<th>Sex</th>
<th>Symptoms</th>
<th>X-ray</th>
<th>Bone Scan</th>
<th>CT</th>
<th>IRM</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>16</td>
<td>M</td>
<td>9m. pain + + + no scoliosis</td>
<td>pre &amp; post</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>L4 left articular process</td>
</tr>
<tr>
<td>Case 2</td>
<td>14</td>
<td>F</td>
<td>1ys. pain A.A.S. + no scoliosis</td>
<td>pre &amp; post</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>L3 left inferior articular process</td>
</tr>
<tr>
<td>Case 3</td>
<td>15</td>
<td>M</td>
<td>1ys. pain + + + Lordoscoliosis</td>
<td>pre &amp; post</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>T12 right</td>
</tr>
<tr>
<td>Case 4</td>
<td>15</td>
<td>M</td>
<td>1ys. pain + + + no scoliosis</td>
<td>pre &amp; post</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>S2 posterior arch</td>
</tr>
</tbody>
</table>

We used the following protocol for treating patients with osteoid osteoma of the spine:
1. Radiopharmaceutical - We used a commercially available radiopharmaceutical: $^{99m}$Tc (technetium 99m)-MDP (methylidiphosphonate). It was administered in a dose similar to the one used in routine bone scans, determining a dosage range of 13.32-15.91 MBq/Kg of corporal weight. The intravenous injection was performed four to 12 hours before surgical procedure. In all the cases, images were obtained one and two hours after the injection. According to the report of Wioland et al.21, the uptake level difference at the nidus is approximately ten to one, which enables a clear identification and confirmation of the excised material. Other authors did not report the ratios of abnormal to normal bone uptake as they are influenced by the amount of dose administered, the location of the lesion and the nature of the surrounding tissues 22.
2. Radioguided surgery - We used a gamma probe equipped with a Cadmium Telluride (CdTe) detector.

3) PROCEDURE - After waiting one to two hours post-injection, images are obtained using a Gamma camera to locate the lesion, following with the probe the scintigraphic image. The proportion of radioactive disintegration detected in an operative field depends: 1. on the amount of injected activity. 2. on the delay between the injection and the surgery. 3) On the thickness of the explored bone and 4) on the avidity of the nidus to concentrate the labeled diphosphonates.

At this stage of the diagnostic algorithm, specificity is not an issue, because the goal of Radioguided Surgery is to locate the lesion, whatever its etiology. The radiopharmaceutical uptake in the lesion is not affected by analgesic therapy. There is no linear relationship between the pathological nature of the bone tissue and the quantity of disintegrations detected in the field.

Based on our experience we have adopted the following protocol for performing Radioguided Surgery in patients with osteoid osteoma of the spine:

a) The “Probe” is handed to the surgeon placed in a sterile endoscopy wrapping sheet.
b) Finding of the highest uptake area in the region of the bone lesion.
c) When the lesion is exposed, the radioactivity of a normal bony region is measured to use it as a reference in the subsequent measures.
d) As the surgeon progresses through the removal, the activity of the extracted bony fragments is measured, until the location of the nidus is determined (highest uptake fragments).
e) The surgical field is then measured to assess background activity and to check that no high uptake area of the level of the nidus remains following the extraction of the lesion.

4) FOLLOW-UP - It consisted of both clinical and radiological evaluations.

RESULTS

In our cases there was delay between the beginning of pain and the diagnosis. The most valuable image studies were scintigram (SPECT) and CT scan. The IRM was of little value (Figures 2B, 2C and 3).

The pain disappeared immediately after the surgery in the four cases and also there was not scoliosis recurrence during two years of follow-up, this is outlined in Table 2. In all cases the location of the process with this method was effective, allowing resection of the nidus in its totality.

<table>
<thead>
<tr>
<th>Name</th>
<th>Surgical Approach</th>
<th>Minimum follow-up</th>
<th>Pain recurrence</th>
<th>Scoliosis recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>L4. Left articular process</td>
<td>4 years 6 months</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>Case 2</td>
<td>L3. Left inf articular process</td>
<td>4 years 3 months</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Case 3</td>
<td>T12. Right articular process</td>
<td>2 years 3 months</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Case 4</td>
<td>S2. Posterior arch</td>
<td>2 years</td>
<td>No</td>
<td>-</td>
</tr>
</tbody>
</table>

DISCUSSION

While many techniques have been used to make an early diagnosis, experience has show that making the definitive diagnosis can be elusive. In cases presented in this report, the average time for diagnosis was 12 months. Often the intra-operative location can be difficult and result a failure to perform an adequate resection leading to recurrence of the lesion. This report seeks to establish a diagnostic algorithm, stressing some considerations. The plain x-rays sometimes demonstrate a small area corresponding to the nidus, surrounded, by a sclerotic area. In some circumstances the x-ray image may not be clearly visible.

Visible or not, the next step is the ⁹⁹ᵐTc-MDP bone scan (if necessary with SPECT). This is a high sensibility study, usually delivering a clear image of localized radiopharmaceutical uptake.

In our experience, the CT has always contributed with important data for the presumptive diagnosis and the lesion anatomy.

The MRI can be confusing as demonstrated in two of our cases (Figs. 1A, 1B and 2B). In the MRI T2 sequence a “blaze” image (soft tissues edema or peritumoral edema) appeared. The MRI can be a good study if it shows the nidus, but this is not always the case. These details must be taken into account to avoid many diagnostic errors. According to Yamamura the high prostaglandin level in the osteoid osteoma tissue would be responsible for the edema around the tumor. The CT erases the soft tissue edema image to improve the visualization of the nidus (Figs. 1B and 2C).

The typical therapeutical approach is the surgical extirpation, although there are cases in which there was a
spontaneous disappearance occurred after five years. When the process is located in the lamina, its location can be suspected because the sheet appears opaque and cribate. Macroscopic pathology doesn’t determine the true depth or exact location when it is located in the articular process as in cases 2 and 3. In these areas it is impossible to place or exact location when it is located in the articular process. Because of this fact, percutaneous resection techniques, guided by CT scan, have been described 15, 19.

Some interventional radiologists can approach the Osteoid Osteoma under CT. This is routine in long bones, but in the spine such method has the potential risk of producing a neurological lesion which frequently restricts this procedure.

We have attempted to use X-rays of the resected fragment to confirm the presence of the nidus. However we have also been unsuccessful in some cases with this method. For these reasons, the radiation guided extirpation 14-16, 21 with a cadmium theluride detector has been found to be a more effective procedure. It allows better defined and more localized resections. This allows the removal of the nidus without making big articular or bone resections that can result in instability or deformity (Fig. 2D). Limiting the size of surgical resection is the main advantage of this technique with resections of no more than 1.5 cm. of diameter.

Regarding staff dosimetry, radiation exposure is higher when the surgeon is working in the thorax and pelvis than performing surgery on the extremities. For a four hours surgery in pelvis, the absorbed dose reaches 100 Sv. At 0.5 m of distance to the patient, the exposition dose is five times lower than that received at 0.1 m, and independent of the surgeon’s position in relation to the patient. As radionuclide guided operations are not frequent, no special radioprotection care of the surgical staff is necessary for radiobiological reasons.

The use of intra-operative Nuclear Medicine in surgical treatment of the Osteoid Osteoma has the advantage of improving the location of the nidus in the bone, the verification of the progress of removal, as well as identification of the absence of residual radioactivity in the surgical field after having extracted the osteoma.

In these cases the use of radioguided surgery allowed nidus resection, with a discrete lesion of the articular facets, avoiding potential spine instability. None of the presented cases required arthrodesis to solve instability problems. This has been described by several authors 11. Our ability to perform a localized resection has allowed us to avoid this complication. Another aspect to keep in mind is the appearance of scoliosis and its persistence after having resected the Osteoid Osteoma. We did not experience any cases in which scoliosis persisted after tumor resection 11.

CONCLUSIONS
This report describes the use of intraoperative nuclear medicine for location of vertebral osteoid osteoma. The SPECT and the CT play an important part in making in the diagnosis 25. The presence of edema in MRI images may be confusing 26.

The use of intra-operative Nuclear Medicine in the surgical treatment of the Osteoid Osteoma improved the location of the nidus. It has also been valuable in the monitoring of resection progress and confirmation of absence of residual osteoma tissue in the surgical field after extraction. This is accomplished with minimal resultant instability.

REFERENCES
11. Ransford AO, Pozo JL, Hutton PA, Kirwan EO. The behaviour pattern of the scoliosis associated with ostoid osteoma or osteoblastoma of the spine.

Figure 3
Probe detector and nidus after resection (Case 1)


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