Original article

Osteoid osteoma of the proximal femur: Treatment by percutaneous bone resection and drilling (PBRD). A report of 44 cases

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\begin{abstract}
Introduction: Osteoid osteoma is a benign osteogenic tumor that is mainly located in the lower limbs. According to Campanacci the proximal femur is involved in 25\% of cases. We present a series of 44 cases of osteoid osteoma located in the neck of the femur or the lesser trochanter treated by the minimally invasive method, CT-guided percutaneous bone resection and drilling (PBRD).

Materials and methods: This series included 44 patients, 20 girls and 24 boys, treated between 1987 and 2012. The average age at surgery was 12.7 years old (range 4–34). The diagnosis was based on the “association” of scintigraphy (hyperfixation) – CT scan (nidus located on the femoral neck or near the lesser trochanter). These patients underwent CT-guided PBRD under general anesthesia. Specific ancillary material was used to reach and remove the nidus and a cylinder of bone was sent to the pathologist for assessment. A lateral or anterior approach was used in all cases except one in which a posterior incision was made. Histological confirmation was obtained in 23 cases (the bone fragment was damaged in 21 cases).

Results: Forty-two patients were reviewed after a minimum follow-up of one year (12–56 months). Two patients were lost to follow-up. Results were evaluated clinically and on CT scan 1 year after surgery: there were 35 cures with complete and permanent pain relief. There were 5 failures and 1 case of recurrence requiring a second CT-guided PBRD procedure as well 2 complications involving femoral fracture (one associated with failure).

Discussion: The proximal femur is a common location of osteoid osteoma. Treatment requires careful preoperative planning to determine the surgical approach for safe removal. PBRD is a minimally invasive technique, allowing complete resection with suitable ancillary equipment. This method should be compared with thermoablation, which is a similar technique.

Conclusion: CT-guided PBRD is a therapeutic option in case of osteoid osteoma of the proximal femur.

Level of evidence: Level IV.

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\end{abstract}

1. Introduction

Osteoid osteomas (OO) represent 10\% of benign bone tumors, and are usually located in the femur [1]. The presenting symptom is nocturnal pain, which is usually relieved by anti-inflammatory drugs. This tumor which has distinct features and progression pattern, mainly occurs in adolescents and young adults [2]. Treatment is essentially surgical and in the last twenty years, percutaneous treatment (resection or thermoablation) performed by experienced surgeons has replaced “en bloc” open resection as reported by Shin et al. [3].

We report a series of 44 cases of OO of the proximal femur (involvement of the femoral neck or the lesser trochanter) treated by CT-guided percutaneous bone resection and drilling (PBRD) a mini-invasive technique first described in 1987 [4]. Involvement of the proximal femur in OO seems to be associated with a risk of more frequent complications when treated by PBRD. The goal of this study was to evaluate the technical difficulties and possible complications encountered during management of this entity by PBRD.

2. Materials and methods

Between June 1987 and September 2012, we treated a series of 44 cases of OO of the proximal femur, or 40\% of all of our 109...
PBRD. The diagnosis was determined by scintigraphy and CT scan, as recommended in the literature [5]. The nidus was located in the femoral neck in (26 cases) or the lesser trochanter (18 cases). A frontal view (Fig. 1a), showed the nidus in the base of the neck (16 cases), in the superior rim (4 cases), and near the growth cartilage of the femoral head (6 cases). An axial view (Fig. 1b), showed the nidus in a posterior position in 14 cases and anterior in 12 cases.

In one case, resection by open surgery was attempted and failed before performing PBRD. One case required a second PBRD, after the failure of a first attempt in another center.

This procedure was always performed under general anesthesia in the CT suite. Perioperative CT-guidance provided precise 3D identification of the nidus and allowed CT-guided resection. Collaboration between the radiologist and the surgeon was therefore essential. Surgery lasted a mean 1h10 minutes (45–95 min) (identification and excision of the tumor). The mean dose of radiation during surgery was 270 mGy·cm (190–360 mGy·cm) for the patient and 0.02 μSv for the surgeon.

The steps of this procedure have been clearly standardized [6]: the patient was installed in the supine position with a pillow under the buttocks for a lateral or anterior approach to the tumor. The prone position was only used for a posterior approach in one case. The nidus was identified to determine the best CT-slice for the instruments: a 2 cm incision was made and a guide wire was aimed at the nidus. The guide wire was inserted by the lateral approach through the vastus lateralis muscle (Fig. 2a), or by anterior approach laterally in relation to the femoral vascular-nerve bundle between the fascia lata tensor and sartorius muscles, through the iliopectineus muscle (Fig. 2b). The wire was used to guide the specific ancillary instruments necessary for the procedure: a drill bit and a 9 mm trephine.

The various instruments were carefully guided towards the osteoid osteoma under control on the selected CT slice. The nidus was removed in a 1-cm diameter bone cylinder (Fig. 3), and sent for histological evaluation. A final burring of the area of the nidus completed the resection.

Hospitalization lasted a mean 2 days, with partial weight-bearing on crutches for the first few days. The patient could return to sports after 1 month. A postoperative follow-up CT scan was performed in all patients approximately 1 year after surgery.

### 3. Results

Two patients were lost to follow-up. Forty-two patients were seen at the follow-up visit after at least one year (12–56 months), which is the minimum delay necessary to evaluate the results and exclude recurrence [1]. Histological confirmation of OO was obtained in 23 cases.

#### Table 1

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age at surgery</th>
<th>Location of OO</th>
<th>Surgical approach</th>
<th>Histology</th>
<th>Complication</th>
<th>2nd PBRD</th>
<th>Outcome final follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>13</td>
<td>Lesser Trochanter</td>
<td>Anterior</td>
<td>No</td>
<td>Targeting error</td>
<td>13 months</td>
<td>Simple at 1 year</td>
</tr>
<tr>
<td>M</td>
<td>20</td>
<td>PT</td>
<td>Lateral</td>
<td>No</td>
<td>Targeting error</td>
<td>Simple at 1 year</td>
<td>Simple at 1 year</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>Neck</td>
<td>Anterior</td>
<td>Nidus confirmed</td>
<td>Targeting error</td>
<td>9 months</td>
<td>Simple at 1 year</td>
</tr>
<tr>
<td>M</td>
<td>11</td>
<td>Neck</td>
<td>Lateral</td>
<td>No</td>
<td>Targeting error</td>
<td>7 months</td>
<td>Simple at 3 months</td>
</tr>
<tr>
<td>M</td>
<td>9</td>
<td>Neck</td>
<td>Anterior</td>
<td>No</td>
<td>“true” recurrence</td>
<td>19 months</td>
<td>Simple at 1 months</td>
</tr>
<tr>
<td>F</td>
<td>7</td>
<td>Neck</td>
<td>Lateral</td>
<td>No</td>
<td>Targeting error</td>
<td>19 months</td>
<td>Simple at 1 months</td>
</tr>
<tr>
<td>F</td>
<td>20</td>
<td>Neck</td>
<td>Lateral</td>
<td>No</td>
<td>Targeting error + fracture</td>
<td>2 months</td>
<td>Simple at 1 year</td>
</tr>
</tbody>
</table>

There were no vascular or nerve complications. Clinical improvement was obtained in 35/42 patients with complete pain relief. The postoperative clinical follow-up assessment did not show any limitation in hip range of motion. Table 1 shows the complications reported in our series.

A femoral fracture occurred in 2 cases (one 4 months after PBRD, the other 2 weeks after the second PBRC), requiring internal fixation. One of the fractures developed in one of the 5 unsuccessful cases.

Five failures and one case of recurrence were reported. A failure (due to a technical error) must be distinguished from recurrence, which involved recurrence of the nidus following excision. These 6 cases required a second PBRD procedure to completely cure the symptoms.

4. Discussion

In our series, 35 of our 42 cases healed without complications (or good results in 83%). Therefore, our results were not as good as other PBRD series reported in the literature (good results in 94% in the study by Engel et al. [7], 92.6% for Reverte-Vinaixa et al. [8], 88% for Fenichel et al. [9] and 94.5% for Sierre et al. [10]). Osteoid osteoma of the proximal femur is a specific location, associated with a risk of complications such as targeting errors and fracture. It should be noted that in our overall series of 109 PBRD, success without complications was obtained in 90% of the cases.

Osteoid osteomas are frequently located in the proximal femur: in 25.4% of the cases according to Campanacci [5] and in 40% in our series. The frequency of this entity confirms the need for this study. Many of the studies of percutaneous treatment, either by drilling [7–10] or thermoablation [11–19], have not differentiated between the femoral neck and other locations in the reported cases. The advantage of our series is that it specifically focuses upon this location.

Histological results were negative in 1 out of 2 cases following PBRD because of mechanical and thermal damage to the cylinder of bone. This unsuccessful confirmation deprives the surgeon of important information, in particular in relation to the risk of recurrence. However, complete excision was confirmed by analysis of perioperative CT scan images [20]. Engel et al. [7] emphasize this, also stating that imaging assessment is impossible with thermoablation, because this approach creates extensive lesions. We use CT scan for follow-up because it is an effective technique to confirm the absence of a residual nidus, while limiting the number of images as much as possible.

Analysis of the causes of our failures and complications is important, in particular to determine the possible influence of the surgical approach.

First, it should be noted that we occasionally had problems locating the nidus as in case n° 7 in Table 1: the “real” nidus appeared after a first PBRD based on a first CT scan, which may have been performed too early.

It should be noted that 3/5 cases performed by lateral approach were unsuccessful (compared to 2/20 cases by anterior approach). This series was too small to reach a conclusion, but we feel that an anterior approach may be better for this indication because it is more direct and there is less risk of a targeting error. On the other hand, the nidus is deeper and more difficult to identify when the procedure is performed by lateral approach.

Besides the 5 failures and 1 case of recurrence, the most severe complication was postoperative fracture. In the case presented in Fig. 4, the fracture occurred with no associated mechanism of trauma in the days following the second PBRD, which suggests that a period of strict non-weight-bearing should be recommended after a second PBRD of the proximal femur, and partial weight-bearing for 1 month for the others. It is difficult to correlate the occurrence of fractures with the location of the nidus because one was located on the lesser trochanter resulting in a subtrochanteric fracture, and the other was located on the femoral neck, resulting in a fracture of the base of the femoral neck. In the same way, the role of the surgical approach is difficult to determine, because of the limited number of cases.

There are other alternative percutaneous methods. Results of radiofrequency thermoablation have been good (97% for Neumann...
et al. [14] and 92% for Hoffman et al. [13]). Rosenthal et al. [11] reported recurrence in 7/74 femoral osteoid osteomas, while Hoffman et al. did not report any. Results have also been shown to be good with laser ablation (Gangi et al. [17] and Roqueplan et al. [18], 99 and 96% of good results respectively), in particular in relation to the risk of postoperative fracture, which seems to be nearly inexistent, even with full weight-bearing after surgery. Nevertheless, these authors reported numerous minor potential complications, that are not found with the PBRD procedure: nerve injury and tendinitis (Roqueplan et al. [18]), skin burns and broken material (Étienne et al. [19]).

CT-guided excision is also possible: Wang et al. [21] reported successful results in 100% of cases in a series of 26 patients with osteoid osteomas in various locations. Although we do not have experience with this technique, one of its major disadvantages seems to be the lack of perioperative CT control, confirming complete tumor excision. Rajasekaran et al. [22] support this technique, in particular for the proximal femur, stating that 3D reconstructions provide confirmation of complete excision.

5. Conclusion

In conclusion, PBRD is a therapeutic option in the management of osteoid osteomas of the proximal femur, requiring specific expertise. The immediate postoperative outcome was uneventful in our 42 cases, however, there were 5 failures and 1 case of recurrence. For this specific location, complications are therefore more frequent than osteoid osteomas in different locations treated by PBRD or thermoablation.
Disclosure of interest

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

References