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Intraoperative localization of an osteoid-osteoma using a gamma probe

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Abstract The purpose of this study was to evaluate whether intraoperative nidus detection with a hand-held gamma probe was efficient enough for use as a routine procedure. Thirty-seven patients with osteoid-osteomas were submitted to surgical treatment. The first group consisted of 19 patients submitted to open nidus resection using a hand-held gamma probe as guide. The control group consisted of 18 patients operated on by conventional technique. The procedures were classified as successful if nidus resection could be confirmed by histology or postoperative imaging studies. Patients in the gamma group were followed for a mean of 13 months; patients in the control group for a mean of 39 months. In the gamma group, 17/19 procedures were successful; in the control

group, only 12/18 procedures were successful. The gamma probe helped to locate the osteoid-osteoma nidus, and the same probe could be used in various hospitals.

Résumé Le but de cette étude était d'évaluer si la découverte intra-opératoire du nidus par sonde gamma était assez effective pour l'envisager comme une procédure habituelle. Trente-sept malades avec un ostéome ostéoïde ont eu un traitement chirurgical. Le premier groupe a consisté en 19 malades traités par résection du nidus guidée par la sonde manuelle. Le groupe témoin a consisté en 18 malades opérés sur par la technique conventionnelle. Les procédures étaient classées comme efficaces si la résection du nidus pouvait être confirmée par l'histologie ou l'étude postopératoire des images. Les malades dans le groupe gamma ont été suivis avec une moyenne de 13 mois, malades dans le groupe témoin avec une moyenne de 39 mois. Dans le groupe Gamma 17/19 procédures étaient efficaces, dans le groupe témoin seulement 12/18 l'étaient. La sonde gamma aide à localiser le nidus de l'ostéome ostéoïde et la même sonde pourraient être utilisée dans les plusieurs hôpitaux.

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Introduction

Osteoid-osteoma is the third-most common benign bone tumor. Its incidence is 11% among benign bone tumors and 3% among all primary bone tumors [5]. Osteoid-osteoma was initially described by Bergstrand in 1930 but only in 1935 was it recognized as a distinct entity [4]. Osteoid-osteoma is prevalent among children and young adults but can be found in older individuals. It is more common in men. Osteoid-osteomas have been described in virtually all bones, with the exception of the sternum, and are more frequent in long bones, especially in the proximal femur.

The diagnosis of osteoid-osteoma is based on clinical, radiographic, and scintigraphic findings. Frequently, patients have pain for months or years until the lesion is discovered. The classic radiographic presentation is of a

small geographic lesion up to 2 cm in diameter in the cortical layer of a long bone. The lesion is surrounded by intense reactive sclerosis. Bone scintigraphy is the best method for localization and diagnosis of the lesion. The classic scintigraphic appearance of a double density is very specific for osteoid-osteoma and is used as a guide for a dedicated computerized tomography (CT) study [9]. There are descriptions of scintigraphically false-negative osteoid-osteomas. These are rare situations with no definite explanation. This may occur when the nidus is smaller than 5 mm and with minimal reactive sclerosis [4].

The treatment of osteoid-osteomas can be medical since after 2 or 3 years the pain may subside with oral nonsteroidal anti-inflammatory drugs [10]. However, surgical treatment is very attractive because the pain disappears immediately after surgery and the patients may resume their normal life. The most frequently performed surgical techniques are in-block resections and nidus curettage with or without adjuvants [2, 20]. Some prestigious institutions prefer percutaneous CT-scan-guided thermal ablation of the nidus with a radio-frequency probe as the treatment of choice. However, this method should not be used in the vicinity of neurovascular structures [19].

Except for percutaneous CT-scan-guided procedures, a major concern during open osteoid-osteoma operation is localization and resection of the nidus with minimal disruption of surrounding tissues to avoid complications [19].

Several methods for localization of the nidus have been described in the literature. These consist of resection of a bone segment or curettage based on landmarks determined by a preoperative image (radiography or CT) [22]; after oral tetracycline with the identification of the golden-yellow fluorescent nidus seen under ultraviolet light [1]; preoperative CT-guided needle or Kirschner wire marks made on the bone surface near the nidus [13].

In the present study, we describe the use of an intraoperative hand-held gamma probe for precise localization of the osteoid-osteoma nidus in comparison to a control group using, at most, radiographs or fluoroscopy for nidus localization.

Material and methods

Thirty-seven patients who were submitted to surgical treatment for osteoid-osteoma were included in this study. Twenty-five patients were males and 12 were females with ages ranging from 4 to 57 (mean 19) years. Patients were divided into two groups. The first group, the gamma-probe group, consisted of 19 patients operated on with the use of a gamma probe as the intraoperative guide for nidus localization. Operations were performed in five different hospitals with the same gamma probe (Europrobe). The control group consisted of 18 patients submitted to resection with, at most, the use of radiography or fluoroscopy as intraoperative guides for nidus localization.

The femur was the bone most frequently involved (17/37 patients) (Fig. 1).

Patients of the gamma-probe group were submitted to a prior three-phase bone scintigraphy for osteoid-osteoma diagnosis. A second bone scintigraphy was performed on the day of the operation. Patients received an intravenous injection of 1,110 MBq of ^{99m}Tc -MDP (adult dose). The children's doses were adjusted according to weight. After 2–3 h, a whole-body scan and static images in the anterior and posterior positions were obtained in a camera-computer system equipped with a low-energy, high-resolution collimator.

All procedures were performed in the operating room. Patients received general or spinal anesthesia. Patients of the gamma-probe group were taken to the operating room after completion of bone scintigraphy. Three patients needed urinary catheterization prior to surgery due to high levels of radioactivity in the urine, which could interfere with the detection of lesions in the pelvic bones or in the proximal femur. A permanent ink mark was drawn over the skin area with the highest radioactive counts to indicate where the surgical incision had to be made. Counts over the normal bone, the sclerotic area, and the nidus were noted. The sclerotic bone over the nidus was resected with a high-speed burr or an osteotome. The nidus was identified and curetted. The nidus cavity was widened until its counts decreased to the level of the counts of the sclerotic area (Fig. 2).

In the control group, nidus identification and resection were performed by open technique using only osteotomes and curettes. Intraoperative radiographic control was performed in two patients with tumors located in the proximal femur. One tibial in-block resected specimen was studied with radiography. Only in one patient was a percutaneous resection of the tibial medial malleolus performed using a trephine.

Fig. 1 Sites of distribution of osteoid osteomas in each group.

Fig. 2 Gamma probe group technique. **a,b** Radiography of an osteoid osteoma in the posterior tibial shaft. **c,d** Typical bone scintigraphy displaying the double-density pattern. **e** CT scan showing reactive sclerosis around the nidus. **f** The most radioactive point mark (arrow) made by the nuclear physician. **g** Bone-surface exposure. **h** Gamma probe over the most radioactive point (nidus). **i** Beginning of nidus exposure. **j** Nidus exposed. **k** Cavity remaining after nidus curettage. **l** High-speed burr making a deeper cavity. **m** Appearance of the surgical incision after suture

The complications were classified as minor and major. Minor complications were those that did not cause functional compromise. Major complications were defined as causing functional compromise or in which a surgical intervention was needed. The parameters used to define a successful procedure were, in decreasing order of importance: nidus identification on histopathology; postoperative images showing no nidus. Postoperative images performed were radiographs, CT scan, or three-phase bone scintigraphy. When histopathologic analysis was inconclusive, the absence of the nidus on postoperative images was evaluated. Statistical analysis was aimed at comparing the success rate between control and gamma-probe groups. Incidence of complications was also compared and significance level used was 5%.

Results

Table 1 displays the results. Mean follow-up was 25 (0–98) months. Patients in the gamma-probe group were followed up for a mean of 13 (1–28) months. Patients in the control group were followed up for a mean of 39 (0–98) months. There was a significant difference between the follow-up time intervals of the two groups ($p=0.0015$).

Five complications were found in four patients. The presence of complications was analyzed in only 36 patients because one of the patients in the control group was lost to follow-up. Complications in the gamma-probe group were a slight limitation of the extension of the metacarpophalangeal joint in one patient and a postoperative thigh hematoma in another patient. Three complications were found in the control group: patellofemoral pain in one patient and a femoral neck fracture followed by avascular necrosis of the femoral head in one patient. No significant correlation was found in the complication rates of the two groups. The success rate was higher in the

Table 1 Absolute and relative results of tested parameters

Parameter	Group			
	Gamma probe		Control	
	Number	Percent	Number	Percent
Number of patients	19	100	18	100
Nidus detected on histopathology	16/19	84	12/18	67
No nidus in control images	14/16	87	8/14	57
Success rate	17/19	90	12/18	67
Complications	2/19	11	3/17	18
Minor complications	2/19	11	1/17	6
Major complications	0/19	0	2/17	12

$p > 0.05$, all tests.

gamma-probe group. However, no significant difference with the control group was found ($p = 0.12$) [(Table 1)].

Discussion

There are several articles and many case reports studying osteoid-osteomas. The majority of these studies are case series limited to the description of the results of a specific surgical technique. Only one retrospective cohort study compares different surgical approaches [17]. The studies using open surgical procedures are case series and fail to compare methods to reach the nidus. The present study is a retrospective cohort study and compares two methods of open procedure because open procedures are still the most frequently performed for resection of osteoid-osteomas by the general orthopedic surgeon. Even with the use of percutaneous resections, open surgery will still be necessary in some instances; for example, when the nidus is located near vital structures.

Some authors claim that there is no need for ancillary methods to locate the nidus [2, 21, 22]. Yildiz et al. [22] recommended in-block resection of femoral neck and talar osteoid-osteomas due to difficulties in finding the nidus. Intraoperative guides would be mostly indicated in these locations in order to perform an economic resection and avoid complications [1, 3, 6–8, 12–15].

Bone scintigraphy followed by intraoperative nidus detection with a hand-held gamma probe is the method that aggregates at least three advantages: a single nuclear medicine laboratory can provide assistance to different hospitals; the procedure can be performed in the vicinity of vital structures; a lower dosimetry in comparison to patients treated with CT-scan-guided procedures.

The present study describes a method that makes the intraoperative nidus visualization easier. It requires surgical precision with the advantage of less aggressive bone resections, preserving more bone tissue. In the present study, postoperative complications occurred in the first months of follow-up in both groups, and there were no differences between the two groups regarding complication rates. This must be viewed with caution because the

follow-up period of the control group was longer than that of the gamma probe group. Since the follow-up periods were different, clinical parameters of success were not used in this study. Therefore, in patients without pain after surgery, regardless of the group, the procedure was considered unsuccessful if no objective parameter (positive histopathology or absence of nidus on postoperative images) was positive.

The success rates of both groups were similar. However, all results were favorable in the gamma-probe group. A positive correlation between histopathology and good treatment results has been described [5, 17]. Two patients from the gamma-probe group had tumor resection based only on local radioactivity. No nidus was seen, but the nidus was identified on histology. These are situations in which, even without nidus identification, the lesions were resected with minimal bone damage.

Positive histopathological analysis is definitive proof that the nidus was reached; however, a negative histopathology does not mean that the nidus was not removed. Pitfalls during the selection and processing of the samples have been described [18]. The control group presented a positive histopathology in 67% of the patient group and in 81% of the gamma-probe group. Both rates obtained in the present study are lower than other reports of osteoid-osteoma identification with gamma probe [8] and with in-block resection [2, 22] in which the histology was 100% positive. However, these studies did not specifically mention histological criteria of positivity. In the present study, the positive histology (84%) was higher than the 70% obtained with CT-guided radiofrequency ablation.

The images performed after surgery defined whether or not the nidus was removed. They had a major impact on the management of patients whose histology was negative, especially those without pain after surgery. In the present study, one patient had a negative histological analysis, no nidus was surgically identified, but the postoperative CT scan demonstrated that the nidus had been resected.

The overall success rate was 90% for the gamma-probe group and 67% for the control group. The two unsuccessful cases in the gamma-probe group occurred in the first three patients that were operated on, indicating that the procedure has a learning curve.

Percutaneous radiofrequency ablation is a major contribution to the treatment of osteoid-osteoma. However, this method is still unavailable for the majority of orthopedic surgeons around the world. Also, radiofrequency ablation has its failure rate and in some instances cannot be applied because of the tumor location [11, 19]. The surgeon or radiologist must have experience with needle and trephine biopsy procedures [16].

In the present study, functional recovery time and incision extension were not evaluated because it was technically impossible to obtain this information in all patients from the control group. The impression is that the incisions were smaller in the patients of the gamma-probe group with osteoid-osteoma of the limbs. Smaller incisions may lead to a faster functional recovery.

Bone scintigraphy followed by intraoperative nidus detection with a hand-held gamma probe gives the surgeon precision when resecting osteoid-osteomas. It is a good choice when the percutaneous radiofrequency ablation is not available or cannot be performed. However, the learning curve is slower than for sentinel node excision.

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