We describe 100 consecutive patients with osteoid osteoma. Of the 97 who had operations, 89 were treated by intralesional excision and eight by wide resection. The three remaining patients were not operated on because the osteoid osteoma was almost painless, or was found in the pedicle of the 12th thoracic vertebra at the site of entrance of the artery of Adamkiewicz. The diagnosis was confirmed histologically in all specimens. No local recurrences were observed at a minimum follow-up of one year. All except one patient were mobilised two to four days after surgery.

A precise preoperative diagnosis of the lesion is mandatory, based on clinical findings, standard radiographs, thin-section CT and a bone scan.

We compared our operative technique with 247 cases in which the percutaneous technique of removal or coagulation of the nidus had been performed. The latter procedure has a less constant rate of primary cure (83% vs 100%). Its principal indication appears to be for osteoid ostomas in the proximal femur and the pelvis.

An osteoid osteoma is a small, benign, painful tumour. Its size is the main distinguishing feature between it and an osteoblastoma and varies between 1.5 and 2 cm.\(^1\)\(^-\)\(^5\)

It is characterised by pain which is continuous, not dependent on physical exercise, usually worse at rest, especially at night, and relieved by non-steroidal anti-inflammatory drugs (NSAIDs).\(^6\) There are rare examples, especially in young children, in which there is little or no pain.\(^7\)\(^-\)\(^9\)

Osteoid osteoma causes an intense and chronic inflammatory response in the surrounding tissues with a periosteal reaction, sclerosis of bone and synovitis\(^10\)\(^,\)\(^11\) because of the production of prostaglandins by the tumour,\(^12\)\(^,\)\(^13\) which regresses spontaneously after removal of the nidus.

The natural history of osteoid osteoma, left untreated, is only partially known. Most patients have operations within one to three years from the start of symptoms because of pain and intolerance of prolonged consumption of NSAIDs. Osteoid osteomas treated conservatively, however, eventually become asymptomatic after a mean of three years;\(^5\) exceptional cases become transformed into osteoblastoma.\(^3\)\(^,\)\(^14\)\^-\(^17\) They do not undergo malignant change. Removal of the nidus is mandatory except in exceptional cases in which the lesions are painless or minimally painful, where the anatomical site is such that a surgical approach can be risky and in patients who elect to have prolonged treatment with NSAIDs, despite possible severe gastrointestinal side-effects.

There are three main approaches to removal of the nidus:

1) Wide en-bloc resection with the surrounding bone.\(^3\)\(^,\)\(^18\)\^-\(^20\)
2) Unroofing of the nidus by gradual removal of the overlying reactive bone and excision with curettes and burrs.\(^1\)\(^,\)\(^17\)\(^,\)\(^22\)
3) Percutaneous CT-guided core-drill excision, or destruction of the nidus by radiofrequency, laser or absolute ethanol.\(^23\)\^-\(^45\)

We have no experience with the percutaneous technique, which has only recently shown promising results. We present our experience of 100 consecutive patients in whom surgery was undertaken by the senior author (MC).

Patients and Methods

We reviewed 100 consecutive patients with osteoid osteoma, all of whom had been diagnosed and treated between 1980 and 1997. Figure 1 gives details of gender, age range and site. Typical pain occurred in 98 patients. Two children,
six and eight years of age, respectively, with the usual features of osteoid osteoma of the tibial shaft had mild and discontinuous pain. The mean duration of symptoms before surgery was 14 months (four months to five years).

The diagnosis and operative planning were based on the clinical findings, plain radiographs, isotope bone scan and thin-section (1 mm) CT in all cases.

Of the 100 patients, 17 had been operated on elsewhere. We reviewed the hospital notes, the preoperative and postoperative images, and the histological findings. In 11, the nidus had not been found and the operation did not relieve symptoms. In six, the nidus had been partially removed and there had been some relief of symptoms, but both symptoms and the features on imaging recurred two to 60 months after surgery.

We operated on 97 patients. The remaining three included two children with an almost painless osteoid osteoma of the tibia in whom the lesions, left untreated, did not show significant radiological changes at a follow-up of three and five years, respectively. The third was an 18-year-old man with an osteoid osteoma in the right pedicle of the 12th thoracic vertebra. Selective angiography showed an artery entering the intervertebral foramen at the site of the osteoid osteoma. He was considered to be at risk of neurological complications, and has been treated conservatively with NSAIDs. The radiological appearance of the lesion has not changed over 18 months.

The technique of unroofing and intralesional excision of the nidus was used in 89 patients and eight had a very limited en-bloc excision. Of these eight, in three the lesion was deep in cancellous bone in the tarsus or iliac crest, in four it was in the shaft of the fibula, and in one the nidus bulged from the cortex of the neck of the femur. When intraloesional excision was used, the gross appearance of the nidus was considered to be diagnostic. We never used confirmatory frozen-section biopsy. When en-bloc resection was carried out the resected specimen was radiographed in the theatre to confirm that the whole nidus had been included. Occasionally, intraoperative radiography and, in one patient, intraoperative CT were performed to confirm the removal of the nidus. We never used an intraoperative isotope bone scan or tetracycline bone labelling.

Internal fixation or bone grafting was never used. Postoperatively, 96 patients did not have external support and resumed gradual mobilisation and full weight-bearing within one to four weeks. Only one patient, aged ten years, who had subluxation of the hip because of prolonged symptoms and severe chronic synovitis for three years from an osteoid osteoma of the neck of the femur, was immobilised in an abduction plaster.

All patients were followed up for a mean of six years (1 to 15).

Operative technique of intralesional excision (Figs 2 to 4). The nidus was found by CT. The surgical approach
should expose the bone which is close to the nidus (Figs 3 and 4). The surface is cleaned of periosteum or synovium.

Some gross features are helpful for localising the nidus. These include an irregular periosteal reaction at the surface of the metaphysis. In the diaphysis the nidus is beneath the apex of the fusiform elevation of the cortex (Fig 4c). Sometimes a small vessel perforates the cortex and brisk bleeding indicates the nidus.

The nidus will appear as a punctiform spot with a reddish colour which contrasts with the white surrounding bone (Fig. 2b). The reactive bone, usually sclerotic and covering the nidus, is removed gradually. We use gouges to remove thin layers of bone tangentially (Figs 2a and 3c) unlike Ward et al\textsuperscript{22} who prefer to use a high-speed burr. Removal of the reactive bone should be done with caution in order not to destroy or miss a very small nidus.

The bone immediately surrounding the nidus was removed. The nidus was exposed as completely as possible (Figs 2c and 3c) and then curetted out of its bed (Fig. 2d). This method allows the surgeon to see the characteristic gross features which differ from the normal and reactive bone. The pathologist is then able to examine the nidus and not simply pieces of the reactive bone which have been removed. The walls of the nidus are bevelled out for 1 to 2 mm in all directions (Fig. 2e). The slivers of the reactive bone which have been removed can be used as grafts to fill the cavity (Fig. 2f), although this is rarely done and is usually unnecessary.

**Results**

The diagnostic accuracy of osteoid osteoma is excellent.\textsuperscript{1,2,4,5,21,22,48,50,51} In our series, there were no diagnostic errors. All 97 patients with the diagnosis of osteoid osteoma who had operations had histological confirmation.
MRI is not indicated because it is only equal or inferior to CT in demonstrating the nidus. It is very sensitive and shows the perilesional inflammatory reaction which may obscure the diagnosis.\textsuperscript{11,50,52,53}

Except for one patient who required a cast, all the patients were mobilised very early at a mean of two days after operation. For sites in the lower limb, full weight-bearing was possible after a mean of 20 days.

All patients had immediate and complete relief of pain after surgery. There were no complications and no local recurrences at a minimum follow-up of one year. Patients remained in hospital for a mean of five days.

All patients resumed normal function in one to three months. The patient with subluxation of the hip secondary to chronic synovitis and muscular contracture had a stable reduction after three months in plaster, and a normal range of movement after three years, but with radiological features of coxa magna.

Discussion

We considered a minimum follow-up of one year to be adequate because local recurrence of the osteoid osteoma occurs within this time.

The correct surgical treatment of osteoid osteoma is to expose and curette the nidus by the gradual excision of minimal reactive bone. This ensures removal of the entire lesion, without recurrence. There is no need for internal fixation or bone grafts. Postoperative mobilisation is immediate with early recovery of full function.

Wide en-bloc resection of the nidus has several disadvantages. It is difficult to know the exact size of the piece of bone to remove. It weakens the bone, and may make it necessary to use internal fixation, bone grafts, and postoperative immobilisation.\textsuperscript{3,18-20}

In our experience intraoperative scintigraphy or tetracycline labelling is not required.\textsuperscript{18,19,46-49}
frozen section biopsy may be used in rare cases, but we have never found it necessary.

It is of interest to compare our surgical treatment with the techniques of percutaneous removal of the nidus which have recently been introduced. From the literature, we found 247 cases of osteoid osteoma treated percutaneously under CT guidance. In most cases a core-drill excision was undertaken. Radiofrequency coagulation, interstitial laser photocoagulation or ethanol injection can also be used and have the advantage of the use of a thinner drill with removal of less bone. In over half of the cases general anaesthesia was used. There were very few complications; only one fracture and one palsy of the extensor hallucis longus were recorded. The percutaneous method was mainly used in the appendicular skeleton and the pelvis. It was rarely applied to a lumbar vertebra. Histological confirmation was obtained in only about 40% of the cases.

The results are incomplete because several papers report a follow-up as short as three months. The available data included 204 patients (83%) who achieved a primary cure, 22 (9%) who received a second, successful, percutaneous procedure, 15 (6%) who were secondarily submitted to surgical excision and six (2%) who had no change in pain after percutaneous treatment.

From this review of the literature, we can conclude that the percutaneous method has some obvious advantages such as reduced cost and shorter stay in hospital. It is often done as an outpatient procedure, or only needs one to three days as an inpatient, and is sometimes carried out under local anaesthesia. It appears to be particularly suited to deep sites, such as in the neck of the femur and in the pelvis.

The percutaneous method is not indicated in most osteoid osteomas of the spine and of the small bones. It should also be avoided when the lesion is close to a neurovascular bundle.
where the core-drill excision should enter the side of the bone opposite the lesion, and in those more than 1 cm across in which multiple perforations and supplementary percutaneous curettage should be used.

The final results show that the percutaneous method is slightly less effective than our surgical method, with only 83% with a primary permanent cure compared with our 100%. There are few complications with both methods. One disadvantage of the percutaneous method is the lack of histological confirmation in over half of the cases. This is not crucial, because the diagnosis on clinical grounds and with imaging is very sound. We have had experience of two patients, not included in this series, who were initially treated elsewhere by percutaneous drilling of the nidi, in whom a typical osteoid osteoma recurred and then transformed into an osteoblastoma.

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