A computer-assisted technique using computed tomography and three-dimensional imaging for the localization and excision of osteoid osteoma allows minimal bone resection, shortened hospital stay, and prompt weight bearing.

Osteoid osteoma is a small, benign bone neoplasm that consists of a well-demarcated nidus surrounded by a reactive zone of sclerosis. It is of unknown etiology and accounts for approximately 10% of symptomatic benign bone tumors. Initial treatment of patients with osteoid osteoma consists of nonsteroidal anti-inflammatory drugs (NSAIDs). If the pain is unresponsive to medical therapy or if patients cannot tolerate prolonged NSAIDs, surgical treatment is indicated.

Classically, complete surgical excision has been the operative treatment of choice. However, lesions located in anatomic areas that are technically difficult to access, such as the femoral head or neck, carry considerable surgical morbidity. En bloc surgical resection has resulted in extended hospital stays, perioperative fractures, the need for bone grafts, internal fixation, or both, and delayed functional recovery. Localization of osteoid osteoma has been aided in the past by nuclear scanning, fluorescence with tetracycline, linear tomography, and intraoperative fluoroscopy. In the past decade, computed tomography (CT) guided radiofrequency ablation, alcohol ablation, and laser photocoagulation have been used extensively.

This article presents a technique for the localization and excision of osteoid osteoma. Computer-assisted guidance allows intraoperative location of the nidus via optically tracked instruments. The nidus, once located, is precisely and accurately excised.
Computer-assisted localization involves preoperative image processing and intraoperative guidance. Diagnostic CT was processed and three-dimensional isosurface models of the tibia were constructed. An optoelectronic tracking system allowed intraoperative guidance of the tibia and calibrated surgical instruments in real-time three-dimensional space.

At surgery, an optoelectronic-targeting device was percutaneously affixed to the tibia using a small fragment external fixator (Synthes, Paoli, Pa). This device allowed the guidance system to use an optoelectronic tracking system (Northern Digital, Waterloo, Canada) to track the tibia and calibrated surgical instruments in real-time three-dimensional space (Figure 3).

An optically tracked needle probe was used to percutaneously contact the tibia to register it to the preoperative plan via a robust registration algorithm. Registration is the computational process that relates the preoperative imaging and plan with the exact position of the patient at surgery. A battery-powered drill (Black and Decker, Milwaukee, Wis), which had been previously modified by the attachment of an optoelectronic target, was tracked by the guidance system. The computer tracked the drill and superimposed an image of the drill onto the translucent visualization model and CT coronal, sagittal, and axial reformat (Figure 4).

Through a limited anteromedial approach, the nidus was localized with the computer-assisted guidance system. A small 3-mm hole was drilled to the nidus using the tracked drill (Figure 5). A tracked 8-mm drill was used to enlarge the bone tunnel. The soft nidus was curetted and sent for pathology. The computer-related hardware was removed and the wounds were closed with Steri-strips (3M, St Paul, Minn). Fluoroscopy was only used at completion to document bone tunnel placement.

The patient was discharged later the same day with weight bearing as tolerated. At 6-week follow-up, the patient was pain free and final pathology confirmed osteoid osteoma. The patient continued to do well and had no pain at final 24-month follow-up.

**DISCUSSION**

Computer-assisted surgery describes a collection of techniques for combining images and three-dimensional tracking devices to improve surgical performance. The first applications were in stereotactic brain surgery; however, many systems have been developed for applications in orthopedic surgery. Robots and guidance systems have been used in total hip and knee arthroplasty, spine surgery, high tibial osteotomy, and distal radius malunion correction.

The computer-assisted technique relies on the initial diagnostic CT, which is processed into three-dimensional images. A volume or surface is then extracted to produce a computational model of the anatomy. Intraoperatively, the patient is registered to the preoperative image by determining a rigid-body transformation. Optical trackers, which are also mounted on modified surgical instruments, are attached to the patient to allow intraoperative tracking with an optical tracking system. Knowing the transformation between the patient and image, the computer displays the three-dimensional location and orientation of an instrument by superimposing a graph-
ic representation of the instrument on the preoperative computer-generated image (Figure 4). Although the tip of the instrument is obscured from direct view, the location of the instrument and anatomy surrounding it can be visualized.

This technique allows precise and accurate localization of lesions within bone. It is especially useful for small lesions located deep within cortical bone where subtle or no surface changes may be present to guide the surgeon. The procedure is conducted without fluoroscopy, thereby decreasing radiation exposure to the surgeon, staff, and patient. Fluoroscopy is used at the completion of the case to document bone tunnel placement.

The planning, registration, and guidance software used in this case were developed for the purposes of research. Commercially available guidance systems have been developed for hip and knee arthroplasty and pedicle screw placement. No other reports of computer-assisted surgical techniques to localize deep bone tumors have been reported.

Our technique has a substantial advantage compared with others in that it enables the surgeon to locate the nidus quickly and accurately, thus facilitating excision. The percutaneous excision via computer guidance allows minimal bone resection, a shortened hospital stay, and expeditious weight bearing.

REFERENCES

Section Editor: Steven F. Harwin, MD

Figure 3: A battery-powered drill has been modified by the attachment of an optoelectronic target, which allows the guidance system to track it in real-time three-dimensional space (A). A model tibia is used to depict the percutaneous attachment of another optoelectronic target (B). Figure 4: The intraoperative guidance system shows the tracked drill, represented by the red missile, and superimposes an image of it on coronal, sagittal, and axial CT reformats. Figure 5: The drill is tracked as it progresses through the tibia with the cross hairs representing the tip of the drill bit. The drill enters the posteromedially situated nidus cavity from a tunnel created through the anterior tibial cortex.