



CASE REPORTS

Keyhole resection of intra-articular osteoid osteoma in the ulnar trochlear notch using 3-dimensional computed tomography-based navigation



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Osteoid osteoma is a relatively common benign bone tumor that mainly occurs in the long bones and is characterized by nocturnal pain that is improved by nonsteroidal anti-inflammatory drugs (NSAIDs). However, intra-articular osteoid osteomas are rare, with an incidence of approximately 13% of osteoid osteomas.² Intra-articular osteoid osteomas sometimes present with symptoms similar to monoarticular inflammatory arthritis, such as joint tenderness, soft-tissue swelling, synovitis, and joint effusion, which may lead to misdiagnoses or treatment delays.

Computed tomography (CT)-guided percutaneous radiofrequency ablation (RFA) is becoming increasingly popular for the primary treatment of osteoid osteoma because of preciseness, minimal invasiveness, safety, and effectiveness.¹ However, the RFA probe generates enough heat to damage adjacent tissues, such as articular cartilage,³ and should be avoided for the treatment of intra-articular osteoid osteoma. Therefore, to minimize the surgical intervention, arthroscopic resection has been recommended for the treatment of some intra-articular osteoid osteomas.

Osteoid osteomas in the elbow articular surface are rare, especially in the ulnar trochlear notch, where there has been only 1 report of an osteoid osteoma open resection.⁵ When an intra-articular osteoid osteoma occurs at a space too narrow to insert an arthroscope, open resection with the temporary release of the medial collateral ligament or olecranon osteotomy are needed to expose the tumor, although these procedures require more recovery time. If possible, minimally invasive tumor resection procedures would be more effective.

We report here for the first time an osteoid osteoma in the ulnar trochlear notch, treated by minimally invasive keyhole resection using 3-dimensional CT-based navigation. The patient consented to publication of this case report.

Case report

A 29-year-old man visited our clinic with right elbow pain and swelling that persisted for 1 year. We found diffuse swelling in the right elbow, but no obvious local tenderness, local heat, or redness. The passive range of motion of the right elbow was 90° in flexion, –50° in extension, 85° in pronation, and 85° in supination. Active and passive movements of the elbow joint both generated pain around the joint. He recalled no episodes of elbow joint injury and no history of any predisposing systemic illness.

No Ethical or Review Board Approval was required for this case report.

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Figure 1 Preoperative imaging of the elbow joint. (A) Preoperative lateral radiograph. (B) Reconstructed sagittal computed tomography (CT) image. (C) Axial CT. (D) Three-dimensional CT of the proximal part of the ulna.

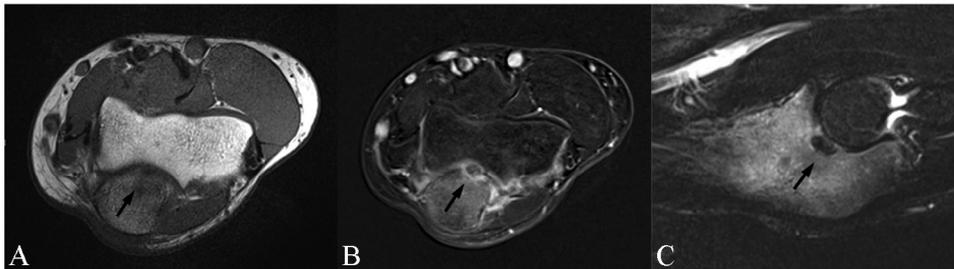


Figure 2 Preoperative magnetic resonance image of the elbow joint. (A) Axial T1-weighted image. (B) Axial gadolinium-enhanced T1-weighted fat-suppressed image. (C) Lateral T2-weighted fat-suppressed image. The → indicates tumor.

Plain radiography showed no obvious findings (Fig. 1, A). A CT scan revealed a low attenuation nidus with internal central calcification in the ulnar trochlear notch (Figs. 1, B-D). T1-weighted spin-echo magnetic resonance imaging (MRI) showed a nidus of low signal intensity (Fig. 2, A). A gadolinium-enhanced T1-weighted fat-suppressed MRI showed enhancement of nidus surroundings (Fig. 2, B). A T2-weighted fat-suppressed MRI showed a high-intensity large area in the proximal ulna indicating bone marrow inflammation (Fig. 2, C).

We diagnosed this as an intra-articular osteoid osteoma using clinical and imaging findings and from the temporal effectiveness of NSAIDs. Because the elbow pain and swelling gradually became worse, an operation was performed. Before the operation, we first created a virtual object of the right ulna bone from CT scan data using simulation software (iPLAN cranial; BRAINLAB, Munich, Germany; Fig. 3, A). This virtual

object was created from CT scan data using automatic segmentation with band thresholding and modified using the brush or erase functions. Then, trajectory planning functions were used to add an 8-mm diameter trajectory positioned between the nidus and the posterior cortex of the proximal ulna as a bone tunnel for tumor resection (Figs. 3, B and C).

At the beginning of the procedure, two 2.4-mm-diameter threaded rods were inserted at the center of the ulnar diaphysis, and 3 reference balls were attached to the stem (Fig. 4, A). Next, an image intensifier-based CT image (ARCADIS Orbic; Siemens, Munich, Germany) of the right elbow joint was taken. Then, the newly acquired 3D CT images were combined with the preplanned object on the navigation system display (KICK; BRAINLAB).

After confirmation of the entry point and the direction of the preplanned bone tunnel with a navigation probe, an 8-mm-diameter bone tunnel was created using a surgical bar (Fig. 4,

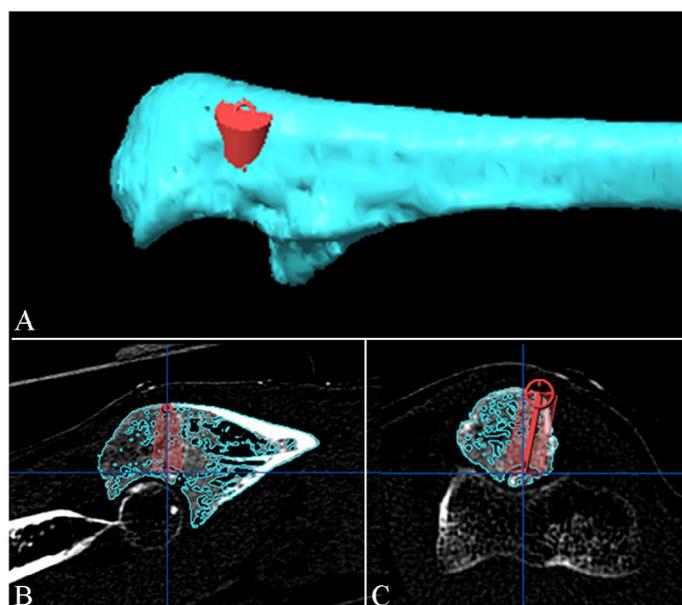


Figure 3 Preplanned images. (A) A created ulna bone object (light blue). An 8-mm-diameter trajectory was positioned between the nidus and the posterior cortex of the proximal ulna as a bone tunnel for tumor resection (red). (B) Sagittal image. (C) Axial image.

(B). Under a microscope and with the assistance of the navigation system, the bone tunnel was made until a part of the bone tumor was confirmed (Fig. 4, C). The base of the tunnel was then enlarged, and the tumor was resected using a small curettage (Figs. 4, D and E). Histologic investigation showed

variable fibrous bone widths and osteoblast rimming with rich small vessels and giant cells consistent with that of an osteoid osteoma (Fig. 5).

After the operation, a long arm splint was applied for 1 week, after which elbow active range of motion exercises

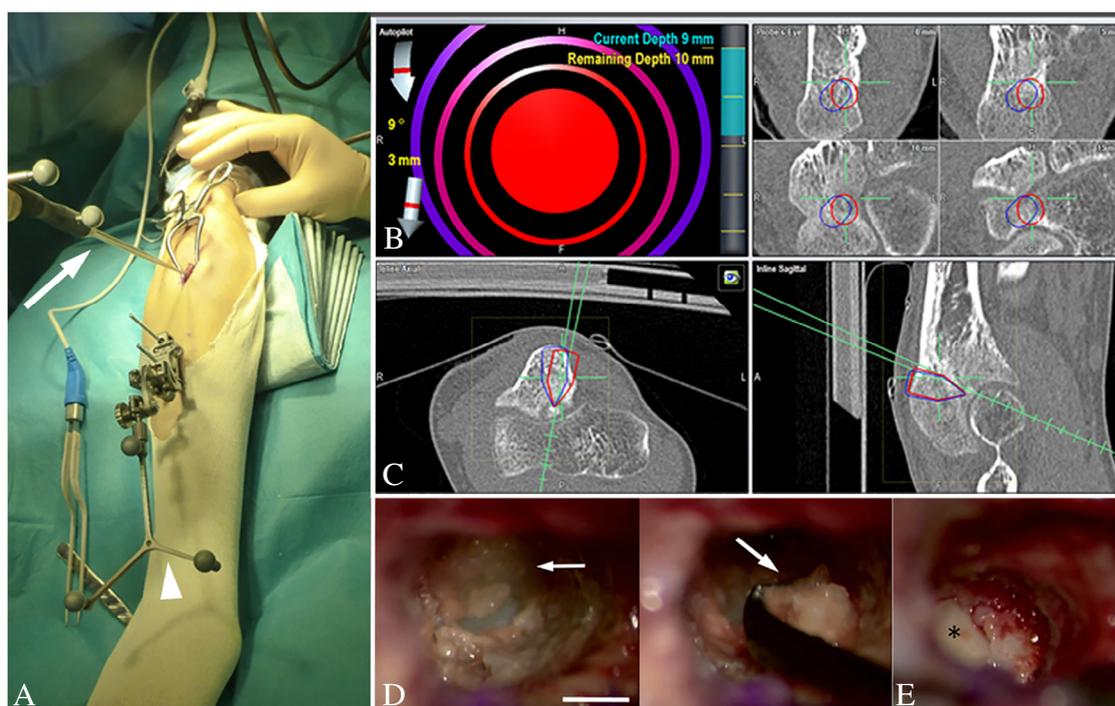


Figure 4 (A) Intraoperative photo after installation of a stem with 3 reference balls on the ulna bone (▷). The ⇔ indicates a navigation probe. (B) Intraoperative monitor image during bone tunnel creation using a surgical navigation system. (C) Microscopic photo of partially revealed bone tumor. The ⇔ indicates tumor. (D) During tumor resection (Bar: 3mm). (E) After tumor resection. *Indicates articular surface of the humeral trochlea.

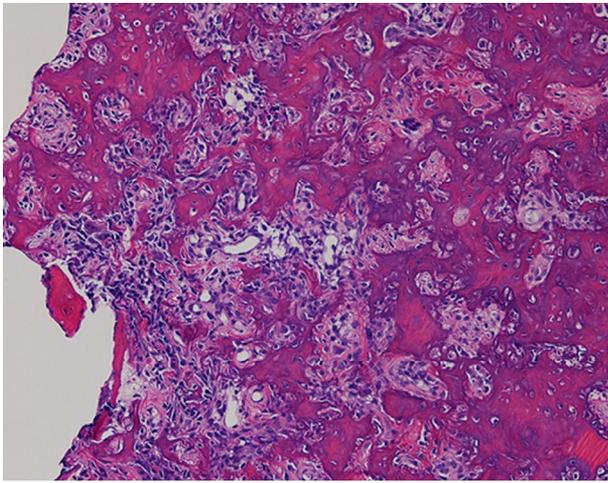


Figure 5 Histology of the bone tumor (hematoxylin-eosin stain, original magnification $\times 200$).

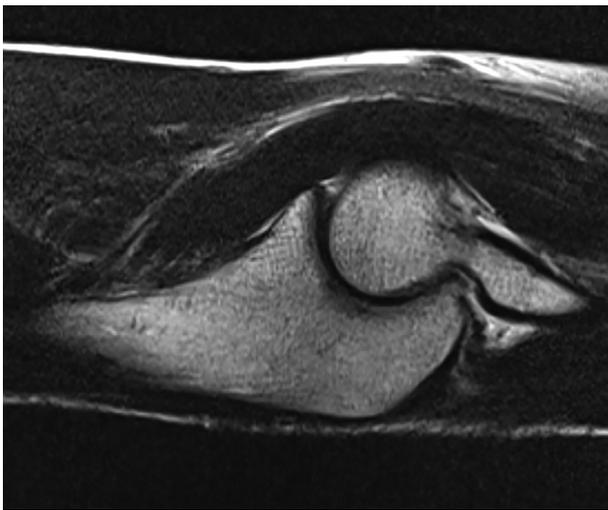


Figure 6 Lateral T2-weighted fat suppressed magnetic resonance image of the elbow 3 years after surgery.

began. Within 2 weeks after surgery, pain and swelling were significantly reduced, and the range of motion was normalized within 1 month. At 3 years after the operation, the patient has no pain or swelling and a normal range of motion of the elbow joint. There is no sign of recurrence in radiographic or MRI images (Fig. 6).

Discussion

This is the first report of a keyhole resection of an intra-articular osteoid osteoma with intraoperative navigation assistance. 3D CT navigation is widely used to assist surgeons in obtaining the correct current location and orientation of surgical instruments in knee, hip, or spine operations. However, it is rarely used in elbow surgery because palpation of representative bony landmarks that identify the bone position and orientation is not difficult during open or

arthroscopic surgery because soft tissues around the elbow joint are thinner than those around the knee, hip, or spine.

The ulnar trochlear notch has 2 facets: the olecranon side facet and the coronoid process side facet.⁶ Between the 2 facets is an isthmus sandwiched by bilateral nonarticular surfaces. In our patient, the osteoid osteoma occurred at this isthmus. Because the ulnohumeral joint space is too narrow to insert an arthroscopic or surgical instrument, open surgery with temporary detachment of the medial collateral ligament origin, or olecranon osteotomy, is required to expose the lesion. However, a less invasive operation would be preferable for faster recoveries.

Keyhole tumor resection is a minimally invasive surgical procedure usually performed with the assistance of a microscope or endoscope for the treatment of tumors deep inside the brain. Although the entry point is a small hole made into the skull, a larger inner area can be viewed by repositioning the microscope to a more suitable location. Support systems, such as stereotactic frames or navigation systems, are also needed to confirm the correct orientation to the lesion.⁴

In our patient, we were able to successfully make a small tunnel in the olecranon from the posterior side cortex to the nidus in the anterior articular surface with the assistance of 3D CT navigation. Although the navigation system is fairly accurate, errors of less than 1 mm seem to be unavoidable. Therefore, after reaching the outer surface of the tumor tissue with navigation system assistance, minimal enlargement of the tunnel base was microsurgically performed, allowing for adequate tumor resection. This was accomplished by changing the position of the microscope despite the very small entry hole.

One disadvantage of navigation surgery is the increased time required for preoperative planning. In this keyhole resection surgery, we preoperatively made a virtual ulna object and then positioned an 8-mm diameter trajectory between the nidus and the posterior cortex of the proximal ulna as a bone tunnel to allow for tumor resection. Although this preoperative planning was very helpful for the intraoperative navigation, it could be omitted to shorten the time spent in the preoperative stage. In such cases, at least the approximate entry point of the olecranon bone tunnel should be preoperatively determined using reconstructed 3D CT images. Then, it is not difficult to create an ideal bone tunnel by confirming the precise direction and depth of the tunnel in real time under intraoperative navigation.

Another disadvantage is the increased time required for intraoperative registration. Ulnar bone registration required installation of a stem with 3 reference balls on the ulna bone, followed by a CT scan before a bone tunnel could be created. This procedure, performed by an experienced surgeon and assistants, takes approximately 15 minutes. Afterwards another 5 to 10 minutes are required to combine the newly acquired 3D CT images and the preplanned object on the navigation system display. Despite this additional time, keyhole tumor resections using surgical navigation systems have the advantage of minimizing postoperative pain and rehabilitation time

compared with conventional tumor resections with olecranon osteotomies or temporary detachment of the medial collateral ligament origin.

Conclusion

Keyhole resection with 3D CT navigation assistance is a useful procedure in selected cases, such as intra-articular osteoid osteomas, which are difficult to treat using RFA or arthroscopy.

Disclaimer

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