Protrusion of Hardware Impairs Forearm Rotation After Olecranon Fixation. A Report of Two Cases

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Publisher Information
The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www.jbjs.org
Protrusion of Hardware Impairs Forearm Rotation After Olecranon Fixation

A Report of Two Cases

By Felix Matthews, MD, Otmar Trentz, MD, Augustinus Ludwig Jacob, MD, Ron Kikinis, MD, Jesse B. Jupiter, MD, and Peter Messmer, MD

Investigation performed at the Division of Trauma Surgery, University Hospital of Zurich, Zurich, Switzerland, and the Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts

Ten-sion-band wire fixation is a common surgical technique that is used in the treatment of olecranon fractures and during osteotomies. A number of problems that are specifically related to the use of Kirschner wires have been identified, including wire migration, skin ulceration, and the need for hardware removal. We found only one published article that described diminished forearm rotation following the use of the tension-band technique.

We observed several instances of limitation of forearm rotation following tension-band wire fixation of the olecranon at our medical center (Division of Trauma Surgery, University Hospital of Zurich). Hence, we evaluated computed tomography scans of these patients and developed a computational simulation model with use of three-dimensional computed tomography reconstruction of the elbow. Unlike other authors who studied cadaver elbows, we employed a vir-

![Image](https://example.com/image.png)

**Fig. 1** A patient with impaired forearm rotation after tension-band wire fixation of an olecranon osteotomy. A: The true lateral radiograph shows no evidence of undue penetration of the Kirschner wires into the soft tissues (arrow). B: Kirschner-wire protrusion (arrow) as seen in the three-dimensional model derived from the computed tomography scan. Impingement of the wires with the soft tissues is highly probable.

**Disclosure:** The authors did not receive any outside funding or grants in support of their research for or preparation of this work. Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

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tual three-dimensional bone model to demonstrate the anatomy of the proximal aspect of the ulna and to simulate Kirschner-wire placement.

**Case Reports**

One hundred and seventeen consecutive patients (seventy-one men and forty-six women) who had undergone internal fixation of the olecranon between April 2003 and November 2004 were retrospectively analyzed. The average age of the patients was 52.1 years (range, twenty-five to eighty-eight years). Of the 117 patients, forty-one underwent osteotomy of the olecranon for exposure of an intra-articular fracture of the distal aspect of the humerus and seventy-six had fixation of an olecranon fracture. The average follow-up period was thirteen weeks (range, six to seventeen weeks). A total of 117 patients (100%) were available for follow-up at six weeks, and a total of ninety-seven patients (83%) were available for follow-up at twelve weeks. Five patients (four men and one woman; average age, 58.2 years [range, twenty-five to eighty-six years]) were noted to have impaired forearm rotation (less than 30° of pronation) that was associated with palpable crepitation on manual examination. Of these five, one patient was diagnosed before discharge, three patients were diagnosed six weeks after surgery, and one patient was diagnosed twelve weeks after surgery. Four of the patients had been treated with tension-band wire fixation combined with longitudinal Kirschner wires, and the other patient had been treated with plate-and-screw fixation.

Postoperative plain radiographs could not explain the limitation of forearm rotation. Three-dimensional computed tomographic reconstructions revealed perforation of the Kirschner wires through the far ulnar cortex and passage into the interosseous space abutting or actually contacting the proximal aspect of the radius. In the one patient treated with plate-and-screw fixation, a computed tomographic reconstruction demonstrated that the tip of the long lag screw was lying adjacent to the proximal aspect of the radius. Our patients were informed that data concerning the cases would be submitted for publication.

**Case 1.** A sixty-eight-year-old patient had an olecranon osteotomy as an operative approach to a distal humeral fracture. The osteotomy site was secured with tension-band wire fixation. Impaired rotation was observed at the time of the six-week follow-up, and physiotherapy was prescribed for joint mobilization. The forearm rotation remained severely impaired at the time of the twelve-week follow-up, with the range of motion limited to between 30° and 90° of supination. Anteroposterior and lateral radiographs and a computed tomography scan of the elbow were acquired.

No evidence of ventral protrusion of the Kirschner wires was seen on the lateral radiograph (Fig. 1, A); however, a protruding Kirschner-wire tip was demonstrated in a three-dimensional computer reconstruction of the computed tomographic scan (Fig. 1, B). Planar oblique reconstructions based on the computed tomography data set showed that the Kirschner wire tip was protruding 8.9 mm from the ulna and was in direct contact with the cortex of the radius.

**Case 2.** An eighty-six-year-old patient with a multifragmentary olecranon fracture was treated with plate and lag-screw fixation of the fracture. At the time of the six-week postopera-

![Fig. 2](https://example.com/fig2.png)

This patient experienced impaired forearm rotation after open reduction and internal fixation of an olecranon fracture. A: The postoperative lateral radiograph depicts a healed fracture in excellent alignment and no evidence of hardware protrusion (arrow). B: The oblique two-dimensional reconstruction from a computed tomography scan, however, demonstrates contact of the lag screw with the radius (arrow).
Simulation of Kirschner-wire insertion in a three-dimensional model of the proximal portion of the forearm, demonstrating how Kirschner-wire protrusion can be concealed on the lateral radiographic projection. A: On the lateral view (left), only about 1 mm of the Kirschner wire appears to extend beyond the cortical bone, but on the anteroposterior ventral view (right) the wire protrudes approximately 10 mm (arrow). B: The optimized Kirschner-wire insertion direction makes use of a more lateral entry point and directs the wires toward the ulnar midshaft. The lateral view (left) is identical, but the wire does not protrude ventrally (arrow). C: The proximal ulnar cross-section has a teardrop shape. However, the true lateral projection of the elbow does not reveal this morphology and can therefore conceal a prominent Kirschner wire. The black arrows show the projection and/or viewing direction for anteroposterior and lateral radiographic views.

Three-dimensional surface reconstruction of the entire ulna and radius with simulated Kirschner-wire placement. The entire ulna is depicted to demonstrate the ulnar midshaft as a reference for insertion. A: Problematic Kirschner-wire position with protruding tips as a result of aiming the wires at the proximal dorsal rim of the ulna. B: The Kirschner-wire position is optimized by aiming the wires at the ulnar midshaft. C: Normal varus angulation of the ulna (α) occurs approximately 8 cm from the tip of the olecranon.
tive follow-up visit, the forearm had a maximum pronation of 15° and a maximum supination of 60° and impaired forearm rotation was diagnosed.

The postoperative radiographs (Fig. 2, A) were not helpful, as they revealed neither misplacement of the lag screw nor penetration of the proximal radioulnar joint. Only the multiplanar computed tomographic reconstruction (Fig. 2, B) showed contact of the lag-screw tip with the proximal portion of the radius. The screw protruded 7.2 mm beyond the ulnar cortex.

Virtual Model

We sought to assess hardware misplacement with use of a three-dimensional computer simulation of the forearm bones. The three-dimensional model was created from the computer tomography data set with use of the Hounsfield unit threshold to discriminate the bone surfaces from the surrounding soft tissues. This bone model was then loaded into a virtual three-dimensional environment that had been developed by our computer-assisted-surgery laboratory. Kirschner-wire entry points and insertion directions were varied when displaying the three-dimensional model of the bone and wires along with the pertinent two dimensional cross-sectional views of the bones in the proximal portion of the forearm.

The computer simulations clearly demonstrated three points: first, that varying the Kirschner-wire insertion directions in the coronal plane can result in identical lateral radiographic projections (Fig. 3, A and B); second, that the proximal ulnar shaft has a teardrop-shaped cross section (Fig. 3, C), the three-dimensional bone morphology of which cannot be determined easily either on standard radiographs or on the more commonly obtained two-dimensional computed-tomography slices; and third (as previously described by Wang et al.64), that the proximal ulnar shaft has a varus configuration. The first two findings lead to the understanding that the teardrop shape of the ulna can effectively mask substantial penetration of the tip of the Kirschner wire through the ventral cortex. The wire protrusion can thus be easily overlooked when only true lateral and anteroposterior radiographic projections are viewed. All three anatomical findings must be taken into consideration when evaluating optimal Kirschner-wire placement.

In light of the fact that longitudinally placed Kirschner wires have been observed to loosen and back out65, thus limiting elbow extension, it has been recommended that the Kirschner wire be placed obliquely to penetrate the ventral cortex of the ulna. We agree that secure wire-anchoring in the ventral cortex is important to avoid loosening and backing out. We therefore do not recommend directing the Kirschner wires down the medullary canal. However, in our simulations, we observed that the standard placement technique will often point the Kirschner wire toward the proximal portion of the radius (Fig. 4, A). This is particularly true when the normal varus angulation of the proximal aspect of the ulna is ignored (Fig. 4, C). We found that choosing a more lateral entry point into the proximal part of the ulna and using its midshaft as a landmark during insertion can optimize the position of the Kirschner wire and avoid interference with the proximal radioulnar articulation (Fig. 4, B).

Discussion

Our findings in the virtual three-dimensional bone model substantiate the findings from both of our clinical cases and the findings from the cadaver studies published earlier.66 They demonstrate that computer simulation of operative procedures can, at least for some issues, be equivalent to cadaver studies and even offer superior visualization. However, as opposed to in vitro studies, precise intraoperative measurement of wire insertion angles can be challenging. We therefore recommend two techniques for Kirschner-wire insertion: (1) choose a more lateral entry point on the olecranon and (2) direct the wires toward the ulnar midshaft. Excessive ventral protrusion should be avoided by careful intraoperative assessment of forearm rotation, both after Kirschner-wire insertion in tension-band wire fixation and after screw placement with plating.

For postoperative follow-up after olecranon osteosynthesis, routine radiographs are usually sufficient. However, should impaired forearm rotation be accompanied by noticeable crepitation, we recommend acquiring a three-dimensional computed tomographic scan of the elbow to help unveil possible anterior protrusion of Kirschner wires or screws that may otherwise not be appreciated on plain anteroposterior and lateral radiographs.

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Felix Matthews, MD
Ron Kikinis, MD
Surgical Planning Laboratory, Brigham and Women’s Hospital, 75 Francis Street, Boston, MA 02115
Otmar Trentz, MD
Peter Messmer, MD
Division of Trauma Surgery, Department of Surgery, University Hospital of Zurich, Rämistrasse 100, CH-8091 Zurich, Switzerland. E-mail address for P. Messmer: peter.messmer@usz.ch
Augustinus Ludwig Iacob, MD
Department of Radiology, University Hospital of Basel, Hebelstrasse 32, CH-4031 Basel, Switzerland
Jesse B. Jupiter, MD
Hand and Upper Extremity Service, Department of Orthopaedic Surgery, Massachusetts General Hospital, Yawkey Center, Suite 2100, 35 Fruit Street, Boston, MA 02114

Note: The authors thank Joachim Wirth, mathematician of the CARCAS Switzerland research group, for his contribution to the simulation software, and Simon Widermuth, radiologist at the University Hospital of Zurich, for the clinical computed tomography scans. They further thank the AO Development Institute in Davos, Switzerland for making available the three-dimensional bone model employed for computer simulations.

doi: 10.2106/JBJS.E.01238
References


