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Delayed Migration of Fractured K-wire Causing Vertebral Artery Invagination After Anterior Atlantoaxial Fixation: A Case Report

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Key words

- Atlantoaxial fixation
- K-wire migration
- Vertebral artery

Abbreviations and Acronyms

- C1:** First cervical vertebra (atlanto)
C2: Second cervical vertebra (axis)
CT: Computed tomography
CTA: Computed tomography angiography
K-wire: Kirschner wire
VA: Vertebral artery

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INTRODUCTION

Since Barbour¹ first described anterior transarticular screw fixation for patients with atlantoaxial instability in 1971, the procedure has been used with increasing frequency. The anterior cervical technique avoids dissection and detachment of spine extensor muscles and does not expose the occipital nerve, thereby preventing postoperative neuralgia of the second cervical vertebra (C2; axis) associated with the posterior approach.^{2,3} The anterior transarticular approach also is useful in patients with unfavorable anatomy for a posterior fusion, such as a high-riding foramen transversarium or excessively narrow C2 pars or pedicle.⁴⁻⁶

Additional proposed advantages of the anterior Smith-Robinson approach include less potential for infection, decreased risk of vertebral artery (VA) injury, and less potential for nervous tissue injury, because the occipital condyles limit Kirschner wire (K-wire) migration or long-screw placement.^{7,8} The supine position for the anterior approach also is

■ **BACKGROUND:** Most of the physician's attention during spinal surgery, when using wires and screws, is toward the avoidance of injuries of critical structures (nerves and vessels). When such wires are broken during surgery, the most important point is to take them out safely or, if it is impossible, to leave them in secure place and follow the patient closely. Migrations of broken Kirschner wire (K-wire) are well known in literature; however, to the best of our knowledge, migration of a fractured K-wire during anterior atlantoaxial fixation of cervical spine has not been reported in the literature.

■ **CASE DESCRIPTION:** We report a case in which a fractured K-wire was imbedded in the lateral mass of C1 for 3 years and then migrated to endanger the dominant right vertebral artery. By using posterior approach and drilling right part of posterior arch of C1, we manage to secure the vertebral artery. The broken K-wire was extracted successfully. In our case, with optimal follow-up, the burred wire inside hard bone was moved in delayed fashion to come out of the bone, grooving the dominant vertebral artery.

■ **CONCLUSIONS:** Our recommendation is to inspect the K-wire before using it and to try retrieve as much as possible when removing it.

preferred by anesthesiologists for elderly patients with medical comorbidities.

Although the anterior transarticular first cervical vertebra (C1 atlanto);—C2 approach is considered a relatively safe procedure, the use of the K-wire presents a potential source of complications, because they can fracture infrequently and become lodged in bone. Other potential complications include injuries to the carotid artery, esophagus, trachea, or inadvertent extension of the screw into the condyle. We describe a case of a patient who underwent C1—C2 anterior transarticular fusion in which the K-wire fractured and migrated in delayed fashion to endanger the right VA.

CASE REPORT

History and Examination

In 1974, an intact 14-year-old boy, K.L., a heavy smoker, presented to the Helsinki University Hospital neurosurgery clinic after falling off a motorized scooter. At the time, he complained only of neck pain, and radiographs revealed a horizontally

oriented type II odontoid fracture. The patient was managed conservatively in a cervical collar, and his neck pain resolved. He was subsequently lost to follow-up until 2011, when he fell from standing and presented to the Emergency Department complaining of neck pain, bilateral upper extremity paresthesias, and right lower extremity weakness. Findings of the neurologic examination confirmed decreased sensation to light touch and pinprick in the distal arms bilaterally. The right leg displayed strength. A noncontrast cervical computed tomography (CT) scan and magnetic resonance imaging without gadolinium revealed nonunion of the previous C2 dens fracture. The floating distal aspect of the odontoid exhibited 4.5 mm of anterolisthesis.

Operation

The patient underwent an anterior transarticular C1—C2 fusion as well as a C2 odontoid screw placement in January 2012. We selected the anterior approach as an elegant and straightforward surgery with no blood loss or muscular damage⁸⁻¹⁰;

however, the patient had some risk factors for nonunion of the odontoid itself, such as being older than 50 years of age and having an old fracture.¹¹ We sought to stabilize C1–C2 because the patient had new trauma and developed neurologic symptoms. The odontoid screw was placed by fixing it in place, which was an easy part of surgery during lateral transarticular fixation. During the procedure, the distal 16 mm of the K-wire in the right C1–C2 screw was fractured distally. The reasons for wire fracture could be bending (overloading) or repetitive use. It was unable to be retrieved and was left in place. Fluoroscopy at the time confirmed the K-wire to be contained completely within bone and not endangering any neurovascular structures. A new K-wire was passed in a slightly different trajectory and the right screw was placed without difficulty. The remainder of surgery was without aberrations or complications.

Postoperative Course

The patient's subjective complaints gradually improved until his neurologic examination was normal. Postoperative cervical CT revealed good placement of the screws with the lodged K-wire closely approximating the right C1–C2 screw (Figure 1). Three months later in April 2012, anteroposterior and lateral upright cervical radiographs were obtained that revealed stable position of the fractured K-wire (Figure 2). The wire remained in the same position throughout multiple imaging studies until radiographs and cervical CT in January 2015 revealed it had migrated 5 mm so that the distal-most tip of the K-wire was protruding through the C1 lateral mass, lateral to the spinal cord and was lying at the superior-anterior aspect of the posterior arch (Figure 3). The patient was neurologically intact without complaint. CT (Figure 4) and CT angiogram (CTA; Figure 5) then revealed the K-wire was abutting the third segment of the dominant right VA in the sulcus arteriosus just as it becomes vertical before entering the dura. After we weighed the risks and benefits with the patient (including potential injury to and hemorrhage from the VA), he consented to removal of the fractured wire.

Figure 1. Initial postatlantoaxial fusion. (A) and (B) Sagittal view depicting appropriate placement of cervical hardware. The fractured K-wire (white arrow) is seen protruding just slightly posterior to the right transarticular screw. The right panel is zoomed in on the retained K-wire (circle).

Figure 2. (A) Sagittal and (B) anteroposterior views of 3-month upright cervical radiography reveals that the fractured K-wire has not moved.

Figure 3. (A) Sagittal and (B) anteroposterior views of the most recent upright cervical radiograph revealing the fractured K-wire had migrated 5 mm and was superior to the arch of C1.

Figure 4. Cervical computed tomography scan revealing the relationship of the migrated K-wire to C1. (A) Sagittal, (B) sagittal, (C) coronal.

Second Operation

The patient was positioned prone in a Mayfield frame with pins, and a midline suboccipital incision was made to expose the craniocervical junction. The posterior arch of C1 was exposed by the use of a standard subperiosteal technique. A focal area of the right posterior arch of C1 was drilled carefully and the VA and retained

K-wire were skeletonized to facilitate greater understanding of the relationships and mobilization of the vessel. Once the VA was appropriately exposed, we used intraoperative Doppler ultrasound to confirm that there was no flow compromise (Figure 6). The artery appeared visually intact without evidence of insult or pseudoaneurysm. We

considered the use of indocyanine green but did not feel confident in the patency of the VA such that we proceeded without it. We then mobilized third segment of the VA posteriorly so that our working angle was superior to the horizontal and lateral to the vertical portions of the third segment. At this point the vessel was secured in a

Figure 5. The center 2 images are 3-dimensional (3D) reconstructions of the computed tomography angiogram (CTA) obtained after the radiograph revealed the K-wire had migrated. They show the relationship between the wire, bone, and vertebral artery (VA) from a posterior view. (A) Sagittal computed tomography scan provided for bony reference. (B) Sagittal CTA

displays the relationship of the wire with the VA in the anteroposterior direction. (C) 3D reconstruction of an axial slice. The view is from a superior, left angle so that the relationship of the medial VA with the wire can be seen. (D) Axial slice of CTA shows the close apposition of the wire and the VA (white arrow).

Figure 6. Intraoperative imaging taken directly from the microscope after drilling of the right posterior arch of C1. (A) Isolation and mobilization of the right VA (white asterisk) inferiorly and medially. The K-wire is covered (black asterisk). (B) Intraoperative Doppler of the vertebral artery to ensure

its patency. (C) and (D) show the K-wire lodged in bone prior to removal (white arrow). (E) Removal of the wire with forceps. (F) After removal, the K-wire's fractured portion measures 16 mm.

posterior position and tip of the K-wire was covered with Tachosil (Baxter Healthcare Corporation, Deerfield, Illinois, USA) and a cotton patty. The wire was slowly removed from the anterior arch along the working trajectory by the use of forceps. We again used Doppler and visual inspection to confirm that the VA was intact. Hemostasis was achieved and the wound was closed in standard surgical fashion.

Postoperative Course

The patient awoke at his neurologic baseline. Postoperative CTA revealed a patent, dominant right VA and expected postoperative findings (Figure 7).

DISCUSSION

This is the first reported case of a fractured, migrating K-wire after anterior

transarticular atlantoaxial fusion. Our review of the literature did not produce any cases of retained K-wires after anterior cervical fusion. The largest series evaluating K-wire fracture in spine surgery was published by Scheer et al in 2014.¹² The rate of K-wire fracture in their minimally invasive transforaminal lumbar interbody fusion series during a 10-year period was 1.2% (6 of 512 patients). The K-wires were all retained within the vertebral bodies and at an average follow-up of 93.7 months, and none of them migrated. There were no complications as a result of the retained K-wire. Lau et al.¹³ reported 1 K-wire fracture of 127 patients who underwent open or minimally invasive transforaminal lumbar interbody fusion. No complications related to the K-wire were described.

Vascular complications of misplaced or migrating hardware can occur and include

devastating blood loss and strokes acutely as well as formation of pseudoaneurysms¹⁴ that may present in delayed fashion. Wilson et al.¹⁵ reported a case of anterior spinal artery pseudoaneurysm rupture 14 months after odontoid screw placement for type II dens fracture. Inamasu and Guiot¹⁶ reviewed the spine literature in 2006 and found that odontoid screws rarely caused iatrogenic injury; however, one of the injuries they reported was a misplaced screw that caused a fatal subarachnoid hemorrhage 4 days postoperatively.

Although bony perforation does not necessarily ensure neurovascular injury, the risk to the spinal cord, nerve roots, VA, and venous plexus are increased significantly.¹⁷ The increased risk conferred by a malpositioned piece of implanted hardware can be assumed similarly for a traveling K-wire. The

Figure 7. Postoperative computed tomography angiogram shows the drilled right posterior arch of C1 and the intact right vertebral artery.

orthopedics literature provides evidence of the catastrophic injuries suffered from migrating K-wires. These mobile instruments with sharp tips have been known to cause severe spinal cord injuries when they migrate after surgical repair of clavicular fractures.¹⁸⁻²⁰ Loncan et al.²⁰ described a case of a patient with Brown-Sequard syndrome 2 months after clavicle surgery. The migrating K-wire also can cause cerebrospinal fluid leak and consequent pseudomeningocele if it penetrates the dura without injuring the Spinal Cord.

Avoidance of K-wire fracture is important because once a distal portion is broken, it usually is embedded in the bone and not retrievable. Techniques to minimize this complication include placing overriding instruments in parallel trajectory to the wire and avoiding kinking/bending of the wire.^{12,21} The use of mallets and taps may increase the risk of the wire fracturing. It is imperative that the surgeon inspects the K-wire before each insertion for any areas of potential damage that could make it prone to fracture. Another technique to avoid fracture of the wire is to avoid overriding the distal 5–10 mm; the wire maybe more likely to break with only a small portion exposed.¹² If a broken K-wire is embedded and unable

to be removed, a new screw trajectory must be chosen so that the broken fragment is not driven past the cortical margin of the bone.

As evidenced by the iatrogenic injuries from malpositioned anterior cervical hardware, the exposed tips of hardware can easily injure vessels with which they are persistently in contact, causing potentially fatal hemorrhage. The orthopedics literature further details the dangers of migrating K-wires. Although these pieces of hardware may remain lodged in the bone in which they are fractured, there is potential for them to become mobile. This may be more likely if the cortical margin is violated during the initial surgery. In our case, we believe that there was some residual movement left between C1 and C2 because no spondylosis was done, causing the broken K-wire to migrate. This might have been prevented by primarily fixating C1 and C2 posteriorly, which is a more common procedure in similar cases. Our experience has taught us that diligent reimaging, for several years, is necessary to ensure early detection should a cervical K-wire become mobile. This can be easily done with anteroposterior and lateral radiographs. If the K-wire is encroaching upon a neurovascular structure, CT/CTA should be

obtained to clearly define the wire location and its relationships. If it is mobile and not contained within bone, early removal is recommended to avoid injury to the nerves, spinal cord or vessels.

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