Placement of unilateral lag screw through the lateral mass of C-1: description of a novel technique

Technical note

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Over the past several decades, many advancements and new techniques have emerged regarding the instrumentation and stabilization of the upper cervical spine. In this article, the authors describe a novel technique in which a unilateral lag screw was placed to reduce and stabilize a progressively widening fracture and nonunion of the right C-1 lateral mass approximately 8 weeks after the initial injury, which was sustained when a large tree branch fell onto the patient’s posterior head and neck.

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Key Words  •  atlas  •  lag screw  •  lateral mass  •  cervical spine  •  C-1  •  atlantodental complex

Illustrative Case

History and Presentation

The patient, a 28-year-old healthy male without any significant medical or surgical history, was admitted after experiencing a traumatic event in which a large tree branch fell onto his posterior head and neck area while he was cutting timber. On admission, the patient was awake and alert, with full strength and sensation throughout his extremities and normal deep tendon reflexes. He did report neck and head pain along with diffuse posterior cervical spine tenderness to direct palpation; however, he did not endorse any paresthesias or other abnormal sensations. Of particular note, the patient reported a 1 1/2 pack per day smoking history.

Initial Imaging

A CT scan revealed a vertical fracture of the right lateral mass of C-1 and slight medial displacement of the fracture fragment with extension of the fracture into the superior and inferior articulating facets. The fracture did not involve the transverse foramen. Also noted were nondisplaced fractures of the laminae of C-4 and articular facets of C-6 and C-7 (Fig. 1). Magnetic resonance imaging confirmed the above-mentioned fractures and did not reveal ligamentous injury. The spinal cord exhibited a normal appearance.

Initial Treatment

Given the initial presentation and imaging results that were not suspicious for instability, it was elected to treat the patient conservatively with a rigid cervical collar, routine activity restriction, and a recommendation for smoking cessation. The patient was discharged approxi-
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Progression After Conservative Therapy

The patient was reevaluated as an outpatient 7 weeks after the injury. He had persistent and progressively worsening neck pain both with and without the use of the rigid cervical orthotic device. He did not exhibit any neurological deficits or pathological reflexes. He did report significant difficulty in tolerating the continuous use of the rigid cervical orthosis. Repeat CT imaging revealed progressive widening and distraction of the right C-1 lateral mass fracture fragment from 3.3 to 5 mm (Fig. 2). Flexion-extension radiographs of the cervical spine did not demonstrate subluxation or instability. Given the worsening pain and progressive distraction and nonunion of the fracture fragments, operative intervention for reduction and fixation of the right lateral mass of C-1 was recommended. At this point, although it was only 7 weeks after the injury, surgical fixation was recommended due to the patient’s admitted noncompliance with instructions regarding use of the rigid cervical collar and progression of pain. After a discussion regarding the risks, benefits, and expectations of surgical intervention, the patient agreed to go forward with surgery. A CT angiogram was obtained, revealing normal vertebral artery anatomy.

Operative Intervention

The patient was taken to the operating room and underwent awake, fiber-optic intubation followed by induction of general anesthesia. His skull was then fixed in the radiolucent Mayfield pin fixation device (Integra LifeSciences), and neuromonitoring (monitoring of somatosensory evoked potentials, which was continued throughout the procedure) was initiated. The patient was positioned prone and his head was secured to the operating table with the Mayfield carbon base. The cervical collar was then removed. The O-arm surgical imaging system (Medtronic) was then used to evaluate the cervical spine alignment with 2D fluoroscopic imaging. A standard, midline posterior approach to the upper cervical spine was employed, with specific care taken to sweep the paraspinal musculature away from the underlying posterior arch of C-1 on the right side only. Once the underlying posterior arch of C-1 was adequately visualized, a dissector was placed and its location at the C-1 posterior arch was confirmed via 2D fluoroscopy. The reference clamp for the navigation system was then placed at the spinous process of C-2. A standard O-arm image acquisition scan was performed, 3D reconstructions were obtained, and the C-1 fracture was easily identified. Using a navigated pedicle probe, the screw insertion site and trajectory were planned. The pilot hole was drilled across the fracture site of the right C-1 lateral mass and found to be without breach on further probing. A K-wire was placed, and 2D fluoroscopy demonstrated bicortical placement. A short-threaded 4.0 × 28–mm trauma screw (Synthes Inc.) was placed over the K-wire and partially advanced. The wire was then removed and the screw advanced fully with excellent cortical purchase. The O-arm image acquisition system was again used to obtain 3D reconstructions, which revealed reduction of the fracture fragments and appropriate location of the screw with bicortical purchase after final screw tightening. The fascial and subcutaneous layers were approximated with interrupted sutures, and the skin incision was closed with staples. There were no changes in intraoperative somatosensory evoked potentials throughout the procedure. The
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Postoperative Course

Radiographs were obtained postoperatively and confirmed appropriate placement of the lag screw (Fig. 3). The patient was discharged on postoperative Day 1 without any problems. He returned to the clinic approximately 4 weeks postoperatively, at which time he reported that his neck pain, muscle spasms, and cervical range of motion were all improved. He remained neurologically intact. A CT scan was obtained at the 3-month follow-up visit and showed significant reduction of the fracture and callus formation indicative of osteosynthesis (Fig. 4). His pain had improved significantly and he remained neurologically intact, although he did admit progressive noncompliance with the use of his cervical orthosis. At last follow-up, 10 months postoperatively, the patient had minimal neck discomfort, had resumed normal activities, and exhibited full cervical range of motion in flexion, extension, and rotation. Another follow-up CT scan obtained at this time demonstrated continued fusion and fracture healing (Fig. 5).

Discussion

Although instrumentation of the upper cervical spine via dorsal wiring of C1–2 was first described by Mixter and Osgood in 1910, technological improvements in instrumentation and arthrodesis over the past 30 years have allowed for a significant expansion of available options for surgical fixation of this region. While the lag screw technique is commonly used in anterior odontoid screw fixation to bring fracture fragments into better apposition, to our knowledge this is the first description of the use of a lag screw to achieve reduction of distracted fracture fragments of the upper cervical spine from a posterior approach. This technique, in our opinion, is suitable only for fractures with distracted fragments whose alignment would not be expected to significantly change with lag screw reduction along the trajectory of the routinely accessible posterior entry points. Furthermore, this technique would not be useful in patients with significant ligamentous compromise at adjacent levels or if comminuted fragments are present. Additionally, this technique is likely only feasible with the assistance of intraoperative 3D imaging. Although our technique is novel in its use of a unilateral lag screw at the lateral mass of C-1, other authors have described the use of lag screws in the human subaxial cervical spine as well as fixation and reduction of the equine C-2 using the lag screw method. In 1994, Jeanneret et al. described the use of transpedicular lag screws in 3 patients to treat articular mass fracture separations in the subaxial cervical spine. Additionally, Barnes et al. described the placement of cortical lag screws in the treatment of a traumatic C-2 fracture in a horse in 1995. Our paper presents a novel technique for...
Placement of unilateral lag screw through C-1 lateral mass reduction and fixation of C-1 or C-2 lateral mass fractures in certain patients.

**Conclusions**

This case illustrates the novel technique of unilateral bicortical lag screw placement from a posterior approach to the upper cervical spine. This technique is surgically feasible using known anatomical approaches and available surgical hardware and is a reasonable option in carefully selected cases.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisi-

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**Fig. 4.** Axial (A–E) and sagittal (F) noncontrast CT images obtained at approximately 3 months after surgery demonstrating significant reduction of the fracture fragments and bicortical purchase of the lag screw. Lucencies between the fracture fragments and sclerosis at the margins of the fracture are evident, indicating early callus formation and bone healing.

**Fig. 5.** Axial (A–E) and sagittal (F) noncontrast CT images obtained approximately 10 months postoperatively showing progressive callus formation, indicative of continued healing, and normal alignment of the upper cervical spine.
References