TECHNICAL NOTE

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Posterior Atlantoaxial Fixation with a Combination of Pedicle Screws and a Laminar Screw in the Axis for a Unilateral High-riding Vertebral Artery

Sei-Yoon Kim, M.D., Jee-Soo Jang, M.D., Ph.D., Sang-Ho Lee, M.D., Ph.D.

Department of Neurosurgery, Gimpo Airport Wooridul Spine Hospital, Seoul, Korea

A vertebral artery (VA) injury presents a difficult problem in atlantoaxial fixation. Recent technical reports described posterior C2 fixation using bilateral, crossing C2 laminar screws. The translaminar screw technique has the advantages of producing little risk of VA injury and the unconstrained screw placement. In addition, biomechanical studies have demonstrated the potential of the translaminar screw technique to provide a firmer construct that is equivalent to methods currently used. We report the successful treatment of C1-2 instability with a left-side high-riding VA. Because of the potential risk of VA injury, we performed a posterior C1-2 fixation with a combination of pedicle screws and a laminar screw in C2. We first placed bilateral C1 lateral mass screws and a right-side C2 pedicle screw. However, placement of the left- side C2 pedicle screw was technically difficult due to a narrow isthmus and pedicle. A laminar screw was inserted instead and authors believe that this posterior C1-C2 fixation with a combination of pedicle screws and a laminar screw in C2 can be a useful alternative technique for the treatment of C1-C2 instability in the presence of a unilateral high-riding VA.

KEY WORDS : Atlantoaxial fixation · C2 laminar screw · High-riding vertebral artery.

Introduction

The transarticular atlantoaxial (C1-2) screw technique and the atlas (C1) lateral mass/axis (C2) pedicle screw fixation technique have been widely applied for C1-2 fixation, since they provide significant stability and excellent long-term fusion results[5,8,18]. However these techniques have the potential risks of causing vertebral artery (VA) injury, which may cause lethal complications[14,19].

The VA makes an acute lateral bend just under the superior articular facet of C2 in approximately 80% of individuals[6,14]. If this bending point is too medial, too posterior, and/or too high, the height/and or the width of the isthmus of C2 becomes narrowed, a condition described as a high-riding VA[15]. However, there remains nearly the same anatomical risk to the VA during placement of a transarticular or C2 pedicle screw[21].

Recent technical reports described posterior C2 fixation using bilateral, crossing C2 laminar screws[13,20]. This can be another option in cases with anomalies of VA anatomy. The authors report on the successful treatment of C1-2 instability with a left-side high-riding VA managed with posterior C1-2 fixation by a combination of a pedicle screw and a laminar screw in C2.

Surgical Technique

After induction with general anesthesia, the patient was placed in the prone position with the head and cervical spine maintained in the neutral position using a Mayfield head holder. Preoperative reduction of C1-C2 was accomplished under fluoroscopy. The posterior upper cervical spine and craniocervical junction were exposed in the usual manner. The posterior arch of C1 was exposed on the lateral aspect to visualize the bilateral lateral masses. The spinous process, laminae, and medial portion of lateral masses of C2 were exposed. C1 lateral mass screws were placed using the technique described by Harms et al.[9], with 3.5 × 22mm polyaxial lag screws (Vertex; Medtronic Sofamor Danek; Memphis, TN, USA). For fixation of the right side of C2, the entry point for placement of a C2 pedicle screw was marked with a high-speed burr. This was in the cranial and medial quadrant of the isthmic surface of C2.

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• Address for reprints : Jee-Soo Jang, M.D., Ph.D., Department of Neurosurgery, Gimpo Airport Wooridul Spine Hospital, 272-28 Gwahae-dong, Gangseo-gu, Seoul 157-822, Korea Tel : +82-2-2660-7615, Fax : +82-2-2660-7659, E-mail : spinejjs@wooridul.co.kr
* At present time Dr. Sei-Yoon Kim is at Department of Neurosurgery, Seoul Chuk Spine Hospital, Seoul, Korea

The pilot hole was prepared with a 2-mm drill bit, and the direction of the bit was approximately 20° to 30° in a convergent and cephalad direction, which was guided directly by the superior and medial surface of the C2 isthmus. Integrity of the pilot hole was verified with a blunt probe. The hole was tapped, and a 3.5×22mm polyaxial lag screw was placed.

The left-side C2 laminar screw was placed using the technique described by Wright NM[20]. A high-speed drill was then used to open a small cortical window at the junction of the C2 spinous process and lamina on the left side, close to the rostral margin of the C2 lamina. With a hand drill, the contralateral (right) lamina was carefully drilled to the proper depth, with the drill visually aligned along the angle of the exposed contralateral laminar surface. The trajectory was kept slightly less than the downslope of the lamina to ensure that any possible cortical breakthrough would occur dorsally through the laminar surface, rather than ventrally into the spinal canal. A 3.5×24mm polyaxial lag screw was then inserted carefully along the same trajectory. In the final position, the screw head remained at the junction of the spinous process and lamina on the left side with the length of the screw within the right lamina. After placement of the screw, all exposed laminar surfaces were decorticated with the high-speed drill. The wires (Songa cable; Depuy; Warsaw, NY, USA) were passed under the C1 and C2 sublaminar spaces. Rods were then cut to proper sizes and inserted. For constructs including C1, each C1 lateral mass screw was connected to the ipsilaterally projecting screw head of the right C2 pedicle screw and the left C2 laminar screw. A tricortical and morselized autologous iliac crest bone graft was harvested from the right posterior iliac crest in the usual fashion. The tricortical graft was inserted between the posterior arch of C1 and the C2 spinous process. Then the wires were tightened on each side of the spine. The morselized bone graft was packed around the exposed laminar bone surfaces. After insertion of the drainage catheter, the surgical wound was closed layer by layer.

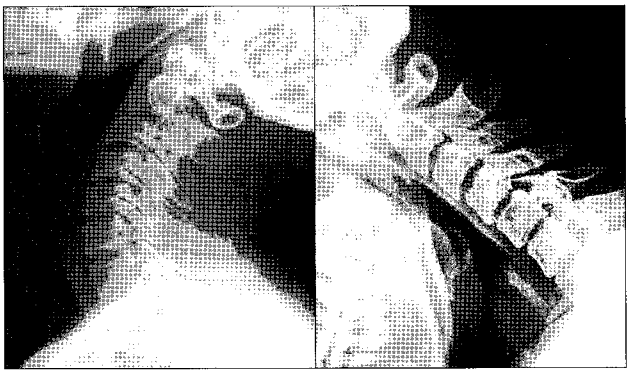

Fig. 1. Preoperative plain X-ray showing a widened atlantoaxial distance of approximately 10mm during flexion.

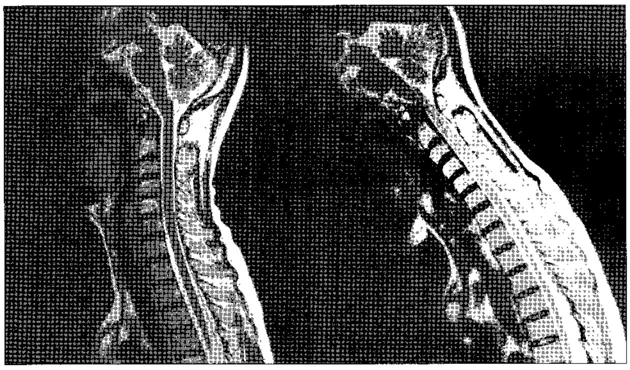

Fig. 2. Dynamic cervical magnetic resonance image demonstrating soft tissue edema, anterior to the odontoid process and obliteration of the ventral CSF space at the C1 level with cord indentation during flexion.

Case Review

A 44-year-old female patient presented with a 6-year history of neck pain and severe occipital headache. On neurological examination, there were no motor deficits, but a sensory

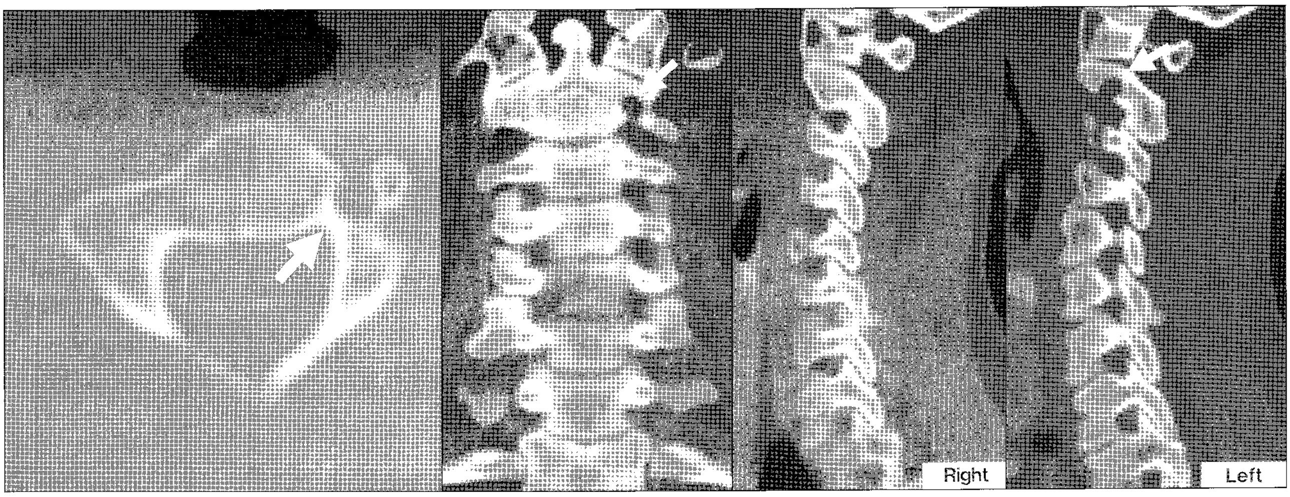

Fig. 3. Cervical computed tomography scan showing that left-side C2 pedicle screw placement is technically difficult due to the high-riding vertebral artery (arrows).

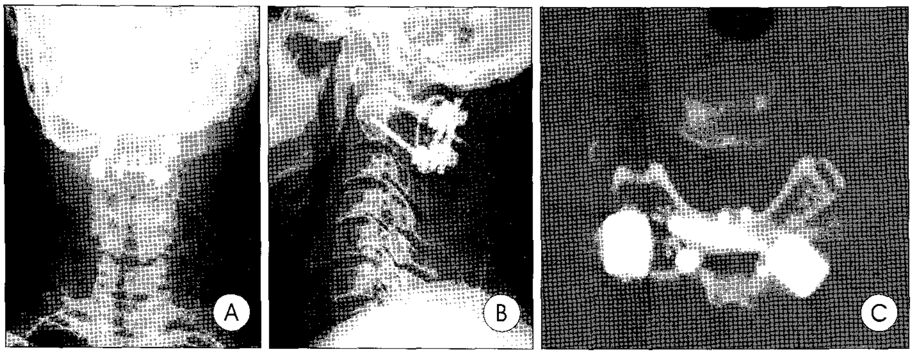

Fig. 4. Postoperative radiography demonstrating atlantoaxial fixation using rods and screws (A, B). Axial computed tomography image after placement of the left C2 laminar screw (C). The laminar screw is crossing through the mid portion of the right C2 laminar.

abnormality was noted on the C2 dermatome. Nine years earlier she was diagnosed with rheumatoid arthritis and she had been taking medication since then.

Plain X-rays demonstrated a C1-2 dislocation of approximately 10mm during flexion (Fig. 1). A cervical MRI demonstrated soft tissue edema, anterior to the odontoid process and obliteration of the ventral CSF space at the C1 level with cord indentation during flexion (Fig. 2). The patient underwent posterior fixation at the C1-2 level with a screw and cable. Bilateral C1 lateral mass screws and a right- side C2 pedicle screw were inserted. However, placement of the left-side C2 pedicle screw was technically difficult due to the high-riding VA (Fig. 3). Because of this situation a laminar screw was inserted instead. Postoperative X-rays and CT scan demonstrated good positioning of the screws (Fig. 4). Postoperatively, the patient experienced a marked improvement of neck pain and occipital headache. There were no complications. The patient was treated with a cervical orthosis for 6 weeks. Dynamic radiographs obtained at 6 weeks demonstrated no evidence of abnormal motion. At 6 months postoperatively, she remained pain free.

Discussion

There are many surgical stabilization techniques for C1-2 fixation. The posterior wiring techniques, such as the Brooks-Jenkins[2] or modified Gallie approach by Dickman et al.[3], are technically simple but have been associated with high non-fusion rates and require a postoperative rigid external orthosis[8]. The transarticular C1-C2 screw technique of Jeanneret and Magerl[10] provides a more rigid construct than the wiring technique. But it is technically demanding due to the high risk of vessel injury in a patient with an aberrant VA. Screw placement is also difficult in obese patients or those with thoracic kyphosis[18]. Recently, several authors have tried using a navigation system for C1-C2 transarticular screw fixation[1,16]. However, the possibility of a VA injury still exits.

Transpedicular screw and rod fixation is a another useful technique for reconstruction of the cervical spine[5,17]. This technique provides immediate rigid fixation, a high fusion rate and intraoperative reduction[18]. Also, it is applicable to both obese and kyphotic patients. But, a small C2 pedicle or the medial location of the VA may preclude safe placement of the C2 pedicle screw[4,14].

Thus, it has been generally recommended that insertion of the screw should be abandoned if the isthmus height is too narrow. However, there were several trials of screw insertion into the narrowed isthmus or pedicle, even though the patient had bilateral high-riding VAs. Neo et al.[15] indicated that the safest trajectory of the C1-C2 transarticular screw fixation was at the most medial and posterior part of the isthmus of C2. And, if a surgeon is well experiential with this technique for inserting a screw exactly on this trajectory, it would be possible to insert screws bilaterally and provide rigid fixation, even in patients with unilateral high-riding VAs[15]. Lee et al.[12] also reported a case of C1-C2 instability with bilateral high-riding VAs. These authors treated the patient with polyaxial screws and rod fixation. In this case, the maximum width of the bilateral C2 pedicles was only 3.6mm with preservation of cancellous bone. They speculated that a slight breaching of the VA groove would not necessarily cases the injury of the artery. Therefore, a C2 pedicle screw was placed with a diameter of 3.5mm along the superomedial portion of the pedicle.

In our case, the isthmus height was 3.2mm and there was absence of cancellous bone on the left pedicle. Which precluded fixation with a transarticular or transpedicular screw.

Wright[20] recently reported on a series of adult patients with C1-C2 instability in which a novel C2 fixation technique with bilateral crossing translaminar screws was used. Leonard JR et al.[13] also reported on a series of pediatric patients treated with the same technique. There are several advantages to a translaminar screw technique in the treatment of C1-C2 instability over other techniques, which include little risk of VA injury and unconstrained screw placement even with variations in the anatomy of C2[7,11,13,20]. Furthermore, recent biomechanical studies have demonstrated the potential of the translaminar screw technique to provide a firmer construct that is equivalent to other methods currently used.

Lapsiwala et al.[11] compared the transarticular screw technique, the C1 lateral mass-C2 pedicle screw technique and the C1 lateral mass-C2 laminar screw technique and found that these three techniques provided equivalent stability to the C1 to C2 complex in flexion-extension and axial rotation. But, these authors demonstrated that the C1 lateral mass-C2 laminar screw technique provided slightly less stiffness than other techniques in lateral bending.

Gorek et al.[7] reported that equivalent acute stability of the C1-C2 motion segment could be obtained from polyaxial screw-rod constructs that use C1 lateral mass screws combined with C2 pedicle screws and/or C2 intralaminar screws in a cadaveric model. However, the authors believe that long-term follow-up evaluation is required to determine whether there are any potential problems with the use of the bilateral crossing C2 laminar screw technique.

Our technique is consistent with other techniques, but difference is that the technique used in the present report is applicable as a combination of two previous techniques. Although we combined out technique with the use of cable to maximize stability, the combination technique of pedicle screws and a laminar screw in C2 provided immediate rigid stabilization.

The main limitation of this is that this represents only one case study. Further, no clinical data are yet available for this combination technique of pedicle screws and a laminar screw in C2. Therefore, long-term clinical outcome evaluations in more patients are needed. However, the authors believe that this posterior C1-C2 fixation technique with a combination of pedicle screws and a laminar screw in C2 can be a useful alternative technique for the treatment of C1-C2 instability in the presence of a unilateral high-riding VA.

Conclusion

Posterior C1-C2 fixation with a combination of pedicle screws and a laminar screw in C2 can be a safe and useful method of stabilization for C1-C2 instability with a unilateral high-riding VA.

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