Traumatic C6-7 Subluxation Associated With C-7 Fracture Treated With a Pedicle Screw System Under Navigation Guidance

—Case Report—

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Abstract

A 51-year-old female presented with traumatic C6-7 subluxation associated with C-7 fracture due to an automobile accident. She underwent pedicle screw fixation at C-6, C-7, and T-1 for stabilization of the spinal column. A neuronavigation system was used to obtain accurate placement of the pedicle screws. The patient recovered well without further neurological compromise. Postoperative cervical radiography showed reasonable restoration of the vertebral column without delayed kyphotic deformity.

Key words: spinal subluxation, spinal fracture, trauma, navigation, pedicle screw

Introduction

Surgical stabilization of the unstable cervical spine can be achieved by various techniques for spinal fixation. Reconstruction of the collapsed spinal column is indicated if disruption of the normal elements compromises the protective function of the spine and threatens neurological function. Transpedicular screw fixation provides a more rigid anchor to prevent collapse or instability of the spinal column, particularly at the cervicothoracic junction, although the risk of injuring the adjacent neurovascular structures cannot be completely eliminated. A neuronavigation system is recommended to minimize such serious complications in this procedure.

We report a case of traumatic C6-7 subluxation associated with C-7 fracture treated by pedicle screw fixation under guidance using a neuronavigation system.

Case Report

A 51-year-old woman was admitted to our emergency room with multiple organ injuries caused by an automobile accident, including traumatic subarachnoid hemorrhage, hemothorax, and multiple laceration wounds on her scalp and face. Neurological examination revealed she was stuporous with paraparesis and positive Babinski reflex on the left. Cervical radiography showed swelling of the retrotracheal soft tissue and C-7 vertebral body fracture with C6-7 subluxation. Axial computed tomography (CT) and three-dimensional CT confirmed fractures of the C-7 lateral mass on the right side and the vertebral body (Fig. 1A–C). Magnetic resonance (MR) imaging revealed a hyperintense intramedullary area and disrupted supraspinous and interspinous ligaments between C-6 and C-7 (Fig. 1D, E). CT angiography showed no occlusion or displacement of the bilateral vertebral arteries (Fig. 1F).

The vertebral body and lateral mass fracture of C-7 with subluxation at C6-7 associated with ligamentous injury was considered unstable. Surgical fixation using spinal instrumentation was indicated to avoid delayed symptomatic kyphosis.
Fig. 1 A, B: Three-dimensional computed tomography (CT) scans revealing C6-7 subluxation (arrow) associated with C-7 vertebral body fracture. C: Axial CT scan revealing fractures of the C-7 lateral mass on the right side and vertebral body. D: Sagittal T2-weighted magnetic resonance (MR) image revealing fracture of the C-7, disruption of the supraspinous and interspinous ligaments at C6-7, and mild anterior cord compression at C6-7. E: Axial T2-weighted MR image showing a hyperintense intramedullary area in the C-7 spinal cord. F: CT angiogram revealing no occlusion or disruption of the bilateral vertebral arteries.

The operative procedure for stabilization of the unstable spine was performed on day 7 after her general condition had stabilized.

Pedicle screw fixation from C-6 to T-1 was planned for correction of the disrupted C-6 and C-7. Neuronavigation equipment, StealthStation (Medtronic-Sofamor-Danek, Memphis, Tenn., U.S.A.), was used in addition to fluoroscopy to achieve accurate placement of the screws. Under general anesthesia, the patient was placed in the prone position with her head under tension with a 4 kg weight. After exposure of the C-5, C-6, C-7, and T-1 laminae, the StealthStation was introduced for registration of the Steffee VSP pedicle screw system (AcroMed Inc., Cleveland, Ohio, U.S.A.). The preplanned entry points for the pedicle screws at the left C-7 pedicle were first identified, with preoperative registration of the navigation system, and were located nearly 5 mm medial from the lateral edge of the lateral mass and close to the inferior margin of the inferior lateral mass of the vertebra adjacent to the cranium.

Under fluoroscopic observation, the cancellous bone in the pedicle was pierced with a probe. The 35-mm probe hole was inspected with a depth gauge. The same procedures were repeated for the bilateral C-6 to T-1 pedicles except for the right C-7 (Fig. 2). The right C-7 pedicle was severely collapsed, and was not suitable for pedicle screwing. Next, marking pins were tentatively inserted into these five pedicles for confirmation of the positions by fluoroscopy. Titanium pedicle screws (4.5-mm diameter, 35-mm length) were then screwed into the bilateral C-6, left C-7, and bilateral T-1 pedicles under both neuronavigation and fluoroscopic guidance. Two titanium rods were applied to the heads of the pedicle screws and fixed with screws. Bone chips harvested from the spinous processes...
Fig. 2 Three-dimensional neuronavigation images of the cervical spine indicating the pedicle screw trajectory site at C-6.

Fig. 3 A, B: Cervical radiographs revealing reasonable alignment of the spine at the cervicothoracic junction after placement of the pedicle screws and rods. C: Postoperative T2-weighted magnetic resonance image revealing maintenance of physiological lordosis without residual cord compression at the cervicothoracic junction.

were placed on the lamina and the lateral mass along the rod. After complete hemostasis was achieved, a drainage tube was placed under the muscle layers, and the wound was closed meticulously.

The patient wore a cervical collar for 2 months postoperatively. She was referred to a rehabilitation center and underwent physical training for 6 months until she became able to walk. Postoperative cervical radiography and MR imaging showed reasonable restoration of the vertebral column without residual cord compression or progression of kyphotic deformity (Fig. 3).

Discussion

The cervicothoracic junction has a unique biomechanical situation in the spinal column, at the transitional zone between the lordotic, mobile cervical spine and the kyphotic, more rigid thoracic spine. Lesions occurring in this area, such as
trauma, are likely to cause instability and pose unique challenges for surgical treatment.\cite{1,3,5,6,7} The compression fracture combined with the lateral mass fracture of the C-7 vertebra due to flexion force and associated tensile force were considered unstable and required surgical stabilization to avoid delayed kyphosis expected to result in further neurological compromise in this patient.

An anterior approach might have been the procedure of choice in this case if the lesion was located at the ventral side of the spinal cord. Similar cases without serious anterior cord compression of the cervicothoracic spinal cord were treated by either an anterior or a posterior approach. However, an anterior approach to the cervicothoracic junction is associated with some difficulty in exposing the anterior aspect of the spinal column. Dissection of the paravertebral muscles and exposure of the anterior aspect of the vertebral bodies above C-6 is almost always performed along the cephalad margin of the omohyoid muscle, whereas the intervertebral disc spaces at C6-7 and C7-T1 are frequently exposed by dissecting the paravertebral soft tissues along the caudal margin of the omohyoid muscle. Continuous retraction of the omohyoid muscle laterally carries the risk of damaging the recurrent laryngeal nerve, resulting in a significant incidence of recurrent laryngeal nerve palsies in one series.\cite{9} Paralysis of the recurrent laryngeal nerve is one of the serious complications associated with an anterior approach to the cervicothoracic junction. Therefore, posterior stabilization should be selected in cases of anterior subluxation without anterior cord compression, such as our case.

Various surgical options are available for posterior spinal fixation, including interspinous wiring, sublaminar wiring, and laminar hooks for slight instability.\cite{8,10,17} If wires or hooks are inadequate to stabilize the collapsed spinal column, screw systems such as lateral mass or pedicle screw fixations are indicated.\cite{5,10} The thickness of the lateral mass decreases towards the lower cervical spine.\cite{1} The lateral mass of C-7 is not sufficiently large to support lateral mass screwing. Conversely, the pedicles at C-7 have relatively large diameters, allowing longer screw length insertion to improve pullout strength.\cite{15} Such increased rigidity allows shorter construction length and less time in external orthoses.\cite{7,11,13,14} Therefore, we used pedicle screw fixation together with placement of bone chips in the present patient. There has been considerable debate about the safety of pedicle screw placement in the lower cervical spine and upper thoracic spine including the cervicothoracic junction.\cite{5,10,14,20} In addition to the risk of nerve tissue damage due to inadequate screwing, lateral perforation of the pedicular cortices is a potential threat to the vertebral arteries on the cervical level and the pleural cavity on the thoracic level.\cite{1,3,20}

Use of a neuronavigation system allows precise spinal localization. The most striking advantage is the provision of the position and orientation of invisible structures such as the pedicles or the vertebral arteries. Placement of screws into the C-3 to C-6 pedicles is associated with an unacceptable risk.\cite{19} However, the use of a neuronavigation system is a valuable supplemental technique to minimize the risks of screw insertion into the cervical pedicle.\cite{21} Therefore, transarticular screw fixation for C1-2 arthrodesis or pedicle screw fixation in the cervicothoracic spine should be performed with a neuronavigation system to avoid serious complications such as penetration of the vertebral arteries. However, errors of the neuronavigation system are possible in patients with a distorted or unstable spine. Therefore, intraoperative fluoroscopy was used to confirm the accuracy of the neuronavigation in the present case. A neuronavigation system combined with intraoperative fluoroscopy can minimize the risk of complications by providing accurate anatomical guidance.\cite{2,17,18}

References


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