DOI: 10.4172/2161-0533.S1-001

Orthopedic & Muscular System: Current Research

Research Article Open Access

Surgical Cervical Reconstruction with Pedicle Screw Fixation for Traumatic Cervical Instability

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Abstract

Cervical reduction and fixation are required in cases of cervical fracture-dislocation with instability. This study evaluated the surgical results of cervical pedicle screw (CPS) fixation using a computed tomography (CT)-based navigation system for the treatment of traumatic cervical instability. Nineteen patients who underwent CPS fixation using a CT-based navigation system for cervical trauma were studied. Preoperative neurological deficits improved by at least 1 grade on the Frankel scale in 12 (63.2%) patients after surgery. None of the patients' neurological deficits worsened after surgery. The mean C2–7 lordotic angle in the neutral position significantly improved from 6.2 to 12.1 degrees after surgery (p = 0.014). The major perforation rate for CPS was 8.2% (7/85 screws). There were no instrumentation-related neural or vascular injuries. The results of this study suggest that CPS fixation using a CT-based navigation system is an effective surgical procedure for the treatment of traumatic cervical instability.

Keywords: Cervical pedicle screw; CT-based navigation; Traumatic cervical injury

Abbreviations: AF: Anterior Fusion; CPS: Cervical Pedicle Screws; CT: Computed Tomography; MRA: magnetic Resonance Angiography; MRI: Magnetic Resonance Imaging

Introduction

Instability of the cervical spine resulting from traumatic force may require internal fixation for stabilization. Many different types of spinal instrumentation have been used in the reconstruction of unstable traumatic cervical spine injuries. Previously, posterior wiring and anterior fusion (AF) were performed to treat such injuries [1,2]. Recent studies have also reported the use of posterior laminectomy and lateral mass instrumented fusion [3,4]. Posterior cervical spine fixation using cervical pedicle screws (CPS) for spinal instability caused by cervical trauma was first reported by Abumi and Jeanneret in 1994 [5,6]. The use of pedicle screws in the cervical spine and the cervicothoracic junction is becoming increasingly common, since pedicle screws improve biomechanical stability more efficiently than lateral mass screws. In addition, they allow for shorter instrumentation time with improved reposition capacity. However, CPS insertion is technically demanding, due to the narrow diameter of the pedicle and the risk of serious neurovascular complications, including vertebral artery tear, spinal cord injury, and nerve root injury [7]. Therefore, we used a computed tomography (CT)-based navigation system to avoid risk of serious damage when performing CPS to treat cervical fracture-dislocation with instability. A case of traumatic C6–7 subluxation treated with CPS using a CT-based navigation system has been reported previously [8]. However, there are few reports on CPS fixation using CT-based navigation systems in cervical fracture-dislocation patients. The purpose of this study was to evaluate the clinical and radiological results of CPS fixation for traumatic cervical instability.

Materials and Methods

Nineteen patients who underwent CPS fixation using a CT-based navigation system for traumatic cervical instability from February 2007 to May 2011 were studied. The patients' details are shown in Table 1. The patients included 14 males and 5 females, with an average age of 56.0 ± 15.2 years (range, 20–80 years). Of the 19 patients, 14 had fracture-dislocation of the cervical spine, 2 had vertebral burst fractures, 2 had pedicle and/or lamina fractures without dislocation, and 1 had cervical instability without fracture or dislocation. CPS were inserted into pedicles at the unstable intervertebral level using a CT-based navigation system (Stealth Station and Stealth Station TREONTM; Medtronic, Sofamor Danek, Memphis, TN, USA). We generally employ polyaxial screws of 3.5 mm diameter from C3 to C6, and 4.0 mm screw for rescue. For C2, C7 and upper thoracic spine, which generally have wide pedicles, 4.0 mm polyaxial screws are sometimes employed. The material and manufacturer are as follows; SUMMIT SI Occipito-cervico-thoracic (OCT) spinal fixation system (Depuy Spine, Inc., Raynham, MA), Vertex Max system (Medtronic, Sofamor Danek, Memphis, TN, USA), Axon system (Synthes, Inc., West Chester, PA, USA), and Oasys (Optimal Alignment System) (Stryker Spine Allendale, NJ, USA).

Clinical results were evaluated using Frankel classifications. Frankel classifications A, B, and C include individuals with little or no useful muscle power below their injury sites. Frankel classifications D and E indicate individuals that have useful or full recovery of the muscles below their injury [9]. Surgical time and blood loss volume were also assessed.

For radiologic evaluation of the patients, cervical sagittal alignment (C2–7 lordotic angle) was measured according to tangential lines on the posterior edge of the C2 and C7 bodies from a lateral radiograph obtained in a neutral position.

All patients underwent reconstruction CT scans (Siemens SOMATOM Sensation 16; Siemens Asahi Meditec Inc., Shinagawa, Tokyo, Japan) of the instrumented inter vertebral levels after surgery.

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Received October 27, 2011; **Accepted** November 07, 2011; **Published** November 18, 2011

Citation: Uehara M, Takahashi J, Hirabayashi H, Ogihara N, Mukaiyama K, et al. (2011) Surgical Cervical Reconstruction with Pedicle Screw Fixation for Traumatic Cervical Instability. Orthopedic Muscul Sys S1:001. doi:10.4172/2161-0533.S1-001

Perforation of cervical pedicles by pedicle screws was evaluated by axial CT images with 1.25 mm slice thickness. Screw insertion status was classified as follows: grade 1 (no perforation), screw is accurately inserted in pedicle; grade 2 (minor perforation), perforation of less than 50% of screw diameter; grade 3 (major perforation), perforation of 50% of screw diameter or more.

Statistical analyses were performed by the Wilcoxon signed rank test using SPSS (SPSS Japan Inc., Tokyo, Japan), and statistical significance was set at $p < 0.05$.

Results

The patient follow-up period ranged from 1–54 months (mean, 14.4 ± 13.4 months). Three of the 19 patients had unilateral vertebral artery stenosis or obstruction upon preoperative magnetic resonance angiography (MRA). A total of 85 cervical and upper thoracic pedicle screws were inserted from C3 to Th2, using the CT-based navigation system. The mean fusion level was 1.5 intervertebral levels (range, 1–3 levels): C3–4, n = 1; C4–5, n = 3; C5–6, n = 4; C6–7, n = 4; C4–6, n = 1; C5–7, n = 2; C6–Th1, n = 1; C4–7, n = 1; C5–Th1, n = 1; C6–Th2, n = 1. The average surgical time was 166 min (range, 90–261 min). The average blood loss was 363 mL (range, 20–1820 mL).

According to the preoperative Frankel scale, grade A was observed in 3 patients, grade B in 2 patients, grade C in 7 patients, and grade D in 7 patients. Postoperatively, grade A was observed in 2 patients, grade B in 2 patients, grade D in 9 patients, and grade E in 6 patients. Preoperative neurological deficits improved by at least 1 grade on the Frankel scale in 12 (63.2%) patients after surgery. None of the patients' neurological deficits were worsened after surgery (Table 2).

The mean C2–7 lordotic angle in the neutral position significantly improved from 6.2 ± 13.6 degrees (range, -15 to 30 degrees) to 12.1 ± 10.0 degrees (range, -5 to 30 degrees) after surgery ($p = 0.014$).

The rate of grade 3 pedicle screw perforation was 8.2% (7/85 screws). All screws perforated laterally, and the vertebral level of screw perforation was C4 in 1 screw, C5 in 5 screws, and C7 in 1 screw. The rate of grade 2 plus grade 3 perforation was 18.8% (16/85 screws). One screw perforated medially in C6. All other screws perforated laterally; the vertebral level of perforation was C3 in 1 screw, C4 in 2 in screws, C5 in 9 screws, C6 in 2 screws, and C7 in 2 screws. No new neurologic deficits developed after surgery. No deaths occurred, and no instrumentation-related neural or vascular injuries were noted.

Case Presentation

Case 15: A 53-year-old male with C5–6 fracture-dislocation

The patient suffered Frankel grade C neurological deficit due to a fall from a stepladder. Preoperative radiography revealed a C5–6 fracture-dislocation and a C2–7 angle of 10 degrees of kyphosis (Figure 1). CT showed right C5 inferior facet fracture and left C5/6 facet dislocation (Figure 2). Magnetic resonance imaging (MRI) showed that there was compression of the spinal cord and signal change at C5/6 (Figure 3). CPS were inserted into the bilateral pedicles of C4, C5, and C6 using

Case	Age at surgery (years)	Gender	Range of fusion	Laminectomy or Laminoplasty	Preoperative Frankel grade	Postoperative Frankel grade
1	53	M	C4-6	C5	C	D
2	62	M	C5-6	C5-6	C	D
3	36	M	C4-7	C4-7	A	A
4	62	M	C6-7	N	C	D
5	58	M	C6-7	N	C	D
6	62	M	C6-7	C6	A	A
7	58	F	C6-Th1	N	C	E
8	20	M	C5-6	N	C	E
9	64	M	C3-4	C3-6	B	D
10	45	M	C4-5	C4	D	D
11	55	F	C4-5	N	D	E
12	55	M	C5-6	C5-6	D	E
13	68	F	C5-6	N	D	D
14	43	M	C5-7	C3-7	D	E
15	75	F	C6-7	C3-7	A	B
16	78	M	C5-7	N	D	D
17	80	M	C4-5	N	D	E
18	55	F	C5-Th1	N	C	D
19	35	M	C6-Th2	C7	B	B
Mean	56.0					

Table 1: Patient clinical profiles and details of surgical procedures.

Pre-op Post-op Frankel grade	A	B	C	D	E
A	2	1	0	0	0
B	0	1	0	1	0
C	0	0	0	5	2
D	0	0	0	3	4
E	0	0	0	0	0

Table 2: Clinical evaluation of Frankel classification pre- and postoperatively.

the CT-based navigation system. Postoperative radiography revealed that the C2–7 lordotic angle in the neutral position was corrected to 2 degrees (Figure 4). Postoperative CT showed that the bilateral C4 and C6 pedicle screws and the left C5 pedicle screw were accurately inserted (grade 1). The right C5 pedicle screw showed minor perforation (Figure 5). There were no neurovascular complications in this patient. His neurological deficit was improved to Frankel grade D after surgery.

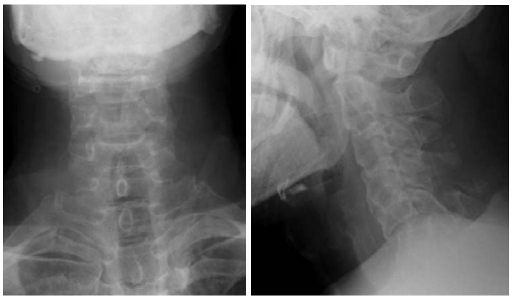

Figure 1: Preoperative radiographs. Preoperative radiographs revealed a C5–6 fracture and dislocation, and a C2–7 angle of 10 degrees of kyphosis.

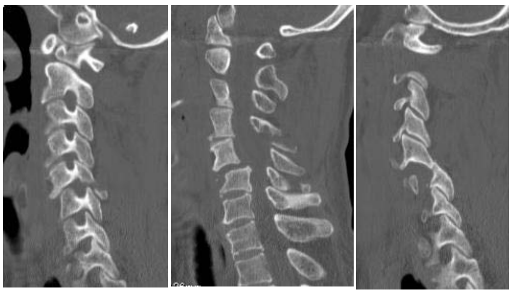

Figure 2: Preoperative computed tomography. Computed tomography (CT) showed right C5 facet fracture and C5/6 facet dislocation.

Figure 3: Preoperative magnetic resonance imaging. Preoperative magnetic resonance imaging (MRI) revealed spinal cord compression and signal change at the C5/6 level.

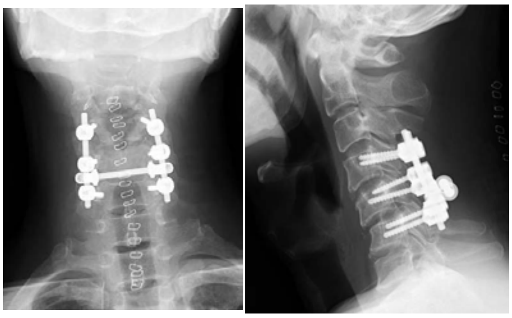

Figure 4: Postoperative radiographs. Postoperative radiographs revealed CPS were successfully inserted into the bilateral C4, C5, and C6 pedicles using the CT-based navigation system. They also showed that the C2–7 lordotic angle in the neutral position was corrected to 2 degrees.

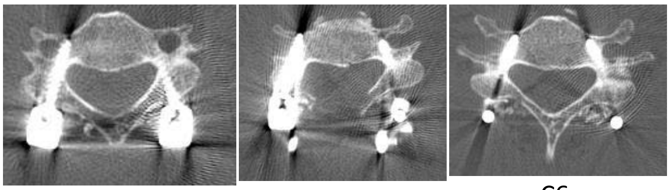

Figure 5: Postoperative CT. Postoperative CT revealed that the bilateral C4 and C6 pedicle screws and the left C5 pedicle screw were accurately inserted (grade 1). The right C5 pedicle screw showed minor perforation (grade 2).

Discussion

The incidence of unstable injuries to the cervical spine is about 30 per million of the population, per year. Surgical treatment allows decompression of the spinal canal when indicated, stabilization of the spinal column, and early mobilization. Surgical stabilization of the unstable cervical spine can be achieved by various methods of spinal fixation. Cervical spine fixation using CPS was introduced as a procedure for the treatment of cervical instability caused by trauma [5,6]. The importance of fixation by CPS for posterior cervical decompression and reconstruction was subsequently reported [10-12]. CPS insertion can achieve rigid fixation more efficiently than other cervical fixation methods [13,14], and can be combined with posterior spinal cord decompression. A strong initial fixation eliminates the necessity for postoperative external fixation, such as a halo vest or neck collar, and patients can stand and walk shortly after treatment. We have demonstrated that this procedure maintains rigid fixation postoperatively and improves clinical symptoms [15]. Due to the rigid fixation of pedicle screws, the method allows for shorter instrumentation times with improved reposition capacity. In the current study, fixation of 1 vertebral level could be performed in 12 of 19 cases (63%).

CPS insertion is technically difficult. Since the diameter of the cervical pedicle is narrower than that of the thoracic and lumbar pedicles, neurovascular complications including vertebral artery tear, spinal cord injury, and nerve root injury can occur [16]. To achieve more accurate and safe insertion of CPS, our institution performs CPS fixation using a CT-based navigation system [17,18]. In the present study, 3 out of 19 patients had unilateral vertebral artery stenosis or obstruction upon preoperative MRA. In these cases, we had to be especially careful to insert pedicle screws into normal side pedicles.

In previous reports on perforation during CPS insertion, the perforation rates for CPS used in the treatment of rheumatoid cervical spine, destructive spondyloarthritis and spinal trauma were 0–22% [17,19], 6.1% [20], and 3.9–9.2% [21], respectively. In our previous study that compared pedicle screw perforation rate according to disease, perforation rates were as follows: spine tumor (0%), rheumatoid cervical spine (3.4%), destructive spondyloarthritis (4.6%), cervical spondylotic myelopathy associated with cerebral palsy (10.0%), and cervical spondylotic myelopathy (15.0%) [15]. Extra care should be taken not to cause perforations when inserting CPS in patients with traumatic cervical instability, since the perforation rate in traumatic cervical instability patients is comparatively high. This is due to an increased rate of emergency surgery and collapse of the cervical structure. Although the perforation rate in the present study was slightly higher than in the above-mentioned previous reports, there were no neurovascular complications. No patients in this study had worsened neurological deficits after surgery, as assessed by Frankel grade.

The major limitation of this study was that in our hospital, doctors in the emergency department perform perioperative management, including the decision to transfer patients to other hospitals. Therefore, it is sometimes difficult to follow up patients for a long enough period to evaluate bone union. However, in all patients followed up for more than 6 months, bone unions were achieved. We concluded that the use of a CT-based navigation system is useful to avoid neurovascular injuries during CPS insertion.

Conclusion

Posterior cervical pedicle screw fixation using a CT-based navigation system improved clinical and radiological results in patients with traumatic cervical instability, without instrument-related neurovascular complications. Therefore, this method has been demonstrated to be an effective surgical procedure for patients with traumatic cervical instability.

References

1. Emery SE, Bohlman HH, Bolesta MJ, Jones PK (1998) Anterior cervical decompression and arthrodesis for the treatment of cervical spondylotic myelopathy. Two to seventeen-year follow-up. J Bone Joint Surg Am 80: 941-951.
2. Chagas H, Domingues F, Aversa A, Vidal Fonseca AL, de Souza JM (2005) Cervical spondylotic myelopathy: 10 years of prospective outcome analysis of anterior decompression and fusion. Surg Neurol 64: 30-36.
3. Sekhon LH (2006) Posterior cervical decompression and fusion for circumferential spondylotic cervical stenosis: review of 50 consecutive cases. J Clin Neurosci 13: 23-30.
4. Kumar VG, Rea GL, Mervis LJ, McGregor JM. (1999) Cervical spondylotic myelopathy: functional and radiographic long-term outcome after laminectomy and posterior fusion. Neurosurgery 44: 771-777.
5. Abumi K, Itoh H, Taneichi H, Kaneda K. (1994) Transpedicular screw fixation for traumatic lesions of the middle and lower cervical spine: Description of the techniques and preliminary report. J Spinal Disord 7: 19-28.
6. Janneret B, Gebhard JS, Magerl F (1994) Transpedicular screw fixation of articular mass fracture separation: Results of an anatomical study and operative technique. J Spinal Disord 7: 222-229.
7. Karaikovic EE, Kunakornsawat S, Daubs MD, Madsen TW, Gaines RW Jr (2000) Surgical anatomy of the cervical pedicles: Landmarks for posterior cervical pedicle entrance localization. J Spinal Disord 13: 63-72.
8. Mahadewa T, Mizuno J, Inoue T, Song J, Nakagawa H (2005) Traumatic C6-7 subluxation associated with C-7 fracture treated with a pedicle screw system under navigation guidance--case report. Neurol Med Chir (Tokyo) 45: 87-91.
9. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, et al. (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. Paraplegia 7: 179-192.
10. Abumi K, Kaneda K (1997) Pedicle screw fixation for nontraumatic lesions of the spine. Spine 22: 1853-1863.
11. Abumi K, Kaneda K, Shono Y, Fujiya M (1999) One-stage posterior decompression and reconstruction of the cervical spine by using pedicle screw fixation systems. J Neurosurg 90: 19-26.
12. Zhou F, Zou J, Gan M, Zhu R, Yang H (2010) Management of fracture-dislocation of the lower cervical spine with the cervical pedicle screw system. Ann R Coll Surg Engl 92: 406-410.
13. Yoshimoto H, Sato S, Hyakumachi T, Yanagibashi Y, Kanno T, et al. (2009) Clinical accuracy of cervical pedicle screw insertion using lateral fluoroscopy: a radiographic analysis of the learning curve. Eur Spine J 18: 1326-1334.
14. Neo M, Sakamoto T, Fujibayashi S, Nakamura T (2005) The clinical risk of vertebral artery injury from cervical pedicle screws inserted in degenerative vertebrae. Spine 30: 2800-2805.
15. Uehara M, Takahashi J, Hirabayashi H, Hashidate H, Ogihara N, et al. (2010) Perforation rates of cervical pedicle screw insertion by disease and vertebral level. Open Orthop J 4: 142-146.
16. Rath SA, Moszko S, Schaffner PM, Cantone G, Braun V, et al. (2008) Accuracy of pedicle screw insertion in the cervical spine for internal fixation using frameless stereotactic guidance. J Neurosurg Spine 8: 237-245.
17. Takahashi J, Shono Y, Nakamura I, Hirabayashi H, Kamimura M, et al. (2007) Computer-assisted screw insertion for cervical disorders in rheumatoid arthritis. Eur Spine J 16: 485-494.
18. Ogihara N, Takahashi J, Hirabayashi H, Hashidate H, Kato H (2010) Long-term results of computer-assisted posterior occipitocervical reconstruction. World Neurosurg 73: 722-728.
19. Ito H, Neo M, Yoshida M, Fujibayashi S, Yoshitomi H, et al. (2007) Efficacy of computer-assisted pedicle screw insertion for cervical instability in RA patients. Rheumatol Int 27: 567-574.
20. Yuzawa Y, Kamimura M, Nakagawa H, Kinoshita T, Itoh H, et al. (2005) Surgical treatment with instrumentation for severely destructive spondyloarthropathy of cervical spine. J Spinal Disord Tech 18: 23-28.
21. Yukawa Y, Kato F, Ito K, Horie Y, Hida T, et al. (2009) Placement and complications of cervical pedicle screws in 144 cervical trauma patients using pedicle axis view techniques by fluoroscope. Eur Spine J 18: 1293-1299.

This article was originally published in a special issue, **Spine Injury** handled by Editor(s). Dr. Xu Chao Jin, Wenzhou medical college, China