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Two-year results of single-level fixation with lateral mass screws for cervical degenerative spondylolisthesis: patient series

Hiroyasu Kodama, MD, Naohiro Kawamura, MD, PhD, Junichi Ohya, MD, Yuki Onishi, MD, Chiaki Horii, MD, PhD, Mitsuhiro Nishizawa, MD, Masaya Sekimizu, MD, PhD, Yuji Ishino, MD, and Junichi Kunogi, MD

Department of Spine and Orthopedic Surgery, Japanese Red Cross Medical Center, Tokyo, Japan

BACKGROUND In surgery for cervical spondylotic myelopathy (CSM) with spondylolisthesis, there is no consensus on the correction and fixation for spondylolisthesis. The authors retrospectively studied whether the correction of single-level fixation with lateral mass screws (LMSs) could be maintained.

OBSERVATIONS The records of patients with CSM with spondylolisthesis who had been treated with posterior decompression and single-level fusion with LMSs from 2017 to 2021 were retrospectively reviewed. Radiographic measurements included cervical parameters such as C2–7 lordosis, T1 slope, and the degree of spondylolisthesis (percent slippage) before surgery, immediately after surgery, and at the final observation.

Ten cases (mean age 72.8 ± 7.8 years) were included in the final analysis, and four cases (40%) were on hemodialysis. The median observation period was 26.5 months (interquartile range, 12–35.75). The mean percent slippage was 16.8% ± 4.7% before surgery, 5.3% ± 4.0% immediately after surgery, and 6.5% ± 4.7% at the final observation. Spearman's rank correlation showed a moderate correlation between preoperative slippage magnitude and correction loss ($r = 0.659$; $p = 0.038$). Other parameters showed no correlation with correction loss.

LESSONS For CSM with spondylolisthesis, single-level fixation with LMSs achieved and maintained successful correction in the 2-year observation.

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KEYWORDS cervical spondylolisthesis; single-level fixation; lateral mass screw

Cervical spondylotic myelopathy (CSM) is the most common cervical spine disease treated by spine surgeons. Although the exact prevalence is unknown, Lannon et al.[1] stated that age-related degenerative changes, such as disc degeneration, hypertrophy and ossification of the intraspinal ligament, and spondylolisthesis, are involved in the onset. Because CSM is thought to be a progressive disease, patients with moderate or severe CSM frequently require surgical intervention. In addition, given the global increase in the aging population, the need for surgical treatment is expected to increase over time.

Patients with CSM may have anterior cervical spondylolisthesis (ACS), but there are not many previous studies on how spondylolisthesis affects CSM or its postoperative outcome. In patients with CSM, ACS was present in nearly 12% on magnetic resonance imaging (MRI) in the present cohort,[2] and neck pain was the first symptom to occur in most patients with degenerative spondylolisthesis.[3] Outside of CSM, the population prevalence of ACS has been estimated to be between 4% and 20%, most commonly occurring at C4–5.[4–7] This is one of the problems that spine surgeons have to treat properly.

ACS has been reported to be a significant risk factor for and predictor of poor neurological outcomes after cervical laminoplasty,[8,9] whereas others have concluded that ACS does not affect CSM before and after laminoplasty.[10,11] There is no consensus on whether ACS should be fixed.

Moreover, there is no research that discusses the range of fixation for the correction of ACS. For single-level ACS, single-level fixation with lateral mass screws (LMSs) may provide sufficient correction, but there is no literature describing the radiological

ABBREVIATIONS ACS = anterior cervical spondylolisthesis; CSM = cervical spondylotic myelopathy; CT = computed tomography; IQR = interquartile range; JOA = Japanese Orthopaedic Association; LMS = lateral mass screw; MRI = magnetic resonance imaging; NRS = numeric rating scale; SVA = sagittal vertical axis.

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results for such a surgical procedure. In this study, we retrospectively investigated whether the correction of single-level fixation with LMSs can be maintained and become a valid treatment.

Study Description

Methods

Subjects

Consecutive patients with CSM with ACS who had undergone cervical decompression and single-level fixation with LMSs at our institution between 2017 and 2021 were retrospectively evaluated. Fixation was performed because of concerns about worsening alignment and spondylolisthesis after decompression surgery, and decompression surgery alone was reported with a poor surgical outcome.[8,9] Cases with posterior spondylolisthesis, trauma, and an observation period of less than 1 month were excluded.

Surgical Procedures

Surgery was performed via a posterior approach with the patient prone. First, only the screw holes were drilled, and after the laminectomy or laminoplasty was performed, the screws were inserted. Screws were inserted with reference to preoperative computed tomography (CT) scan and radiographic images without using a navigation system. At the discretion of the surgeon, autologous bone grafting into the immobilized facet joint was performed. The length of time for wearing the cervical collar was 2 to 3 months, depending on the surgeon.

Patient Demographics and Radiographic Measurements

Patient medical records were retrospectively reviewed to examine age, sex, current smoking habits, dialysis status, surgical procedure including the presence or absence of bone grafting to the facet, preoperative and postoperative neck pain using the numeric rating scale (NRS), cervical myelopathy severity (Japanese Orthopaedic Association [JOA] score),[12] and follow-up period.

Radiographic parameters included degree of spondylolisthesis (percent slippage) before surgery, immediately after surgery, and at the final observation; rate of change before and after surgery; rate of change from before surgery to the final observation; preoperative T1 slope, C2–7 angle, and C2–7 sagittal vertical axis (SVA); and bone union status at the final observation.

Anterior slippage was measured by the distance from the vertical line from the posteroinferior corner of the cranial vertebral body to the vertical line from the posterosuperior corner of the caudal vertebral body on a cervical radiograph in the neutral position.[13] The percent slippage is the ratio of the overhanging part of the superior vertebral body to the diameter of the inferior vertebral body (Fig. 1). Bone union was determined based on radiographic findings at the final observation.

Outcomes

The main outcome of this study was the percent slippage before surgery, immediately after surgery, and at the final observation to determine whether correction was maintained. The secondary outcome was the risk factors for the exacerbation of slippage.

Statistical Analysis

Spearman's rank correlation was used to test the correlation between postoperative correction loss and magnitude of preoperative slippage, C2–7 SVA, C2–7 angle, T1 slope, postoperative neck pain, and JOA score. The Mann-Whitney U-test was used to investigate the correlation between the degree of correction loss and sex, age, smoking status, hemodialysis, and bone grafting to the face. The relationship between the bone union rate at the final observation and gender, smoking status, dialysis, and bone grafting was also investigated using the Mann-Whitney U-test.

Statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University), a graphical user interface for R 3.5.1 (R Foundation for Statistical Computing).[14] More precisely, EZR is a modified version of R commander (version 2.5–1) designed to add statistical functions frequently used in biostatistics.

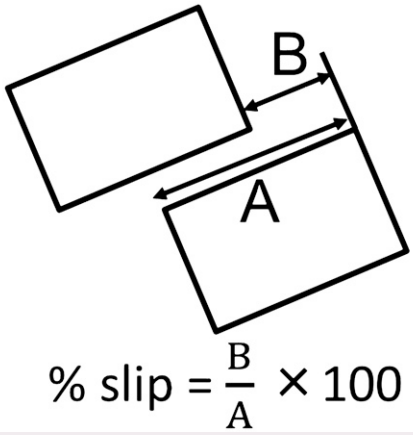

FIG. 1. Slippage percentage (% slip) is the ratio of the overhanging part of the superior vertebral body (**B**) to the diameter of the inferior vertebral body (**A**).

Results

A total of 10 patients were included. Patient demographics are shown in Table 1. There were 8 males and 2 females, with a mean age of 72.8 ± 7.8 years. None of the patients were habitual smokers, and 4 (40%) were on hemodialysis. The median observation period was 26.5 months (interquartile range [IQR], 12–35.75 months). The number of cases and levels of fixed vertebrae were 5 at C3–4, 4 at C4–5, and 1 at C5–6. No patient underwent cervical reoperation until the final observation.

Radiographic parameters are shown in Table 2. The average percent slippage was 16.8% before surgery, 5.3% immediately after surgery, and 6.5% at the last follow-up. The average correction loss from immediately after surgery to the last observation was 1.2%. Spearman's rank correlation showed a moderate correlation between preoperative

TABLE 1. Patient demographics

Variable	Value
Age in yrs (range)	72.8 ± 7.8 (61–85)
Sex: M/F	8/2
Observation period in mos (IQR)	26.5 (12–35.75)
No. of cases for each fixation level	C3–4: 5; C4–5: 4; C5–6: 1
Smoking	0 (0%)
Hemodialysis	4 (40%)

TABLE 2. The results of radiographic measurements

Variable	Average	Range
% slippage		
Before surgery	16.8 ± 4.7	10–21
After surgery	5.3 ± 4.0	0–13
At final observation	6.5 ± 4.7	0–15
Screw loosening	0%	
Bone fusion rate	90%	

slippage magnitude and correction loss ($r = 0.659$; $p = 0.038$). Radiographs of a representative case are presented in Fig. 2.

The correlation between each parameter is shown in Table 3. The preoperative T1 slope averaged 24.5°, which had no significant correlation with correction loss or preoperative percent slippage ($r = -0.401$, $p = 0.25$; $r = -0.13$, $p = 0.71$, respectively). The values of the C2–7 angle and C2–7 SVA were also not correlated with correction loss ($r = -0.426$, $p = 0.22$; $r = -0.0454$, $p = 0.901$, respectively). Neck pain decreased from a mean preoperative NRS score of 2.75 ± 0.89 (range, 2–4) to a mean of 1.78 ± 1.09 (range, 1–4) at the final observation. The preoperative JOA score was 10.2 ± 1.3 (range, 9–12), and it increased to 12.3 ± 1.9 (range, 9–16) at the final observation. These clinical parameters had no statistical correlation with correction loss ($r = -0.426$, $p = 0.22$; $r = -0.0454$, $p = 0.901$, respectively).

The Mann-Whitney U-test showed no association between correction loss and sex, age, smoking, hemodialysis, and bone grafting to the facet joint.

The bone union rate at the last observation was 90%, and there was no relationship between sex, smoking, dialysis, and bone grafting.

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

Observations

The present study revealed that the correction of single-level fixation with LMSs for ACS was sufficiently maintained with only a 1.2% increase in percent slippage during the median observation period of 2 years, although preoperative slippage averaged 16.8%.

TABLE 3. Spearman's rank correlation between each parameter

Variable	Value
Preoperative % slippage: correction loss	$r = 0.66$; $p = 0.038$
T1 slope: correction loss	$r = -0.40$; $p = 0.25$
T1 slope: preoperative % slippage	$r = -0.13$; $p = 0.71$
C2–7 angle: correction loss	$r = -0.43$; $p = 0.22$
C2–7 SVA: correction loss	$r = -0.05$; $p = 0.90$
Correction loss: final JOA score	$r = -0.36$; $p = 0.32$
Correction loss: neck pain	$r = 0.27$; $p = 0.47$

In recent years, the LMS has been widely used for fusion surgery because of its safety. Although fixation with an LMS is considered to have a low risk of neurovascular injury and is frequently used because of its safety,[15] it is inferior in strength to a pedicle screw. In the lumbar spine, posterolateral fusion without interbody fusion for spondylolisthesis has been reported to result in a high reoperation rate because of implant failure or pseudoarthrosis.[16] These facts raise some concern for stability and effectiveness for the maintenance of alignment by an LMS in ACS. Because the cervical spine has fewer cephalad parts than the lumbar spine, the load on the fixed part should be smaller, which may have resulted in a small amount of correction loss in our study.

Using Spearman's rank correlation to examine the factors involved in correction loss, only the magnitude of preoperative percent slippage showed a moderate correlation. The other factors, such as preoperative T1 slope, C2–7 angle, C2–7 SVA, age, sex, smoking, hemodialysis, and bone grafting to the facet joint, had no statistical correlation with postoperative correction loss. Thus, for those cases with a large preoperative percent slippage, special care such as a longer level of fixation may be necessary to avoid postoperative correction loss. However, the clinical significance of correction loss is unclear. In this study, no correlation was found between correction loss and postoperative JOA score or neck pain. Because all patients underwent laminectomy as well as fixation, the recurrence of anterior spondylolisthesis due to correction loss, which was only 1.2% on average, would not have had a clinical influence on the spinal cord.

Facet fusion was obtained in 90% of patients in this case series, which is an acceptable result. On the other hand, even in the case in which bone union was not obtained, there were no clinical

FIG. 2. Radiographs from a case on hemodialysis (81-year-old female): preoperative (**A**), immediately after surgery (**B**), and 1 year after surgery (**C**).

symptoms. The JOA score and neck pain score were 13 points and 1 point, respectively, which were average results; thus, no special treatment including reoperation was required.

Generally, spine surgeons often choose two different approaches (anterior and posterior) for CSM. Each approach has its advantages and disadvantages. For example, the anterior approach has advantages such as direct decompression of the spinal cord from the anterior compressive lesion and preservation of the posterior muscles and ligaments; however, the approach has the risk of severe complications such as esophageal injury and airway stenosis. This approach may be preferred for single-level disc herniation, ossification of the posterior longitudinal ligament with a large occupying ratio, or CSM with kyphosis. On the other hand, the posterior approach is relatively safe with less risk of fatal complications as described above, and it is possible to decompress multilevels with a simple procedure. However, postoperative cervical lordosis is smaller than anterior fixation and is associated with axial pain.[17,18] The long-term incidence of adjacent segmental pathology is estimated to be 23.9% in the anterior approach and 20% to 30% in the posterior approach.[19,20] There is no high-quality evidence to indicate a clear advantage of one approach over the other in terms of neurological and functional results.[18] The posterior approach is often selected for elderly patients with multiple stenosis and no kyphosis deformity, such as the case series in this study.

Few studies have focused on the surgical outcomes for CSM patients with cervical spondylolisthesis[10,21]; thus, whether cervical fixation is necessary seems to be unclear. Suzuki et al.[22] reported that in approximately 20% of cases in which laminoplasty was performed for cervical spondylotic myelopathy with spondylolisthesis, there was an exacerbation of spondylolisthesis of approximately 1 mm, but translational motion in anteroposterior bending was reduced. Even in CSM with spondylolisthesis, laminoplasty alone showed some improvement in the JOA score.[22]

However, because there is no comparative study for fusion surgery in patients with CSM with ACS, it is unclear whether fusion surgery should be performed. There is no previous study that discusses the range of fixation, and the surgical method was determined by each spine surgeon and facility given the small number of cases.

This study is the first to report on the correction and maintenance of a single level of LMS fixation to correct cervical spondylolisthesis. The results of this study suggest that a single-level correction and fixation with LMSs can be a valid treatment for ACS.

There are several limitations to this study. First, it is a retrospective, single-center study with a small sample size. The statistical results should be interpreted with caution because the sample size may not detect a difference in radiographic and clinical parameters. Because the number of surgical cases of cervical spondylolisthesis is generally small, future work with larger sample sizes is needed. Second, there are no comparisons with uncorrected cases or with cases with more than two-level fixations. Third, 40% of cases were on hemodialysis, and the background may be slightly different from that of the normal population. Patients on hemodialysis are related to an increasing risk of implant failure because of poor bone quality.[23–25] In this study, although 40% of the patients were on hemodialysis, correction loss in patients on hemodialysis was not more frequent than in patients not on dialysis, which supports the validity of single-level fixation with LMSs.

Lessons

In surgery for CSM associated with cervical degenerative spondylolisthesis, single-level fixation with LMSs could achieve and maintain successful correction until bone union was obtained, contributing to the achievement of good postoperative alignment.

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Disclosures

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

Conception and design: Kodama, Kawamura, Nishizawa, Kunogi. Acquisition of data: Kodama, Ohya, Onishi, Horii, Nishizawa, Sekimizu, Ishino. Analysis and interpretation of data: Kodama, Kawamura, Onishi. Drafting the article: Kodama, Kawamura, Horii, Kunogi. Critically revising the article: Kodama. Reviewed submitted version of manuscript: Kodama, Kunogi. Approved the final version of the manuscript on behalf of all authors: Kodama. Statistical analysis: Kodama. Administrative/technical/material support: Kodama, Nishizawa, Sekimizu, Kunogi. Study supervision: Kodama, Kawamura, Kunogi.

Correspondence

Hiroyasu Kodama: Japanese Red Cross Medical Center, Tokyo, Japan. hiroyasukodama@yahoo.co.jp.