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Transforaminal Lumbar Interbody Fusion Using Wedged Cages for Isthmic Spondylolisthesis : A Short-Term Radiological Analysis

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Objective : The ability to induce segmental lordosis has been reported to be marginal with transforaminal lumbar interbody fusion(TLIF). Therefore, we analyzed the short-term radiological outcomes of TLIF using 8° wedged cages for isthmic spondylolisthesis.
Methods : Twenty-seven patients with isthmic spondyloisthesis who underwent single level TLIF with pedicle screw fixation (PSF) using 8° wedged cages were retrospectively evaluated. Changes in disc height, degree of anterolisthesis, segmental lumbar lordosis, whole lumbar lordosis and L1 axis S1 distance were evaluated using standing lateral radiographs before surgery, at 6 weeks follow-up and at the final follow-up.
Results : The mean age of the patients was 49.9 years (range, 38 to 64 years). The affected levels were L4-5 in 17 cases and L5-S1 in 10. There were 18 cases of Grade I isthmic spondylolisthesis and 9 cases of Grade II. At a mean follow-up duration of 9.9 months (range, 6 to 18 months), the disc height ($p<0.001$) was significantly increased, and the degree of anterolisthesis was significantly reduced ($p<0.001$). Regarding the sagittal balance, the segmental lumbar lordosis was significantly increased ($p=0.01$), but other parameters were not significantly changed after surgery.
Conclusion : TLIF with PSF using 8° wedged cages significantly increased the segmental lumbar lordosis.

KEY WORDS : Isthmic spondylolisthesis · Lordosis · Transforaminal lumbar interbody fusion(TLIF).

Introduction

Since Harms and Rolinger[9] introduced transforaminal lumbar interbody fusion(TLIF), TLIF has been performed as an alternative to conventional posterior lumbar interbody fusion(PLIF)[8,11,16,17,20-22]. TLIF has several advantages over other fusion methods[10,11,21,25] and the clinical outcomes associated with TLIF have been reported to be comparable to those of PLIF or anterior lumbar interbody fusion[8,20,22]. Recently, with the development of percutaneous instruments for the spinal surgery, the pioneers of minimally invasive spine surgery have modified TLIF technique, referred to as minimally invasive TLIF[12,18,19,23]. As a result of the minimally invasive approach, injuries to muscles, adjacent facet joints and ligaments are minimal during surgery[12], therefore fusion disease can be avoided with these new techniques.

Although there have been many reports concerning the clinical outcomes of TLIF, changes of sagittal balance after this surgical technique has rarely been reported. According to the report by Kwon et al.[16], the ability to induce segmental lordosis was found to be marginal with this technique. Therefore, we thought that lordotic cages could be used in TLIF procedure to gain a good sagittal balance. Therefore, we analyzed short-term radiological outcomes of 27 patients who underwent TLIF with pedicle screw fixation(PSF) using wedged cages for low-grade isthmic spondylolisthesis.

Materials and Methods

A retrospective analysis was performed on 27 patients who underwent TLIF with PSF using 8° wedged cages for single level isthmic spondylolisthesis (Grade I or II) from De-

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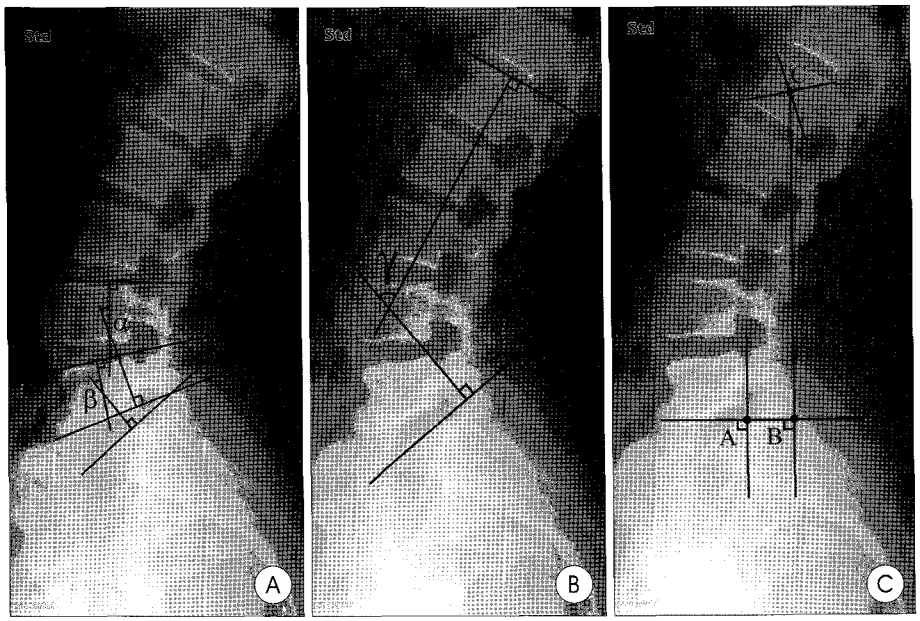

Fig. 1. A : The segmental lumbar lordosis(SLL) at L4–5 (α) was defined as the angle subtended by the superior endplate line of L4 and inferior endplate line of L5. The SLL at L5–S1 (β) was defined as the angle subtended by the superior endplate line of L5 and superior endplate line of S1 (A). B : The whole lumbar lordosis (γ) was defined as the angle subtended by the superior endplate line of L1 and superior endplate line of S1. C : The L1 axis S1 distance (AB) was defined as the horizontal distance from the L1 plumb line to the superior posterior corner of the S1 body.

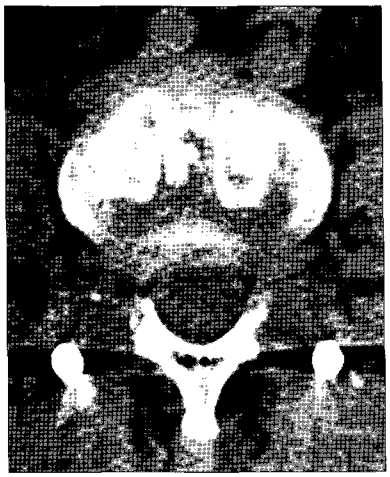

Fig. 2. Postoperative computed tomography obtained after transforaminal lumbar interbody fusion.

cember 2003 to November 2004. The inclusion criteria of this study was as follows : 1) single level isthmic spondylolisthesis (grade I or II) demonstrated on simple radiography, computed tomographic scan and magnetic resonance imaging, 2) radicular symptoms and/or back pain consistent with the radiologic findings and 3) unsuccessful conservative therapy for at least 6 weeks. Patients who underwent simultaneous deco-mpression at adjacent segments were excluded. All patients underwent standing lateral radiographs before surgery, at 6 weeks follow-up and at the final follow-up.

Changes in the disc height, degree of anterolisthesis, segmental lumbar lordosis(SLL), whole lumbar lordosis(WLL) and L1 axis S1 distanc(LSD)[13] were evaluated before surgery, at 6 weeks follow-up and at the final follow-up (Fig. 1). All of measurements were performed by a single radiologist, who was blinded to the aims of this study, using picture archiving and communications systems.

The results are expressed as a mean ± standard deviation. After the first measurements, the second measurements were performed more than one month later in order to ensure there was no recall of previous results. The means of the two measurements were calculated in order to minimize the intra-observer error. The mean intra-observer error was found to be 0.74mm (range, 0.10mm to 1.89mm) for disc height and LSD. For the degree of anterolisthesis, the mean intra-observer error was 0.92% (range, 0.12% to 2.08%). For SLL and WLL, the mean intra-observer error was 1.04° (range, 0.1° to 2.3°). The mean values for each parameter obtained before surgery and at the each follow-up were compared.

Statistical analysis was performed using a paired sample *t* test and Fisher's exact test. A p value of less than 0.05 was considered statistically significant.

Surgical Technique

All patients underwent surgery in the prone position; a radiolucent Wilson Frame and Jackson tables were used for all cases. Under fluoroscopic guidance the proper site for the incision was marked at approximately 3 to 4cm off the midline. Then a modified Wiltse transmuscular paraspinal approach was performed on one side[12,26]. The total facetectomy was performed using a high-speed drill and Kerrison rongeurs. Next the ligamentum flavum was removed, which resulted in decompression of the ipsilateral exiting and traversing roots. After performing discectomy and preparation of the end plate, an 8° wedged polyetheretherketone cage (anteroposterior diameter, 25mm) filled with graft material (cancellous autobone harvested from the lamina mixed with cancellous allograft) was inserted. In most cases, the cages were easily inserted into disc space. However, in some cases, we had to drill posterior portion of vertebral body to insert the cages. The same procedure was performed on the contralateral side. After performing insertion of monoaxial pedicle screws under the guidance of antero-posterior and lateral fluoroscopic images, compression and fixation of pedicle screws were performed in conventional way (Fig. 2).

Table 1. Demographics of the patients

Characteristics	
Number of cases	27
Sex	
Male	12
Female	15
Mean age (years)	49.9
Level	
L4-5	17
L5-S1	10
Grade of anterolisthesis	
I	18
II	9

Table 2. Changes of radiographic parameters concerning sagittal balance after surgery

	SLL (°)	WLL (°)	LSD (mm)
Before surgery	15.05±7.86	49.37±10.39	10.11±20.55
6 weeks follow-up	17.59±6.05	48.60±10.40	6.70±19.06
Final follow-up	17.79±6.58	49.77±10.01	6.23±20.48
p value*	0.018	0.80	0.15

* The mean values for each parameter obtained before surgery and at the final follow-up were compared using paired sample *t* test

Results

The mean age of the patients at surgery was 49.9 years (range, 38 to 64 years). There were 12 males and 15 females. The affected levels were L4-5 in 17 cases and L5-S1 in 10. There were 18 cases of Grade I isthmic spondylolisthesis and 9 cases of Grade II. The demographics of the patients are summarized at (Table 1).

The mean operation time was 157.2 minutes (range 105 to 240 minutes). The mean blood loss during operation was 434.4cc (range 210 to 860cc). There was no complication during surgery or at peri-operative period.

The mean disc height (mm) was 7.79±2.90 preoperatively, 11.52±2.42 at 6 weeks follow-up and 10.69±2.01 at the final follow-up. Compared with the preoperative value, the postoperative mean disc height was significantly increased at 6 weeks follow-up ($p<0.001$) and at the final follow-up ($p<0.001$). The difference of the mean disc height at 6 weeks follow-up and at the final follow-up was statistically significant ($p=0.004$), suggesting subsidence of cages over time. The mean degree of anterolisthesis (%) was 19.76±8.89 preoperatively, 7.63±7.16 at 6 weeks follow-up and 7.37±6.56 at the final follow-up. Compared with preoperative values, the postoperative mean degree of anterolisthesis significantly decreased at 6 weeks follow-up ($p<0.001$) and at the final follow-up ($p<0.001$). There was no significant difference in the mean degree of anterolisthesis between at 6 weeks follow-up and at the final follow-up ($p=0.58$).

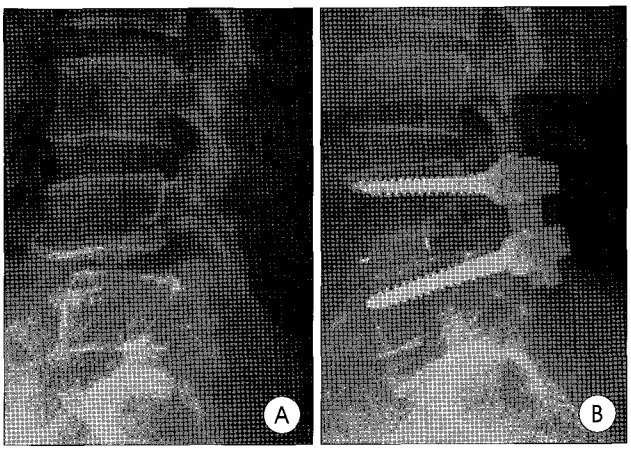

Fig. 3. Standing lateral radiography obtained before surgery (A) and 12 months after surgery (B) showing increased segmental lumbar lordosis.

The mean SLL (°) was 15.05±7.86 preoperatively, 17.59±6.05 at 6 weeks follow-up and 17.79±6.58 at the final follow-up. Compared with preoperative values, the postop-erative mean SLL increased at 6 weeks follow-up ($p=0.009$) and at the final follow-up ($p=0.018$). The postoperative mean SLL did not change significantly over time ($p=0.65$). The mean WLL (°) was 49.37±10.39 preoperatively, 48.60±10.40 at 6 weeks follow-up and 49.77±10.01 at the final follow-up. Compared with the preoperative values, the postoperative mean WLL did not change significantly at 6weeks follow-up ($p=0.60$) and at the final follow-up ($p=0.80$). The mean LSD (mm) was 10.11±20.55 preoperatively, 6.70±19.06 at 6 weeks follow-up and 6.23±20.48 at the final follow-up. Compared with the preoperative values, the postoperative mean LSD also did not change significantly at 6 weeks follow-up ($p=0.20$) and at the final follow-up ($p=0.15$). Therefore among the parameters studied for sagittal balance, only SLL changed significantly after surgery (Table 2).

Considering SLL, 12 patients (44.4%) showed an increase of SLL and 6 (22.2%) had a decrease of SLL at the final follow-up (we defined an increase or a decrease as a change more than 2 inter-observer errors). Nine patients had no significant change of SLL. Therefore 77.8% of the patients showed no change or an increase in SLL after surgery at the final follow-up. For WLL, 12 patients (44.4%) showed an increase of WLL and 9 patients (33.3%) had a decrease of WLL at the final follow-up. Therefore including the 6 patients without significant change of WLL, 66.7% of patients showed no change or an increase in WLL after surgery at the final follow-up. The relationship between SLL and WLL after surgery was also analyzed using radiography performed at the final follow-up. Of 6 patients showing a decrease of SLL after surgery, 5 showed a decrease of WLL also. Whereas, of 21 patients not showing a decrease of SLL, only 4 showed a decrease of WLL after surgery. Therefore, a decrease of SLL after surgery showed a significant

relationship with a decrease of WLL after surgery (p=0.008) (Fig. 3). For LSD, there was a decrease of LSD in 15 patients and no change in 1 at the final follow-up. Eleven patients showed an increase of LSD at the final follow-up. Unlike WLL, a decrease of SLL did not have a significant relationship with an increase of LSD after surgery (p=0.19).

Discussion

Sagittal balance is believed to be responsible for the long-term outcome of patients undergoing fusion procedures, especially with regard to adjacent segment disease[1-3,24]. Akamaru et al.[1] reported on a study of cadaver spines and found that hypolordotic alignment at L4-5 caused the greatest amount of flexion-extension motion at L3-4 and the differences were statistically significant when compared with in situ or hyperlordotic fixation. Umehara et al.[24] also reported on a study using cadaver spines that hypolordosis in the instrumented segments caused increased loading of the posterior column of the adjacent segments; this might explain the degenerative changes at the junctional level that have been observed as long-term consequences of lumbar fusion. Considering clinical outcomes, however, conflicting results have been reported. Kawakami et al.[13] reported that both preoperative LSD and lordosis at follow-up assessment affected surgical outcome. Whereas, according to the report by Goldstein et al.[6], changes in lordotic angles are not predictive of clinical outcome.

There have been several reports concerning changes of sagittal balance after PLIF or posterolateral fusion[3-7,13-15], whereas reports concerning sagittal balance after TLIF are rare. According to the report of Kwon et al.[16] who analyzed radiological outcomes of 35 consecutive adult patients with isthmic spondylolisthesis who underwent TLIF, the average slip angle was not altered after surgery; furthermore a number of patients showed substantial kyphotic change. They concluded that the ability to induce segmental lordosis was marginal with TLIF. However, although 56.6% of the patients underwent two-level fusion, they only evaluated the slip angle at the level of isthmic spondylolisthesis and they did not analyze changes of sagittal balance of whole lumbar spine. In this study, we analyzed patients who underwent TLIF with PSF using 8 degrees wedged cages under the supposition that TLIF could achieve a good sagittal balance with the wedged cages. We analyzed patients who underwent single-level TLIF and those who underwent multi-level fusion or simultaneous decompression at adjacent segment were excluded. We also analyzed the sagittal balance of the whole lumbar spine using WLL and LSD along with SLL.

The result of study showed that the mean SLL could be significantly increased by TLIF using 8° wedged cages. However, the increase of mean SLL (2.54°) was less than expected considering that we used 8° wedged cages. We think that the preserved anterior annulus and the geometry of the wedged shape cages used in this study may explain this result. Because the 8° wedged cage used in this study has an anterior-posterior length of 25mm, it may provide a posterior block to the 'lordosis-producing' compression[7]. Therefore, to produce more SLL in TLIF the wedged cages should have a smaller anterior-posterior diameter and should be designed to be placed more anterior, as suggested by previous studies[7,16]. In this study, the mean WLL and LSD did not change significantly, even with 8° wedge cages, despite a significant increase of the mean SLL. Therefore, the ability to induce good sagittal balance of the whole lumbar spine still appears to be marginal with TLIF even with 8° wedged cages. This study also showed that the decrease of segmental lordosis had a significant relationship with the decrease of the whole lumbar lordosis. Therefore, when performing TLIF, one should try to avoid a decrease of SLL to achieve a good sagittal balance of the whole lumbar spine.

The limitations of this study were as follows. First, the follow-up period was relatively short. Second, this study focused on changes of radiologic findings after surgery, thus clinical outcomes were not mentioned in the 'Result' section.

Conclusion

TLIF with PSF using 8° wedged cages significantly increased the mean SLL.

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Commentary

The authors provided valuable information of the segmental lumbar lordosis after transforaminal lumbar interbody fusion using weged cages for isthmic spondylolisthesis.

This article is focused the surgical techniques and the changes of postoperative radiological lordotic angle rather than clinical results. The authors reported that 8 degree angle cage significantly increased the segmental lumbar lordosis. However, all cases underwent TLIP with 8 degree angle cage only. It may be better if this article could be demonstrated the result of comparing the other various angle cages.

In addition, we expect more valuable information including the clinical results and radiological findings after a long term follow-up.

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