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Salvaged Surgery of Non-fusion Stabilization for the Adjacent Segmental Diseases after Posterior Spinal Fusion

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Abstract

Posterior lumbar fusion with instrumentation provides immediate stability on spine and is an effective surgical technique in deformity correction, whereas ASD remains as a mid/long term issue. In this study, we applied posterior decompression and non-fusion stabilization with SSCS to total of 21 patients (13 males and 8 females), who had undergone posterior lumbar fusion in the previous five years and then suffered ASD. The mean age was 69.4 years (range: 49 to 85) and the mean period between the primary surgery and the revision surgery was 5 years and 9 months (range: 11 months to 18 years). Site of ASD occurrence was at; upper level on 16 patients, lower level on 4 patients and upper/lower level on 1 patient. Preoperative JOA score 14.6 improved to postoperative 23.8 at the follow-up (improvement rate: 63%). ROM of the operated segments was significantly decreased from mean 8.2 to 1.7 degrees. We applied non-fusion stabilization with SSCS to salvage ASD occurred after posterior lumbar fusion with instrumentation. In case that further spinal fusion is applied to ASD, it could cause another ASD. Therefore non-fusion stabilization seems to be meaningful.

Keywords: Adjacent segment disorder; Non-fusion stabilization; Posterior spinal fusion

Introduction

Posterior lumbar fusion with instrumentation is an effective treatment for unstable degenerative diseases, but adjacent segment disorder (ASD) remains as a mid/long term issue. One report indicates that the revision surgery rate for ASD is 36.1% with minimum 10-year follow-up. Non-fusion stabilization might be one of the methods to reduce this problem. However, the number of implants available for such technique in Japan is very limited to Graf band system, Segmental Spinal Correction System (SSCS) and Isobar TTL. We had tried Graf band system and Isobar TTL, but the surgical results were not so good.

The SSCS is a very unique system having both solid rod and pedicle screw with mobility in sagittal plane, whereas offering a strong stability for rotation (Figure 1). Since it is slightly mobile in sagittal plane, rigidity can be smoothly transferred to adjacent segments, which might reduce ASDs. Looking at our review of 52 patients [1] with minimum 2-year follow up, there was only one screw breakage (breakage rate: 0.47%) and we determined that SSCS would be appropriate for clinical use. In this study, we applied non-fusion stabilization with the SSCS after decompression to salvage ASD which had occurred after posterior lumbar fusion with instrumentation. In case that further spinal fusion is applied to ASD, it could cause another ASD. Therefore non-fusion stabilization seems to be meaningful.

Material and Methods

The subjects to apply non-fusion stabilization were total of 21 patients (13 males and 8 females), who had undergone spinal fusion in the past five years. The mean age was 69.4 years old (range: 49 to 85). The mean period between the primary surgery and the revision surgery was 5 years and 9 months (range: 11 months to 18 years). Site of ASD occurrence was at upper level on 16 patients, lower level on 4 patients and upper/lower level on 1 patient. The instruments used at the primary surgeries were; Expedium (7 patients), Steffee plate (4 patients), Graf band (4 patients), Xia (2 patients), Legacy (2 patients). Dianalock (1 patient) and Zielke (1 patient). Five out of the total of 21 cases had been conducted at other hospitals. The surgical techniques for the primary surgeries were; TLIF (14 patients), PLF (3 patients) and Graf non-fusion stabilization (4 patients). The Graf band's four cases found to have been resulted in spinal fusion because the facets had been fused. The instrumented segments in the primary surgeries were; mono-segment (13 patients), bi-segment (7 patients) and tri-segment (1 patient). The SSCS non-fusion stabilization was applied to; mono-segment (18 patients) and bi-segment (3 patients). The indications were; spinal canal stenosis (14 patients), disc herniation (3 patients), degenerative spondylolisthesis (2 patients) and both spinal canal stenosis and disc herniation in upper and lower segments respectively (2 patients).

Segmental Spinal Correction System (SSCS)

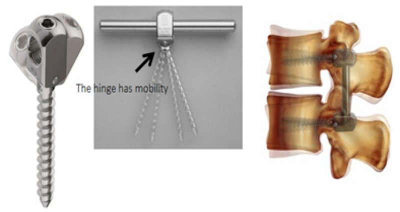

Figure 1: SSCS has a unique structure with a hinged screw, which controls rotation and translation, but allows some motion in flexion and extension.

Results

Preoperative Japanese Orthopedic Association (JOA) score [2] (which correlates to Oswestry Disability Index and Roland-Morris Disability Questionnaire) 14.8 ± 2.6 improved to 22.6 ± 5.8 at the follow-up. Hirabayashi improvement rate (Postoperative JOA score – Preoperative JOA score / full score – Preoperative JOA score ×100) was 54.9%. ROM of the operated segments significantly decreased from 8.4 ± 1.6 to 1.8 ± 3.6 degrees ($P<0.01$ paired t-test). Total of 90 pedicle

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screws were used in this study and there were two screw breakages in one case (2.2%) but no hinge breakage and screw loosening were observed. With the one case of screw breakage, the patient had developed a low back pain during competitive dancing one year after the surgery, which revealed the broken screws. The low back pain became mild by conservative treatment.

Case Presentation

51 years old male, in September 2007, the patient was diagnosed as L4 degenerative spondylolisthesis and L5/S1 foraminal stenosis, and then underwent bi-segmental TLIF. The preoperative symptoms disappeared; however, he suffered pain and numbness in lower extremities 20 months after the operation. X-P showed mild retrospondylolisthesis on L3, and L3/4 spinal canal stenosis was confirmed by MRI. Although preoperative ROM of L3/4 was 5 degrees, the sagittalization of the facet was observed and we therefore removed the instrumentation, applied at the primary surgery, and stabilized L3/4 with SSCS after partial laminectomy. As of 22 months after the surgery, JOA score improved from 18 to 29 points. The ROM of L3/4 has been stable with 2 degrees (Figure 2).

Discussion

There have been discussions for degenerative diseases with instability between rigid spinal fusion group and non-fusion group but they have not reached a consensus yet. There is no doubt that stabilization of diseased segments with spinal fusion is advantageous from the aspects of pain relief and recovery of nerve tissue.

However, the biggest drawback of the conventional spinal fusion is ASD. Ohwada et al., [3] reported that PLIF for lumbar degenerative spondylolisthesis had developed another spondylolisthesis in 37.5% at adjacent segment and revision surgery rate was 27.5% with minimum 10-year follow-up. Ghiselli et al., [4] reported revision surgery rate after lumbar posterior fusion with Kaplan-Meier method were 16.5% and 36.1% in respective 5- and 10-year follow-up.

Reviewing these issues, motion preservation technology has got attention, which is designed to achieve both decompression and reconstruction of spine, while preserving physiological spine motion. The pedicle screw-based posterior motion preservation technique, in particular, can be easily performed and expected to undergo further development.

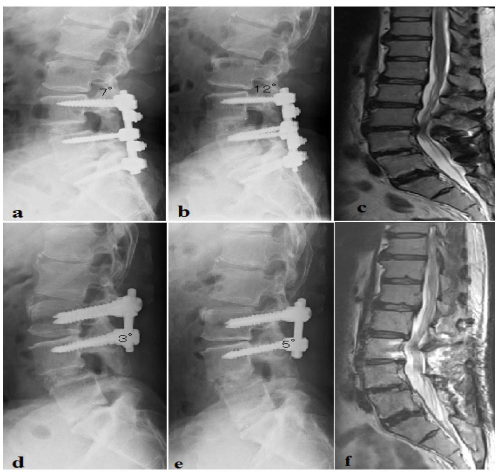

Figure 2: (a) Cobb angle of L3/4 was 7°in flexion position. (b) Cobb angle of L3/4 was 12° in extension position. (c) MRI showed L3/4 canal stenosis. (d) L3/4 stabilization using SSCS after removal of L4-S1 instrument. Cobb angle of L3/4 was 3° in flexion position. (e) Cobb angle of L3/4 was 5° in extension position. (f) MRI showed good decompression.

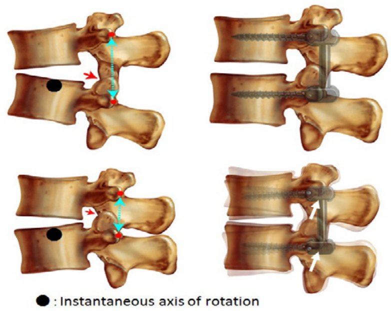

Figure 3: In case of flexion instability, facet joint greatly slides up and down centering on instantaneous axis of rotation. With the SSCS, the rod and screw head are tightened in neutral position. Therefore, sliding of the facet joint is controlled. On the other hand, hinged screw allows micro-motion in the disc.

SSCS is different from any of the other implants. It is a pedicle screw-based system with rigid rod, and has a unique structure to allow micro-motion by a hinge in the screw head [5].The screw moves 20 degrees in sagittal plane due to the hinge, but is stable for horizontal and rotational directions. That means, it controls lateral bending, rotation and translation and only allows the motion in sagittal plane.

SSCS was developed by Prof. Archibald H. von Strempel and has been clinically used mainly in Germany since 1988. He originally used the system with PLF, but started multi-center study of non-fusion stabilization without bone grafts since 2004, under the concept of motion preservation [6].

Since SSCS maintains stability against rotation and is slightly mobile in the sagittal plane, rigidity can be smoothly transferred to the adjacent segments, which is expected to reduce the incidence of ASD [1,7]. Among 52 patients, who underwent SSCS at our facility, only one screw breakage occurred (breakage rate: 0.47%) and only one patient (1.9%) required revision surgery for an ASD with a minimum 2-year follow-up [1].

It is reported that the instantaneous axis of rotation (IAR) [8] of flexion and extension is located dorsal to the disc on the superior part of the vertebral body. If there is instability, the disc would have posterior angulation centering on the IAR in flexion and the facet joint greatly slides (flexion instability). With the SSCS, the rod and the screw head are tightened in neutral position, and therefore sliding of the facet joint is completely controlled. Thus, flexion instability (i.e. instability in sagittal plane direction) is removed, whereas it still allows micro-motion in disc because of the hinge located between the thread and the head of the pedicle screw. This micro-motion is considered to function as a shock absorber like a car suspension and prevent ASD (Figure 3). In our study, preoperative ROM of 9.6 degrees in subject disc significantly reduced to 2.0 degrees postoperatively [1]. Further consideration is necessary to find out whether the average motion of 2.0 degrees is enough to prevent ASD or not, but it seems to have less effect on adjacent segments compared to rigid fusion [7].

One of the causes of ASD is the increased intradiscal pressure in the discs adjacent to the operated segments [9], and this increased pressure is reported to occur even in cases with non-fusion stabilization [10]. The advantage of non-fusion stabilization lies in its function that slightly compensates for the ROM of the adjacent discs to the operated segments [1,7] which inevitably increases with fusion. Given the natural course of degenerative diseases, unstable operated segments would gradually become stable as osteophytes develop. The concept underlying motion preservation technology is to surgically make a soft landing into the stabilization phase at the unstable spine that causes pain at the best time in patient's life.

With SSCS, breakage of hinge is concerned due to its structure but no breakage case has been reported yet. Its dynamic compression test had demonstrated no implant failure after 10,000,000 cycles and the screw hinges remained intact showing no wear debris [11]. This 10,000,000-cycle compression test correlates with about 30 years of lifetime [11]. It is also reported that load on the screw is reduced by its hinge [12,13]. In many cases where pedicle screws are used, stress usually concentrates on the pedicle screw and it breaks at pedicle part, but with the hinged screw stress on pedicle is reduced. According to the data from multi-center study, there were breakages only on 2 of 1604 screws (0.12%) and 1 of 658 rods (0.15%) [6]. The hinged screw is even more physiologic in the aspect of load sharing and it puts reduced load on the device [12,13]. By moderately sharing the load to segments and discs, and therefore stress shielding is less likely to occur compared to rigid screw.

The indications of the SSCS are; 1) mild degenerative spondylolisthesis with remaining anterior column structure, 2) lumbar canal stenosis or disc herniation with posterior angulation in flexion position (flexion instability) and 3) lumbar lesion with sagittalization of facet joint. We defined instability as a case where there was more than 5 degrees of posterior angulation, more than 3mm of anterior spondylolisthesis or sagittalization of facet joints [1]. Further evaluation is necessary to determine the level of instability to apply the SSCS, but severe instability is not an indication since we do not use bone grafts.

In this study, we extended the indication of SSCS to existing ASD. Some of the cases did not completely fit the above-mentioned definitions of instability; however, we determined them as indications for non-fusion stabilization because decompression surgery could have compromised the support for facet joints even though there was no obvious instability, and force was concentrated in the discs in cases with ASD. In case that further spinal fusion is applied to ASD, it could cause another ASD.

I cannot come up with a clear conclusion to solve the problem because the follow up is too short and it is a preliminary study. However, I believe it is meaningful to reduce the rigidity by non-fusion stabilization because applying further spinal fusion to existing adjacent segment disease could create a negative spiral of causing another adjacent segment disease. Since I started this method, there has been no adjacent segment disease occurred.

Conclusion

We applied non-fusion stabilization with the SSCS to salvage ASD occurred after posterior lumbar fusion. The short term results were good.

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