Received: 27.01.2011 / **Accepted:** 22.08.2011
DOI: 10.5137/1019-5149.JTN.4214-11.1

Anterior Lumbar Interbody Fusion Combined with Percutaneous Pedicle Screw Fixation for Degenerative Lumbar Instability: Minimum Four-Year Follow-up

Dejeneratif Lomber İnstabilitede Anterior Lomber İntervertebral Füzyon ile Perkütan Yoldan Yapılan Pedikül Vida Sabitlemesi: En Az 4 Yıllık İzlem

Shujie TANG[1], Weiguo XU[3], Brandon J. REBHOLZ[2]

[1]Jinan University, Medical School, Department of Traditional Chinese Medicine, Guangzhou, China
[2]Medical College of Wisconsin, Department of Orthopaedic Surgery, Milwaukee, USA
[3]Tianjin Hospital, Department of Orthopaedic Surgery, Tianjin City, China

Correspondence address: Shujie TANG / E-mail: wkdd2009@hotmail.com

ABSTRACT

AIM: Our goal was to investigate the long-term results of anterior lumbar interbody fusion combined with percutaneous pedicle screw fixation for degenerative lumbar instability.

MATERIAL and METHODS: Forty-seven patients that had undergone anterior lumbar interbody fusion combined with percutaneous pedicle screw fixation for degenerative lumbar instability at Tianjin Hospital between May 2003 and January 2007 were reviewed retrospectively. Radiographic results including the fusion rate, disc space height, segmental lordosis and whole lumbar lordosis were analyzed, and clinical outcomes were assessed using the Japanese Orthopaedic Association score.

RESULTS: In 47 patients, no surgery-related neurological deficit or wound breakdown was observed and 45 patients obtained a solid fusion. The mean JOA score increased significantly ($p<0.05$) from 9.4 before surgery to 24.6 six months after surgery and 26.1 at final follow-up. The disc space height, segmental lordosis and whole lumbar lordosis increased significantly from pre-operative values to both six months post-operatively ($p<0.05$) and at the final follow up ($p<0.05$). Radiographic evidence of adjacent segmental degeneration was found in 14 patients (29.8%) and symptomatic adjacent segmental disease developed in 1 patient (2.1%).

CONCLUSION: Anterior lumbar interbody fusion combined with percutaneous pedicle screws fixation in patients with degenerative lumbar instability results in good clinical and radiographic outcomes at long-term follow-up.

KEYWORDS: Anterior lumbar interbody fusion (ALIF), Degenerative lumbar instability, Japanese Orthopaedic Association (JOA), Adjacent segmental degeneration (ASD)

ÖZ

AMAÇ: Perkütan yoldan yapılan pedikül vidalaması ile anterior yoldan yapılan lomber intervertebral füzyonun dejeneratif lomber instabilitede uzun dönemli etkinliğinin incelenmesi.

YÖNTEM ve GEREÇLER: Tianjin Hastanesinde, dejeneratif lomber instabilitesi olan, bu nedenle perkütan yoldan pedikül vidalaması ve anterior yoldan lomber intervertebral füzyon işlemi ile 2003 Mayıs ve 2007 Ocak arasında tedavi edilen 47 hasta retrospektif olarak incelenmiştir. Füzyon hızı, disk aralığı yüksekliği, segmental lordosiz ve tüm lordosiz açıları radyografik olarak incelenmiştir. Klinik bulgular Japon Ortopedi Derneği skorlaması ile değerlendirildi.

BULGULAR: Hastaların 45'inde güçlü füzyon gelişti. Hastaların hiçbirinde yara yeri ile ilgili sorun olmadı, ayrıca cerrahiye ikincil olarak gelişen nörolojik hasar saptanmadı. JOA skorları cerrahi öncesine göre istatiksel olarak anlamlı ölçüde arttı ($p<0,05$) 9,4, önce 24,6 - 26,1. Disk aralığı yüksekliği ve segmental lordoz ve tüm lordoz açıları istatiksel olarak anlamlı ölçüde arttı ($p<0,05$). Hastaların 14'ünde (%29,8) komşu segmentte dejenerasyon görülürken, hastaların 1'inde (%2,1) komşu segment hastalığı gözlendi.

SONUÇ: Perkütan yoldan yapılan pedikül vidalaması ile anterior yoldan yapılan lomber intervertebral füzyonun dejeneratif lomber instabilitede klinik ve radyolojik olarak uzun dönemli sonuçları iyi olarak bulunmuştur.

ANAHTAR SÖZCÜKLER: Anterior intervertebral füzyon, Dejeneratif lomber instabilite, Japon Ortopedi Derneği, Komşu segment hastalığı

INTRODUCTION

Lumbar instability is defined as the loss of ability of the spine under physiologic loads to maintain its pattern of displacement (19). Symptomatic instability has been successfully treated with posterior lumbar interbody fusion (PLIF) in combination with posterior spinal fusion. More recently, anterior lumbar interbody fusion (ALIF) has become more widely accepted. This has led to its use in the treatment of lumbar instability. While some biomechanical studies demonstrate that ALIF alone may be sufficient for stabilization, it was associated with a high pseudarthrosis rate and the need for posterior stabilization was recognized(6) (18). Subsequently, some surgeons have combined ALIF with percutaneous pedicle screw fixation for the treatment of degenerative lumbar instability. However, few reports have been published demonstrating the long-term clinical and radiological outcomes of ALIF combined with percutaneous pedicle screws for degenerative lumbar instability.

We retrospectively reviewed 47 patients who underwent ALIF combined with percutaneous pedicle screws at Tianjin Hospital between May 2003 and January 2007 with a minimum of four years follow-up. The purpose of the present study is to investigate the long-term clinical and radiographic results of ALIF augmented with percutaneous pedicle screws for the treatment of degenerative lumbar instability.

MATERIAL and METHODS

Patient population

Forty-seven patients who had undergone ALIF combined with percutaneous pedicle screws for degenerative lumbar instability at Tianjin Hospital between May 2003 and January 2007 were reviewed retrospectively. Of these 47 patients, there were 31 males and 16 females with an average age of 45.2 years (range from 35.3 to 58.5 years). The mean follow-up period was 56.8 months (ranging from 48 to 76 months). Thirty-six patients underwent single-level and 11 patients underwent two-level ALIF with percutaneous pedicle screws for degenerative lumbar instability. Patients presented with axial back pain, neurogenic claudication, radiculopathy, pseudoradicular pain, or a combination of these. All patients were diagnosed according to the criterion from Dupuis (7), and had to have been treated conservatively for at least 3 months without success before consideration for surgical intervention.

Surgical Technique

All procedures were performed through an anterior midline incision and retroperitoneal dissection. Following exposure of the disc space, the anterior longitudinal ligament was excised and the intervertebral disc was removed. The endplates were carefully prepared and an anterior stand-alone cage filled with BMP was placed. After completion of the ALIF, the anterior incision was closed and the patient was repositioned prone. Percutaneous pedicle screw fixation was performed under fluoroscopic guidance.

Radiologic evaluation

The radiographs of all patients were evaluated preoperatively, 6 months after the operation and at the final follow-up. An independent observer made all radiographic assessments using standard anteroposterior, lateral, and flexion-extension radiographs of the lumbar spine. The measurements were performed twice for each parameter with an adequate time interval in order to prevent bias from distorting the results. The average values of the two measurements were used for evaluation. Successful interbody fusion was determined by the formation of a transvertebral osseous bridge anterior and posterior to the cage, and absence of the following: radiolucency between the cage and endplate, loosening or breakage of pedicle screws, and motion on dynamic flexion-extension radiographs (13). The segmental lordosis (SL) (Figure 1) (3), whole lumbar lordosis (WLL)(Figure 2) (3) and disc space height (DSH)(Figure 2) (13) were measured using image J software (version alpha 4.0.3.2; http:// www.scioncorp.com). With the aid of computer guidance, all images were corrected for radiographic magnification error according to standard implant reference points and implant dimensions (23).

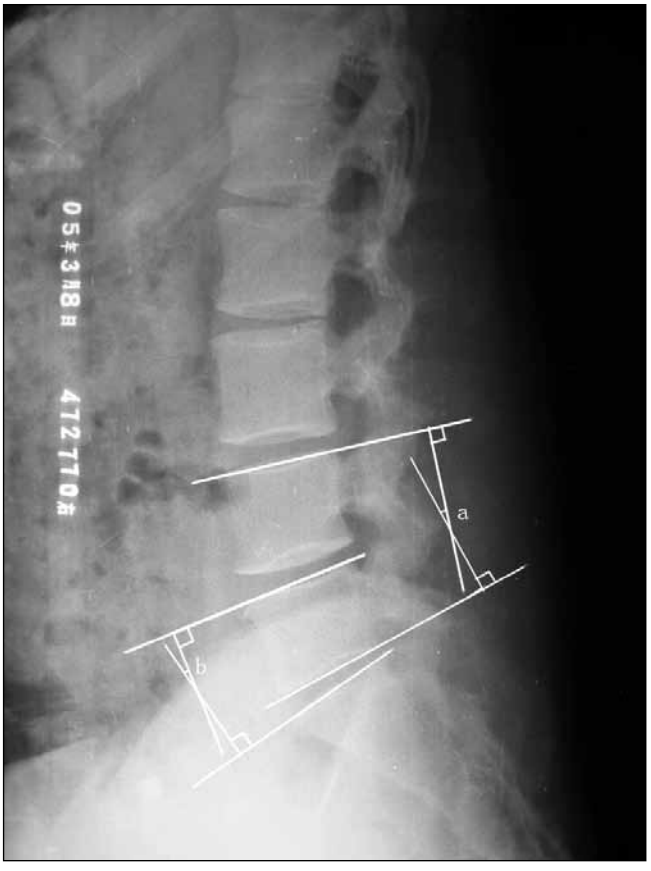

Figure 1: The segmental lordosis (SL) at L4-5 (a) was defined as the angle subtended by the superior endplate line of L4 and the inferior endplate line of L5. The SL at L5-S1 (b) was defined as the angle subtended by the superior endplate line of L5 and the superior endplate line of S1.

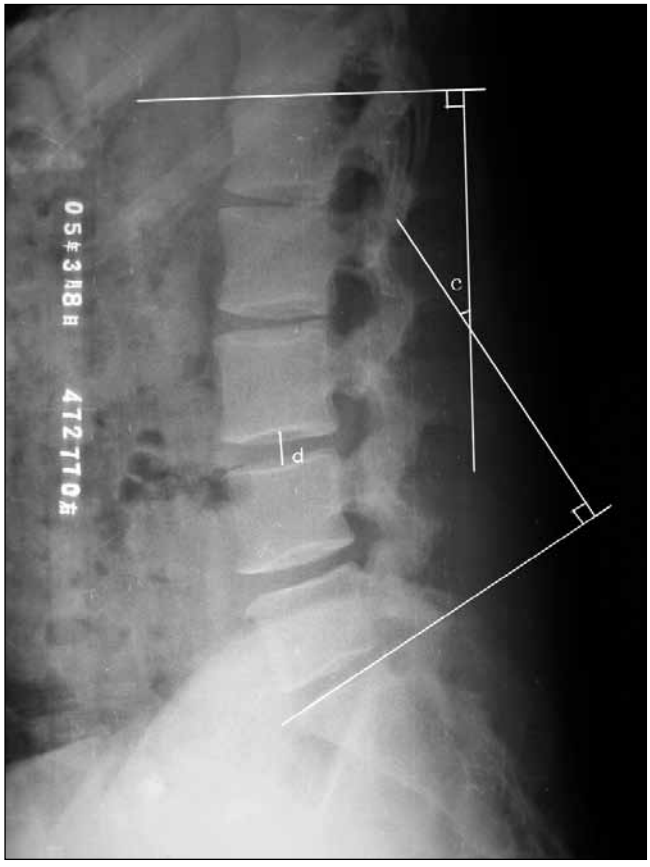

Figure 2: The whole lumbar lordosis (WLL) (c) was defined as the angle subtended by the superior endplate line of L1 and the superior endplate line of S1. The disc space height (DSH) (d) was determined to be the distance from the midpoint of the anteroposterior diameter of the inferior endplate to the superior endplate.

Adjacent segmental degeneration (ASD) was diagnosed when plain radiographs demonstrated one or more of the following at the segment adjacent to the fused segment that were not present preoperatively: more than 4 mm of anterolisthesis or retrolisthesis, more than 10 degrees of angular motion between adjacent vertebral bodies on flexion and extension radiographs, spinal stenosis caused by facet joint hypertrophy, degenerative scoliosis, more than 10% loss of disc height, and more than 3 mm of osteophyte formation (3, 16, 20).

Clinical evaluation

The Japanese Orthopaedic Association (JOA) score was used to assess the clinical outcomes, which is composed of subjective symptoms, clinical signs, impairment of activities of daily living, and urinary bladder function(15). A perfect score is 29 points. JOA recovery rate (%) = (JOA score at the final follow-up preoperative JOA score) X 100/ (29 - preoperative JOA score) (21). Surgery outcomes were assessed based on the recovery rate and were classified using a four-grade scale: excellent, improvement of over 90%; good, 75% to 89% improvement; fair, 50% to 74% improvement; and poor, below 49% improvement (5). We assessed the JOA score of all patients preoperatively, 6 months after the operation and at the final follow up. In addition, we assessed the procedural complications, operating room time and blood loss.

Statistical Analysis

Statistical analysis was performed using SPSS17.0 (SPSS Inc., Chicago, IL, USA). Paired sample t-test and Wilcoxon Signed Ranks tests were used. A probability value of < 0.05 was considered to indicate statistical significance.

RESULTS

In 47 patients, no surgery-related neurological deficit or wound breakdown was observed. The mean operation time was 110±15 minutes for monosegmental procedures and 180±25 minutes for bisegmental procedures. Total intraoperative blood loss was 85±26 ml for monosegmental procedures and 127±32 ml for bisegmental procedures.

Significant improvements ($p<0.05$) in JOA score were observed between pre-operative and post-operative evaluations with an increase from an average of 9.4 before surgery to an average of 24.6 six months after surgery and 26.1 at the final follow up. The difference between the mean score six month after surgery and that at final follow up were not significant ($p>0.05$). At six months follow-up, 21 patients (44.7%) achieved an excellent result, 19 patients (40.4%) a good result, 6 patients (12.8%) a fair result, and 1 patient (2.1%) a poor result. At final follow up, this improved slightly with excellent results in 22 patients (46.8%), good in 21 (44.7%), fair in 3 (6.4%) and poor in 1 (2.1%). This difference in clinical improvement between the two follow-up periods is insignificant ($p>0.05$).

The radiographic data preoperatively, six months after surgery and at final follow-up are summarized in Table I. The mean disc space height (DSH) increased from 9.3 preoperatively to 15.8 mm ($p<0.05$) six months after surgery and 15.2 mm ($p<0.05$) at final follow-up. The segmental lordosis (SL) increased 8.7° ($p<0.05$) from preoperative measures to six months after surgery and 6.9° ($p<0.05$) at final follow up. The mean whole lumbar lordosis (WLL) changed from 49.7° preoperatively to 57.8° ($p<0.05$) six months after surgery, and 53.6° ($p<0.05$) at the final follow up. Comparing the means six months after surgery to those at final follow-up, there were no significant changes in DSH, SL and WLL ($p>0.05$). Radiological evidence of successful fusion was observed in 45 patients (95.7%) at final follow up.

Radiographic evidence of adjacent segment degeneration was present at final follow-up in 5 patients (45.5%) who underwent two-level procedures and in 9 patients (25%) who underwent single-level procedures. This difference between single-level and two-level procedures was not significant ($p>0.05$). Only 1 patient, who underwent a two-level procedure, had symptoms attributable to the degenerated adjacent segment, but required no additional medical treatment.

Table I: Radiological Outcome of 47 Patients

Parameters	Preoperative	Six months after surgery	P value[a]	Final follow up	P value[b]
DSH (mm)	9.3	15.8	P<0.05	15.2	p>0.05
SL(°)	12.9	21.6	P<0.05	19.8	p>0.05
WLL(°)	49.7	57.8	P<0.05	53.6	p>0.05
Fusion rate (%)				95.7	

DSH=Disc space height, SL=segmental lordosis, WLL=whole lumbar lordosis, [a]between preoperative and six months after surgery, [b]between six months after surgery and the final follow up.

DISCUSSION

One commonly used surgical treatment for degenerative lumbar instability involves the use of a posterior lumbar interbody fusion device, and concomitant posterior pedicle screw stabilization. Several authors have expressed concerns with PLIF and instrumentation. These include substantial tissue dissection and retraction, tissue denervation, increased operative time and blood loss (24) (10, 17). In Sears' (22) series, 34 patients underwent posterior lumbar interbody fusion, with a mean surgical time of 186 minutes and mean operative blood loss of 659 ml. Similarly Wang(26)described 32 patients with lumbar instability treated using posterior lumbar interbody fusion, and had a mean surgical time of 216.25 minutes and a mean operative blood loss of 1095.31 ml.

Compared to posterior lumbar interbody fusion modes, anterior lumbar interbody fusion (ALIF) has many advantages. One of these is the potential to restore normal lordosis in order to correct the spinal malalignment. This may offer a protective effect on the adjacent level stresses and lower the rate of adjacent segment degeneraion. Anterior lumbar interbody fusion techniques additionally have a low possibility of neural injury, relatively less blood loss, short hospital stay and a high fusion rate (9, 11, 12, 20). Percutaneous pedicle screw fixation provides rigid, three column fixation and can be implanted through small, paramedian incisions with less trauma to the paraspinal muscles and less blood loss compared to open posterior exposures of the lumbar spine. When combined with ALIF, percutaneous pedicle screw fixation offers a mechanically rigid construct, similar to a traditional 360° fusion, but with potentially less morbidity (2). This study was performed to assess the long-term clinical and radiological outcomes of ALIF combined with percutaneous pedicle screws for degenerative lumbar instability. The results of this study demonstrate favorable clinical and radiological outcomes and no surgery-related neurological deficit or wound breakdown. Compared to the report from Sears W and Wang R, the mean operation time in our study was relatively short and total intraoperative blood loss was small. In addition, 45 patients obtained a solid fusion and the JOA score increased significantly from before surgery to six months after surgery and at the final follow up.

At the same time, our study indicated ALIF combined with percutaneous pedicle screw could significantly restore the sagittal alignment of lumbar spine. An anterior cage with enough height and lordotic angle can be inserted easily in ALIF, as a result, the disc space height and segmental lordosis can be restored more easily than other interbody fusion methods. The addition of posterior percutaneous pedicle screws increases the stability of construct. This may help to avoid subsidence of the anterior cage, maintaining the proper DSH, SL and WLL, and ultimately helping to facilitate fusion. This was demonstrated in our study with improvement in DSH, SL and WLL from before surgery to six months after surgery and at final follow up.

Several authors have suggested that abnormal sagittal lumbar alignment after lumbar fusion may aggravate ASD. Umehara et al. (25) studied the effect of sagittal malalignment after transpedicular posterolateral fusion in human cadavers. They found altered biomechanics resulting in increased loading of the posterior column and increased posterior shear forces at the proximal adjacent segment. Kumar et al. (14) further studied patients who underwent instrumented posterolateral fusions and found very high rates of ASD when alterations of abnormal sagittal alignment were present. Akamaru et al. (1) reported that hypolordotic alignment of the fused segments caused the greatest amount of flexion-extension motion at the superior adjacent segment and suggested that this was related to ASD. In the present study, 14 patients (29.8%). had radiographic evidence of adjacent segment degeneration Min et al. (20), evaluated 48 patients who underwent instrumented PLIF, ALIF, or TLIF with an average follow-up of 44.6 months. Thirty patients (62.5%) were diagnosed with radiographic adjacent segment degeneration, however the author suggested ALIF might have a protective effect against the development of ASD. The rate of ASD in the present study is relatively low, which may be consistent with the assertion that there may be some protective effect of ALIF on the development of ASD. We believe that restoration of normal segmental lordosis may contribute to the low rate of ASD in the present study.

Some authors have suggested that the development of adjacent segment degeneration may be more severe in multilevel fusion compared to single-level fusion. Chen (4) established a three-dimensional nonlinear finite element model of the lumbar spine to simulate ALIF. He found that with more levels fused the stress of the disc adjacent to interbody fusion increased more than that of single fusion level in flexion, torsion and lateral bending. Gillet (8) reviewed 106 patients following a lumbar fusion with an average follow up less than 5 years and correlated an increased incidence of ASD with longer fusions. In the present study, the ASD rate

in single level ALIF is 25% and two-level is 45.5%, but there is no significant difference between the two groups. The small sample size may account for some of this effect, and a large-scale, controlled study may be needed in the future to clarify the issues.

CONCLUSION

We retrospectively reviewed forty-seven patients who underwent ALIF combined with posterior percutaneous pedicle screw fixation for degenerative lumbar instability at our institution with good long-term radiographic and clinical results. We suggest ALIF augmented with posterior percutaneous pedicle screws be an ideal alternative to treat degenerative lumbar instability.

REFERENCES

1. Akamaru T, Kawahara N, Tim YS, Minamide A, Su KK, Tomita K, Hutton WC: Adjacent segment motion after a simulated lumbar fusion in different sagittal alignments: A biomechanical analysis. Spine (Phila Pa 1976) 28:1560-1566, 2003
2. Anderson DG, Sayadipour A, Shelby K, Albert TJ, Vaccaro AR, Weinstein MS: Anterior interbody arthrodesis with percutaneous posterior pedicle fixation for degenerative conditions of the lumbar spine. Eur Spine J 20(8): 1323-1330, 2011
3. Bae JS, Lee SH, Kim JS, Jung B, Choi G: Adjacent segment degeneration after lumbar interbody fusion with percutaneous pedicle screw fixation for adult low-grade isthmic spondylolisthesis: Minimum 3 years of follow-up. Neurosurgery 67:1600-1607, 2010
4. Chen CS, Cheng CK, Liu CL, Lo WH: Stress analysis of the disc adjacent to interbody fusion in lumbar spine. Med Eng Phys 23:483-491, 2001
5. Chen Z, Zhao J, Liu A, Yuan J, Li Z: Surgical treatment of recurrent lumbar disc herniation by transforaminal lumbar interbody fusion. Int Orthop 33:197-201, 2009
6. Christensen FB, Karlsmose B, Hansen ES, Bunger CE: Radiological and functional outcome after anterior lumbar interbody spinal fusion. Eur Spine J 5:293-298, 1996
7. Dupuis PR, Yong-Hing K, Cassidy JD, Kirkaldy-Willis WH: Radiologic diagnosis of degenerative lumbar spinal instability. Spine (Phila Pa 1976) 10:262-276, 1985
8. Gillet P: The fate of the adjacent motion segments after lumbar fusion. J Spinal Disord Tech 16:338-345, 2003
9. Hsieh PC, Koski TR, O'Shaughnessy BA, Sugrue P, Salehi S, Ondra S, Liu JC: Anterior lumbar interbody fusion in comparison with transforaminal lumbar interbody fusion: Implications for the restoration of foraminal height, local disc angle, lumbar lordosis, and sagittal balance. J Neurosurg Spine 7:379-386, 2007
10. Kawaguchi Y, Yabuki S, Styf J, Olmarker K, Rydevik B, Matsui H, Tsuji H: Back muscle injury after posterior lumbar spine surgery. Topographic evaluation of intramuscular pressure and blood flow in the porcine back muscle during surgery. Spine (Phila Pa 1976) 21:2683-2688, 1996
11. Kim JS, Choi WG, Lee SH: Minimally invasive anterior lumbar interbody fusion followed by percutaneous pedicle screw fixation for isthmic spondylolisthesis: Minimum 5-year follow-up. Spine J 10:404-409, 2010
12. Kim JS, Kang BU, Lee SH, Jung B, Choi YG, Jeon SH, Lee HY: Mini-transforaminal lumbar interbody fusion versus anterior lumbar interbody fusion augmented by percutaneous pedicle screw fixation: A comparison of surgical outcomes in adult low-grade isthmic spondylolisthesis. J Spinal Disord Tech 22:114-121, 2009
13. Kim SB, Jeon TS, Heo YM, Lee WS, Yi JW, Kim TK, Hwang CM: Radiographic results of single level transforaminal lumbar interbody fusion in degenerative lumbar spine disease: focusing on changes of segmental lordosis in fusion segment. Clin Orthop Surg 1:207-213, 2009
14. Kumar MN, Baklanov A, Chopin D: Correlation between sagittal plane changes and adjacent segment degeneration following lumbar spine fusion. Eur Spine J 10:314-319, 2001
15. Kuroki H, Tajima N, Kubo S: Clinical results of posterolateral fusion for degenerative lumbar spinal diseases: a follow-up study of more than 10 years. J Orthop Sci 7:317-324, 2002
16. Lee CS, Hwang CJ, Lee SW, Ahn YJ, Kim YT, Lee DH, Lee MY: Risk factors for adjacent segment disease after lumbar fusion. Eur Spine J 18:1637-1643, 2009
17. Logroscino CA, Proietti L, Pola E, Scaramuzzo L, Tamburrelli FC: A minimally invasive posterior lumbar interbody fusion for degenerative lumbar spine instabilities. Eur Spine J 20 Suppl 1:S41-S45, 2011
18. Loguidice VA, Johnson RG, Guyer RD, Stith WJ, Ohnmeiss DD, Hochschuler SH, Rashbaum RF: Anterior lumbar interbody fusion. Spine (Phila Pa 1976) 13:366-369, 1988
19. Maigne JY, Lapeyre E, Morvan G, Chatellier G: Pain immediately upon sitting down and relieved by standing up is often associated with radiologic lumbar instability or marked anterior loss of disc space. Spine (Phila Pa 1976) 28:1327-1334, 2003
20. Min JH, Jang JS, Jung B, Lee HY, Choi WC, Shim CS, Choi G, Lee SH: The clinical characteristics and risk factors for the adjacent segment degeneration in instrumented lumbar fusion. J Spinal Disord Tech 21:305-309, 2008
21. Ogawa H, Hori H, Oshita H, Akaike A, Koyama Y, Shimizu T, Yamada K, Ishimaru D: Sublaminar wiring stabilization to prevent adjacent segment degeneration after lumbar spinal fusion. Arch Orthop Trauma Surg 129:873-878, 2009
22. Sears W: Posterior lumbar interbody fusion for degenerative spondylolisthesis: Restoration of sagittal balance using insert-and-rotate interbody spacers. Spine J 5:170-179, 2005
23. Siepe CJ, Hitzl W, Meschede P, Sharma AK, Khattab MF, Mayer MH: Interdependence between disc space height, range of motion and clinical outcome in total lumbar disc replacement. Spine (Phila Pa 1976) 34:904-916, 2009
24. Styf JR, Willen J: The effects of external compression by three different retractors on pressure in the erector spine muscles during and after posterior lumbar spine surgery in humans. Spine (Phila Pa 1976) 23:354-358, 1998
25. Umehara S, Zindrick MR, Patwardhan AG, Havey RM, Vrbos LA, Knight GW, Miyano S, Kirincic M, Kaneda K, Lorenz MA: The biomechanical effect of postoperative hypolordosis in instrumented lumbar fusion on instrumented and adjacent spinal segments. Spine (Phila Pa 1976) 25:1617-1624, 2000
26. Wang R, Lin X, Shi S, Xiu Z, Guo Y: Instability of lower lumbar treated with posterior lumbar interbody fusion with autologous iliac crest or interbody fusion cage: A comparative study. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 22:928-932, 2008