

# Surgical Outcome of Reduction and Instrumented Fusion in Lumbar Degenerative Spondylolisthesis

Farzad Omid-Kashani<sup>1</sup>, MD;  
Ebrahim Ghayem Hassankhani<sup>1</sup>, MD;  
Reza Shiravani<sup>2</sup>, MD;  
Masoud Mirkazemi<sup>2</sup>, MD

<sup>1</sup>Orthopedic Research Center,  
Department of Orthopedics, Imam Reza  
Hospital, Mashhad University of Medical  
Sciences, Mashhad, Iran;

<sup>2</sup>Student Research Committee, Imam  
Reza Hospital, Faculty of Medicine,  
Mashhad University of Medical  
Sciences, Mashhad, Iran

## Correspondence:

Farzad Omid-Kashani, MD;  
Department of Orthopaedics,  
Orthopaedic Research Center, Imam  
Reza Hospital, Mashhad University of  
Medical Sciences, Mashhad, Iran  
Postal Code: 913791- 3316

Tel: +98 51 37646500

Fax: +98 51 38595023

Email: [omidif@mums.ac.ir](mailto:omidif@mums.ac.ir)

Received: 21 October 2013

Revised: 05 February 2014

Accepted: 16 February 2014

## Abstract

**Background:** Lumbar degenerative spondylolisthesis (LDS) is a degenerative slippage of the lumbar vertebrae. We aimed to evaluate the surgical outcome of degenerative spondylolisthesis with neural decompression, pedicular screw fixation, reduction, and posterolateral fusion.

**Methods:** This before-after study was carried out on 45 patients (37 female and 8 male) with LDS operated from August 2008 to January 2011. The patients' pain and disability were assessed by visual analogue scale (VAS) and Oswestry disability index (ODI) questionnaire. In surgery, we applied distraction force to facilitate slip reduction. All the intra- and postoperative complications were recorded. The paired t-test and Pearson correlation coefficient were used for statistical analysis.

**Results:** The mean age of patients and mean follow-up period were  $58.3 \pm 3.5$  years and  $31.2 \pm 4.8$  months, respectively. The mean slip correction rate was 52.2% with a mean correction loss of 4.8%. Preoperative VAS and ODI improved from 8.8 and 71.6 to postoperative 2.1 and 28.7, respectively. Clinical improvement was more prominent in more reduced patients, but Pearson coefficient could not find a significant correlation.

**Conclusion:** Although spinal decompression with fusion and posterior instrumentation in surgical treatment of the patients with LDS result in satisfactory outcome, vertebral reduction cannot significantly enhance the clinical improvement.

Please cite this article as: Omid-Kashani F, Hassankhani EG, Shiravani R, Mirkazemi M. Surgical Outcome of Reduction and Instrumented Fusion in Lumbar Degenerative Spondylolisthesis. *Iran J Med Sci.* 2016;41(1):13-18.

**Keywords** • Spondylolisthesis • Lumbosacral region • Spinal fusion • Instrumentation

## What's Known

- In the surgical treatment of degenerative lumbar spondylolisthesis, neural decompression, posterolateral fusion, and instrumentation are the norms. However, the role of vertebral reduction is controversial.

## What's New

- We found that although spinal decompression with fusion and posterior instrumentation in the patients with LDS result in a satisfactory outcome, vertebral reduction cannot significantly increase the clinical improvement.

## Introduction

Lumbar degenerative spondylolisthesis (LDS) is an acquired slippage of one lumbar vertebra on the lower one as the result of degenerative instability, in the absence of a defect in the pars interarticularis.<sup>1</sup> The disease is frequently seen in middle and old aged female and patients may have no clinical symptoms.<sup>2</sup> Most of the time, the symptomatic patients respond well to non-surgical treatments such as lifestyle modification (reducing environmental pain generators), medication, physical therapy, weight reduction, multidisciplinary pain clinics or epidural injection.<sup>3,4</sup>

In refractory cases with intolerable symptoms (a dramatic decline in quality of life, unresponsive to a reasonable trial of >3 months conservative treatment, rest pain, progressive

neurologic deficit, or sphincter disturbances) surgery may be necessary.<sup>5,6</sup> At the present time, 70-80% of the surgically treated patients have a satisfactory outcome, but due to the continuing degenerative process the results get worse over time.<sup>6</sup>

Poor prognostic factors commonly quoted for the patients with surgical treatment, include age >65 years, chronicity of symptoms >24 months, instrumentation >4 levels, inability to restore sagittal balance, comorbidities >4, preoperative back pain more than leg pain, posterolateral fusion versus 360 degrees, intermittent claudication more than several hundred meters, previous surgery, and inability to fuse.<sup>5,7-10</sup> A range of surgical techniques has been used for surgical treatment of LDS. These include indirect reduction alone, decompression alone, decompression plus lumbar fusion with or without instrumentation, decompression and slip reduction plus instrumented fusion.<sup>11</sup> In this study, we aimed to evaluate the surgical outcome of degenerative spondylolisthesis with neural decompression, pedicular screw fixation, and posterolateral fusion.

## Materials and Methods

The research method was a randomized before-after clinical trials study. After local institutional review board approval (code number 88194) and based on standard error calculation, this study was carried out on 45 surgically operated patients with refractory LDS from August 2008 to January 2011. Our inclusion criteria were LDS unresponsive to more than three months aggressive conservative treatment, progressive neurologic deficit (especially motor deficit) and a careful clinical and radiological evaluation that confirmed patients' complains were due to the LDS. We excluded those patients with associated significant comorbidities (like psychoneurotic disorders, advanced diabetes mellitus, severe untreated hip, or knee osteoarthritis, etc.), previous lumbar spine surgery, underlying lumbar congenital or traumatic lesion, and a follow-up period of less than two years.

Preoperatively, routine standing anteroposterior and lateral views of the lumbosacral spine and magnetic resonance imaging scan were obtained from all patients. Vertebral slippage was measured by the slip percentage method, first mentioned by Taillard.<sup>12</sup> This method describes the degree of slip as a percentage of the anteroposterior diameter of the top of the lower vertebra. One of the advantages of this method is its percentage expression; therefore, differences in radiological

magnification and patient's body size do not distort the results. This index was measured preoperatively, immediate postoperatively and at the last visit. Correction rate was calculated as below:

Slip Correction Rate (%) =  $\frac{(\text{Preoperative} - \text{Postoperative slip percentage})}{\text{Preoperative slip percentage}} \times 100$ .

The patients' pain and disability were assessed by a 0-10 numerical rating scale (VAS and ODI) questionnaire version 2.1.<sup>13,14</sup> The latter has been previously translated and validated for the Persian speaking patients.<sup>15</sup> These forms are completed by the patients themselves. The surgical procedure was explained in simple terms to patients and they signed the informed consents. All the surgical procedures were performed by a single surgical team and in the same manner.

## Surgical Technique

After the general anesthesia was inducted, the patient was placed in prone position. Initially, efficient neural decompression, pedicular screw insertion, and posterolateral spondylodesis were carried out as routinely performed and then vertebral reduction tried.<sup>16</sup> Throughout these years, we used a mixture of local bone graft besides matchstick allograft (10 pieces 5×5×35 millimeters of freeze dried cortical cancellous matchstick, tissue regeneration corporation (TRC), Kish, Iran) to achieve posterolateral fusion. At the time of screw insertion, depending on the amount of replacement needed, the proximal screws' head should be placed ahead of the distal screws. Therefore, with tightening of the proximal screws, the slipped vertebra will come back to the original place. To do this, we first tightened both distal screws (usually L5 vertebral pedicular screws) to the longitudinal rods. Then, we applied mild distracting force between proximal and distal screws to facilitate the reduction maneuver and later we tightened the proximal screws to draw back the slipped vertebra (Figure 1).

All the intra- and postoperative complications were recorded. One or two days after surgery, the patients began to walk with a rigid lumbosacral orthosis and slip percentages were calculated again. Postoperatively, they are followed-up by X-ray and physical examination at 6 weeks and 3, 6, 12 months, and then annually. At annual visits, the questionnaires were completed again. To confirm osseous union, we relied on observing the bony bridge between transverse processes on plain anteroposterior and Ferguson radiographs.<sup>17</sup> We did not use computerized tomography to



**Figure 1:** 49-year-old man with L4-L5 LDS presented with debilitating claudication and pain. Surgery could reduce slip percentage from 17% preoperatively to 1% postoperatively.

verify spondylodesis except in symptomatic patients.

#### Statistical Analysis

Pre- and postoperative indices were compared with paired t-test. The results were given as mean and standard deviation (SD) or range. Statistical package for the social sciences (SPSS) software version 16 was used for statistical analysis, data management, and documentation. P values <0.05 were interpreted as statistically significant. The Pearson correlation coefficient was used to measure the linear dependence between the amount of vertebral reduction and clinical (ODI) improvement.

#### Results

We evaluated 45 patients that included 37 (82.2%) women and 8 (17.8%) men. The mean age of the patients at surgery and the mean follow-up period were  $58.3 \pm 3.5$  years (ranged 43-76) and  $31.2 \pm 4.8$  months (ranged 24-52), respectively.

All of these 45 patients had a slip of grade I or II. The distribution of the spondylolisthesis levels in our patients was as follows: L4-5 (35 cases, 75.5%), L5-S1 (3 cases, 6.7%), L3-4 (3 cases, 6.7%), L3-L4-L5 (3 cases, 6.7%), L2-L3 (1 case, 2.2%), and L4-L5-S1 (1 case, 2.2%). The mean pre- and postoperative clinical and radiological indices (at the last follow-up visit) are shown in Table 1. The mean slip correction rate was  $52.2 \pm 11.6\%$  (ranged 21-95%) with a mean loss of correction of  $4.8 \pm 1.1\%$  (ranged 0-11%). Slip reduction of more than 5% was obtained in 39 cases (86.7%), ranged 0 to 31%.

Pearson correlation between the amount of vertebral reduction and ODI improvement was

**Table 1:** Pre- and postoperative radiological and clinical characteristics of our patients

Variables	Preoperative	Postoperative	P value*
Slip (%)	24.9±11.0	11.9±13.7	0.031
ODI*	71.6±15.4	28.7±21.2	0.001
VAS*	8.8±1.3	2.1±2.8	0.001

\*ODI: Oswestry disability index, \*VAS: Visual analogue scale, \*Comparison based on paired t-test

not statistically significant ( $r=0.15$ ,  $P=0.322$ ). Although regarding to positive "r", one may initially conclude that with more obtaining of vertebral reduction, the more improvement in ODI can be achieved; this correlation was not significant statistically.

We did not encounter any significant intraoperative complications, but we had two superficial postoperative wound infections (4.4%), both in diabetic patients and both responded efficiently to local wound care, antibiotics, and blood sugar control. Neurologic injury did not occur in any patient. Postoperative implant failure (screw breakage at the distal level) was seen in only one patient due to asymptomatic pseudoarthrosis. None of the patients required reoperation.

#### Discussion

Our findings confirm vertebral reduction, neural decompression, posterolateral fusion, and instrumentation with pedicular screws and rods in surgical treatment of patients with refractory LDS has resulted in a significant improvement in pain and disability. Although vertebral reduction was associated with improved function, we cannot find a significant correlation between these two indices statistically.

We had carried out a relatively similar study on 23 patients with LDS in 2008 and followed them up for an average period of 29 months.<sup>18</sup> In that study, we treated them without any attempt on vertebral reduction. Other details of the research were completely alike and ODI improved from preoperative 72.2% to 14.4% at the last postoperative visit. In comparison with that study, in the present research (the same surgical techniques, but with the accomplishment of vertebral reduction) ODI improved from 71.6% to 28.7%. It seems that reduction maneuver in the present study could not lead to significantly better functional outcomes.

In another retrospective study conducted by Han et al., they evaluated the clinical outcomes and loss of correction in 37 patients with low grade LDS with a mean follow-up period of 36.4 months.<sup>19</sup> For assessing pain and disability

improvement, they also used VAS and ODI, but they also used computerized tomography beside a plain radiograph to appraise fusion status and loss of correction. In their study, they achieved a postoperative reduction rate of 76.4%, although in 34 cases (91.9%), 5.8% of correction was lost. At the last follow-up visit, ODI and VAS also showed a significant improvement in comparison with preoperative indices. Their complications included superimposed degenerative scoliosis (2 cases), upper adjacent segment retrolisthesis (1 case), screw breakage (1 case), and postoperative infection (1 case). In contrast to our study, they could gain more reduction rate, but their loss of correction was also higher. These authors finally recommended reduction, decompression, and posterolateral instrumented fusion, although limited loss of correction commonly occurs.

Different methods have been used for vertebral reduction in spondylolisthesis.<sup>20,21</sup> Weisskopf attempted to reduce spondylolisthesis by temporary adjacent segment distraction.<sup>20</sup> He believed that this indirect force facilitated vertebral reduction. In a study on 32 patients, he and his colleagues momentarily instrumented the upper adjacent vertebra to apply distraction on the instrumented vertebrae and then lumbar interbody fusion was also performed. At the last follow-up visit (averaged 32 months), they reported 81% reduction rate, 100% bony union, and significant improvement in quality of life (assessed by short form 36 questionnaire). Bednar in 2002 reported the surgical outcome of LDS in 56 patients treated by instrumented fusion and slip reduction without associated laminectomy.<sup>22</sup> The mean follow-up period was 33 months clinically and 28 months radiologically. They attained clinical and imaging outcomes comparable to previous outcomes published in the literature had been achieved by in situ fusion and laminectomy. The author concluded that laminectomy may not be required in surgical treatment of LDS. In the present study, laminectomy was performed routinely, but we also could not find a significant advantage for slip reduction in LDS surgery.

In 2006, Gaetani and colleagues reported functional disability in 76 cases with surgically treated LDS.<sup>23</sup> All the patients were treated by decompression, posterolateral fusion, and stabilization and followed up for more than two years. ODI showed an improvement more than 20 points in 55.7% of the patients. Functional outcomes of surgery between the patients with bony union and pseudoarthrotic cases were similar and they recommended instrumented

spondylodesis in the surgical treatment of these patients.

There are many controversies about vertebral reduction, spinal sagittal rebalancing, and their relationship with surgical outcome of the patients.<sup>8,21,23,24</sup> Overall, most authors seem to agree with re-establishment of the normal anatomy. In this regard, Kawakami et al. conducted a study about the effects of lumbar sagittal balance on clinical outcome of surgery in LDS.<sup>8</sup> They used L1 axis S1 distance as a radiologic index for evaluating the sagittal balance. They retrospectively assessed 47 patients with a mean follow-up period of 3.6 years and they finally concluded that in the patients with a L1 axis S1 distance more than 35 mm, a reduction of the vertebral slip may advance functional outcome of surgery. In the study we conducted, we could not gain a strong relationship between vertebral reduction and surgical results, although we did not have any neural injury as well.

Our study had several important limitations. One of these drawbacks was its retrospective design that may unconsciously distort the results. We did not use postoperative computerized tomography for careful evaluation of the fusion mass, although the osseous union is not meant to cure. It would have been better that we could compare two separate groups with and without slip reduction and follow them up for a longer period. The strengths of our study were its acceptable number of patients and follow-up assessment. In the future, it is strongly recommended that a randomized control trial study should be conducted.

## Conclusion

In conclusion, although spinal decompression with fusion and posterior instrumentation in surgical treatment of the patients with LDS result in satisfactory outcome, vertebral reduction cannot significantly enhance the clinical improvement.

## Acknowledgement

This study was funded by the Student Research Committee, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran (Dr R. Shiravani, thesis number 2714). The authors acknowledge the assistance of Ms. Ariamanesh for her advice in designing, revising the manuscript, and statistical analysis.

**Conflict of interest:** None declared.

## References

- Hu SS, Tribus CB, Diab M, Ghanayem AJ. Spondylolisthesis and spondylolysis. *J Bone Joint Surg Am.* 2008;90:656-71. PubMed PMID: 18326106.
- Hammerberg KW. New concepts on the pathogenesis and classification of spondylolisthesis. *Spine (Phila Pa 1976).* 2005;30:S4-11. doi: 10.1097/01.brs.0000155576.62159.1c. PubMed PMID: 15767885.
- Kalichman L, Hunter DJ. Diagnosis and conservative management of degenerative lumbar spondylolisthesis. *Eur Spine J.* 2008;17:327-35. doi: 10.1007/s00586-007-0543-3. PubMed PMID: 18026865; PubMed Central PMCID: PMC2270383.
- Sengupta DK, Herkowitz HN. Lumbar spinal stenosis. Treatment strategies and indications for surgery. *Orthop Clin North Am.* 2003;34:281-95. PubMed PMID: 12914268.
- Sengupta DK, Herkowitz HN. Degenerative spondylolisthesis: review of current trends and controversies. *Spine (Phila Pa 1976).* 2005;30:S71-81. doi: 10.1097/01.brs.0000155579.88537.8e. PubMed PMID: 15767890.
- Issack PS, Cunningham ME, Pumberger M, Hughes AP, Cammisa FP. Jr. Degenerative lumbar spinal stenosis: evaluation and management. *J Am Acad Orthop Surg.* 2012;20:527-35. doi: 10.5435/JAAOS-20-08-527. PubMed PMID: 22855855.
- Keorochana G, Laohacharoensombat W, Wajanavisit W, Chanplakorn P, Woratanarat P, Chatchaipun P. Functional outcome after decompression and instrumented arthrodesis in degenerative lumbar spinal stenosis: factors influencing unsuccessful outcome change. *J Med Assoc Thai.* 2011;94:1487-94. PubMed PMID: 22295737.
- Kawakami M, Tamaki T, Ando M, Yamada H, Hashizume H, Yoshida M. Lumbar sagittal balance influences the clinical outcome after decompression and posterolateral spinal fusion for degenerative lumbar spondylolisthesis. *Spine (Phila Pa 1976).* 2002;27:59-64. doi: 10.1097/00007632-200201010-00014. PubMed PMID: 11805637.
- Majid K, Fischgrund JS. Degenerative lumbar spondylolisthesis: trends in management. *J Am Acad Orthop Surg.* 2008;16:208-15. PubMed PMID: 18390483.
- Rousseau MA, Lazennec JY, Bass EC, Saillant G. Predictors of outcomes after posterior decompression and fusion in degenerative spondylolisthesis. *Eur Spine J.* 2005;14:55-60. doi: 10.1007/s00586-004-0703-7. PubMed PMID: 15197628; PubMed Central PMCID: PMC3476678.
- Watters WC, 3<sup>rd</sup>, Bono CM, Gilbert TJ, Kreiner DS, Mazanec DJ, Shaffer WO, et al. An evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spondylolisthesis. *Spine J.* 2009;9:609-14. doi: 10.1016/j.spinee.2009.03.016. PubMed PMID: 19447684.
- Taillard W. Spondylolisthesis in children and adolescents. *Acta Orthop Scand.* 1954;24:115-44. PubMed PMID: 13217798.
- Fairbank JC, Pynsent PB. The Oswestry Disability Index. *Spine (Phila Pa 1976).* 2000;25:2940-52. PubMed PMID: 11074683.
- Wewers ME, Lowe NK. A critical review of visual analogue scales in the measurement of clinical phenomena. *Res Nurs Health.* 1990;13:227-36. doi: 10.1002/nur.4770130405. PubMed PMID: 2197679.
- Mousavi SJ, Parnianpour M, Mehdian H, Montazeri A, Mobini B. The Oswestry Disability Index, the Roland-Morris Disability Questionnaire, and the Quebec Back Pain Disability Scale: translation and validation studies of the Iranian versions. *Spine (Phila Pa 1976).* 2006;31:E454-9. doi: 10.1097/01.brs.0000222141.61424.f7. PubMed PMID: 16778675.
- Martin CR, Gruszczynski AT, Braunsfurth HA, Fallatah SM, O'Neil J, Wai EK. The surgical management of degenerative lumbar spondylolisthesis: a systematic review. *Spine (Phila Pa 1976).* 2007;32:1791-8. doi: 10.1097/BRS.0b013e3180bc219e. PubMed PMID: 17632401.
- Whitley AS, Sloane C, Hoadley G, Moore AD. *Clark's Positioning in Radiography.* 12<sup>th</sup> ed. Hodder Arnold: London; 2005. p. 139.
- Behtash H, Ameri E, Mobini B, Tabatabaai S. The results of decompressive surgery and instrumented posterolateral fusion in refractory degenerative spondylolisthesis. Tehran University of Medical Sciences. 2009;66 809-13. Persian.
- Han SJ, Zhang JG, Qiu GX, Wang NG, Zhu Y, Wu ZH, et al. [Clinical results of posterolateral fusion in treating lumbar low-grade spondylolisthesis]. *Zhonghua Wai Ke Za Zhi.* 2011;49:119-24. doi: 10.3760/cma.j.issn.0529-5815.2011.02.005. PubMed PMID: 21426825.
- Weisskopf M, Ohnsorge JA, Wirtz DC,

- Niethard FU. Reduction of spondylolisthesis by temporary adjacent segment distraction. *Z Orthop Ihre Grenzgeb.* 2006;144:511-5. doi: 10.1055/s-2006-942162. PubMed PMID: 16991069.
21. Hu SS, Tribus CB, Diab M, Ghanayem AJ. Spondylolisthesis and spondylolysis. *J Bone Joint Surg Am.* 2008;90:656-71. PubMed PMID: 18326106.
22. Bednar DA. Surgical management of lumbar degenerative spinal stenosis with spondylolisthesis via posterior reduction with minimal laminectomy. *J Spinal Disord Tech.* 2002;15:105-9. doi: 10.1097/00024720-200204000-00003. PubMed PMID: 11927818.
23. Gaetani P, Aimar E, Panella L, Levi D, Tancioni F, Di Ieva A, et al. Functional disability after instrumented stabilization in lumbar degenerative spondylolisthesis: a follow-up study. *Funct Neurol.* 2006;21:31-7. PubMed PMID: 16734999.
24. Li Y, Hresko MT. Radiographic analysis of spondylolisthesis and sagittal spinopelvic deformity. *J Am Acad Orthop Surg.* 2012;20:194-205. doi: 10.5435/JAAOS-20-04-194. PubMed PMID: 22474089.