

Transpedicular Screw Fixation for Degenerative Lumbar Spine Stenosis with Segmental Instability

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ABSTRACT

Objectives: Evaluation of the Transpedicular Screw Fixation as a surgical treatment for the degenerative lumbar spine stenosis with segmental instability. **Methods:** A prospective, uncontrolled and interventional study conducted on thirty patients with low back pain and associated sciatica and claudication due to degenerative spinal stenosis and instability between March 2017-August 2018. Pain assessment, dynamic x rays and MRI was done perioperatively. **Results:** By comparison of pre- and post-operative translational motion, it has been found that more cases tend to be “fixed in plane” with high statistically significant testing ($p=0.00677$) by using Wilcoxon signed rank. In the same line, angular motion was compared perioperatively with the same test above, it has been found that vertebral line is more fixed as regard angular motion with high statistically significant result ($p=0.0074$). By comparing both variables to test the existence of good operative results with presence of “changed” vertebral alignment from instable to stable. It has been found that good results were statistically significant associated with changed alignment from moving to unmovable spinal segment ($p < 0.0001$). **Conclusion:** Posterolateral pedicle screws insertion for degenerative lumbar spine is a good option for restoration of sagittal balance, decompression of canal stenosis and needs no demanding experience or learning curve to serve patients with lumbar spine stenosis and instability.

Keywords: degenerative lumbar, segmental instability, screw fixation.

INTRODUCTION

Multilevel degeneration with lumbar canal stenosis is a common issue worldwide ⁽¹⁾. The pathological changes involve osteophyte formation at the disk level, facet hypertrophy and ligamentum flavum hypertrophy ⁽²⁾. The condition is manifested as buttock pains and neurogenic claudication.

Wide decompressive laminectomy, nerve root release and discectomy (if necessary) had remained the gold standard to operate patients with lumbar canal stenosis ⁽³⁾. When there was instability, posterolateral interpedicular fusion was carried out in the past ⁽⁴⁾. However, there was confusion in the literature concerning the role of fusion even in the presence of instability in degenerative lumbar canal stenosis due to absence of prospective reserches.

The hypothesis tested by the Spinal Laminectomy versus Instrumented Pedicle Screw (SLIP) trial was that lumbar laminectomy with instrumented (rigid pedicle screws affixed to titanium alloy rods) fusion would result in greater improvement than that with laminectomy alone. In the primary outcome measure, the change in the physical-component summary score of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36; range, 0 to 100, with higher scores indicating better physical health-related quality of life) — at 2 years ^(5,6). This study is designed for evaluation of the interpedicular arthrodesis as a surgical treatment for the degenerative lumbar spine stenosis with segmental instability.

PATIENTS AND METHODS

This study was prospective, uncontrolled and interventional study conducted on thirty patients with

low back pain with associated sciatica and claudication due to degenerative spinal stenosis and instability.

The study has been approved by the ethical board of university hospital.

Inclusion criteria

1. Above 40 years old
2. Both genders
3. Degenerative spondylolisthesis only
4. Multi-level spinal instability

Exclusion criteria

1. Recurrent canal stenosis
2. Traumatic cases or pathological fractures.
3. Osteoporosis

Preoperative record

1. Full history taking, general and neurological examination and full labs
2. MRI LSS.
3. Dynamic LSS x-ray.
4. Pain assessment score (visual scale).

After induction of general anesthesia and putting patient on prone position, sub-periosteal muscle separation was done. The exposure of laminae by spinous process splitting, neural decompression with bilateral total facetectomy was done to achieve wide exposure of the disc space and the neural elements to prevent possible nerve root impingements, while preserving the area PS entry. Ps were placed under fluoroscopy guidance by CBT as described previously ^(2,4) with slight modifications.

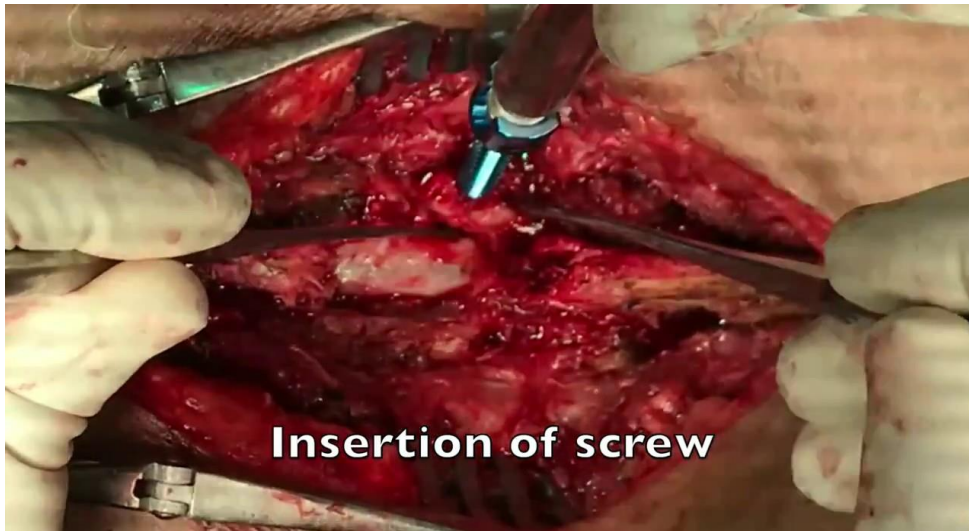


Figure (1): operative image of insertion of screws.

The upper corner of vertebra in the anterior-posterior view and upper endplate was targeted to gain access under control of fluoroscopy. The screw length was measured by a probe inserted along with screw trajectory (see figure 1). Reduction screws were used for slipped vertebrae. Subsequently, the total discectomy consisted of excision of the annulus and cartilaginous end plate was performed as much as possible, whereas the osseous end plate was preserved.

Postoperative record

1. Clinical assessment of symptoms and signs of spinal stenosis
2. Clinical assessment of pain severity (by visual analogue score and numeric rating scale)
3. Radiological assessment by LSS x-ray
Radiographic fusion was considered present if the following features were observed:
 1. no motion across the fusion site on flexion-extension X-rays,
 2. trabeculae intercalating the fusion site,
 3. Absence of lucency in or around the screw site.
 If the fusion was questionable, CT scans were performed.

Neurological outcome: all patients were evaluated clinically at discharge, three months and six months postoperative. The evaluation will be according to **Odom's (1958)** criteria for the evaluation of outcome as follows:

1. **Excellent:** all preoperative symptoms relieved, abnormal signs unchanged or improved.
2. **Good:** minimum persistence of preoperative symptoms, abnormal signs unchanged or improved.
3. **Fair:** definite relief of some preoperative symptoms, others unchanged or slightly improved.
4. **Poor:** signs and symptoms unchanged.

Statistical Analysis

Analysis of data was done by IBM computer using SPSS (statistical program for social science version 25).

RESULTS

Demographic distribution

The mean and standard deviation of age in our group of patients were 51years \pm 10. The minimum and maximum of age in our study were (61-41 years). The age was not normally distributed ($p=0.042$). Gender distribution was equal in our study (50%) for each. By using histogram measures, gender was not normally distributed ($p < 0.0001$).

Clinical presentation

In table (1), the neurogenic claudication was not presented in 10% of cases (3). Equal pain upon walking was seen in 70% of cases while unequal distribution was seen in less than 6% of cases.

Table (1): Claudication frequency in our study.

		Frequency	Percent
Valid	No	3	10
	Equal on both sides	21	70
	One side more severe than other	6	20
	Total	30	100.0

Levels that were targeted for lumbar pedicle screw fixation and revised during imaging examination were mostly of lower lumbar vertebrae (L3-L4-L5) in 63.3% of cases. Single level disease was seen in 20% of cases. Multiple level disease was seen in 20%. All multilevel cases were double levels. L2-3 was attributed in spondylolisthesis in 26.7% (5) of cases. Double level disease was seen most commonly in L3-5 in 5 cases versus one case involved L4-S1.

The median grade of spondylolisthesis was the first grade. In table (2), grades of spondylolisthesis was plotted. Thirty percent of cases had 0 grade

spondylolisthesis in MRI, during re-examination of them by dynamic X-rays, all cases (9) were attributed to grade I (see table 2).

Table (2): Frequency distribution of spondylolisthesis grades

	Frequency	Percent
GI	28	93.3
GII	2	6.7
Total	30	100.0

Odom’s results

As stated before, operative satisfaction was measured by Odom’s criteria. The accepted results were seen in 27 cases (90%). Accepted results is an umbrella term included all categories but “Poor” category.

Table (3): Frequency of operative outcome according to Odom’s criteria

	Frequency	Percent
Excellent	7	23.3
Good	12	40.0
Fair	8	26.7
Poor	3	10.0
Total	30	100.0

Canal stenosis was measured by computed scan or MRI scan. Dimensions were then interpreted as central canal stenosis or lateral or both. Lateral canal stenosis was found as solo finding in 9 cases (30%). Mixed pathologies was found to be the second most findings.

Degrees of canal stenosis were classified into mild moderate and severe stenosis after taking canal dimensions and plotted against normal parameters. Mild stenosis

was seen in 6 cases, moderate stenosis was seen in 14 cases while severe stenosis was seen in 10 cases.

Preoperative translational motion

In sagittal plane, vertebral translational movement was graded as mild moderate and severe. Seven cases (23.3%) were classified as mild. Fifty percent (23.3%) of cases were classified as moderate. Eight cases were classified as severe translational movement.

Angular motion of translated vertebrae was classified as well as translational movement.

Odom’s results

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Postoperative Clinical features

The mean and standard deviation of VAS for both leg and back is illustrated in table (4). Patients with lowest grade of muscle power were re-examined again

immediately postoperative and found that each weakness got improvement for only one degree (G3 to G4). Table (4) illustrated the changes in the grade. The decrease in VAS score is measured by the following formula

$$\Delta VAS = \frac{(VAS\ post - VAS\ pre)}{VAS\ pre} * 100$$

So, the changes in back VAS was 31.5% reduction in low backache after surgery. As well, change in leg VAS was 67.48% reduction in leg pain after decompression and fusion surgeries (see figure 2).

Table (4): Descriptive statistics of postoperative VAS for both back and leg pain

	Mean	SD	Median	Min-Max	Range
Back	5	1.3	5	2-7	5
Leg	2.52	1.08	2	1-4	3
Grade	No.		Grade	No.	
G5	2		G2	0	
G4	4		G1	0	
G3	3		G0	0	

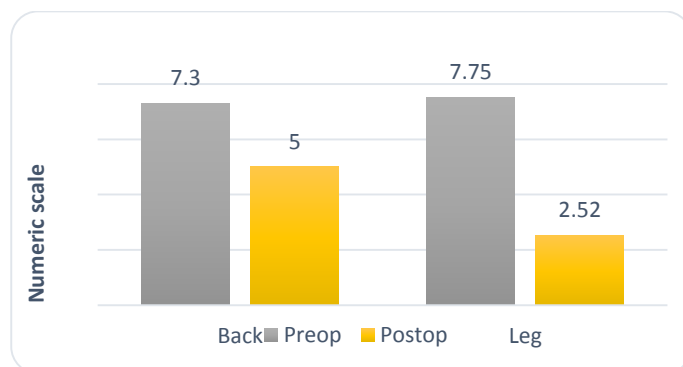


Figure (2): Perioperative pain score in back and leg.

Postoperative radiographic results

Postoperatively, the translational and angular motions were graded with the same maneuver by examining the postoperative CT and MRI lumbosacral spine. The term olisthesis means presence of any motion in any plane, only 3 cases exhibited presence of motion at postoperative dynamic x rays.

Back VAS pre and post

The pain scores were examined perioperatively as regard back region. By using Wilcoxon signed rank as a nonparametric test where p value was less than 0.0001. This clearly denoted statistically significant difference between both measures and indicating great relief of back pain despite small mean difference (-2.3018).

Leg VAS pre and post

Preoperative leg VAS score and postoperative were also measured. Absence of normal distribution of both data make testing with nonparametric tests more logic. By using Wilcoxon signed rank, it has been found that there was statistically significant difference

between both measures with greater relief of leg pain after surgery ($p < 0.0001$). There was greater mean difference between both measures (-5.2300).

Odom's criteria

By using single test mean, it has been found that there was statistical difference in Odom's criteria ($p < 0.0001$). Which indicated low number of poor outcomes among our study sample.

Perioperative dynamic changes

By comparison of pre- and post-operative translational motion it has been found that more cases tend to be "fixed in plane" with high statistically significant testing ($p=0.00677$) by using Wilcoxon signed rank.

In the same line, angular motion was compared perioperatively with the same test above. It has been found that vertebral line is more fixed as regard angular motion with high statistically significant result ($p=0.0074$).

Odom's criteria versus olisthesis

By comparing both variables to test the existence of good operative results with presence of "changed" vertebral alignment from instable to stable. It has been found that good results were statistically significant associated with changed alignment from moving to unmovable spinal segment ($p < 0.0001$).

DISCUSSION

This study was a prospective, uncontrolled and interventional trial conducted on thirty patients with low back pain and associated sciatica and claudication due to degenerative spinal stenosis and instability.

In our study, there was statistical significant association between good operative results and fixed spinal segment ($p < 0.0001$). Therefore, fixation of spinal segments is highly associated with relief of low back pain.

In our study, the total number for enrolled patients were 30. In **Mori and colleague** ⁽⁵⁾ study, thirty-two patients were enrolled in the study. Thirty-two consecutive patients were enrolled. **Boissiere et al.** ⁽⁷⁾ performed their study on lumbosacral fusion with 39 cases only. In **Dusad et al.** ⁽⁸⁾, a total of 87 patients were included and divided into two groups: patients who underwent navigation-guided MIS TLIF (study group: 27 patients; L4-L5/L5-S1, 9/18) and those who underwent conventional fluoroscopy-guided non-navigated MIS TLIF (control group: 60 patients; L4-L5/ L5-S1, 26/34).

Our study population was not small as regard with other studies mentioned above. Large number of cases are not needed in small volume centers.

In our study, age mean and standard deviation of age in our group of patients were 50 years \pm 10. The minimum and maximum of age in our study were (41-61 years).

In **Costa et al.** ⁽⁹⁾, mean age of the population was 77.8 years (range 75-82). **Schaeren and coworkers** ⁽⁴⁾ performed their trial and found that age at the operation time point was 66.53 (range, 47-80).

In **Mori et al.** ⁽⁵⁾, mean age at the time of surgery was 68 years (range, 51-84 years). In **Dusad and coworkers** ⁽⁸⁾, the age mean and SD were 57.54 (8.03).

The cause of diversity in ages belong to two factors; first, the advanced anesthetic tools in spine surgeries. Second, **Costa and coworkers** ⁽⁹⁾ performed their study in over 75 years old group.

Gender distribution was equal in our study (15:15) for each in our study. In **Mori and colleagues** ⁽⁵⁾, there were 5 males and 27 females. There were 30 females and 6 males in **Schaeren et al.** ⁽⁴⁾. In **Costa and colleagues** ⁽⁹⁾, 31 (58.4 %) female and 22 (41.6 %) male. In **Dusad et al.** ⁽⁸⁾, there were 36 male and 51 females.

In our study, we insisted to target equal gender selection including sex bias to avoid what commonly shared by previous prospective studies.

In our study, the mean and SD of back and leg pain preoperatively was 7.3 ± 1.4 and 7.75 ± 1.4 respectively. **Mori et al.** ⁽⁵⁾ reported that pre-operative VAS was 7.8 which is consistent with our study.

In our study, the neurogenic claudication was not presented in 43.3% of cases (13). Equal pain upon walking was seen in 50% of cases while unequal distribution was seen in less than 7% of cases. In agreement with our study, **Schaeren et al.** ⁽⁴⁾ in their study reported that twelve patients (33.33%) had impaired sensation in terms of hypoesthesia and 4 patients (11.11%) had diminished muscle strength (grade M4/5) according to affected level of the stenosis lesion. Nobody had acute bladder or colon disturbances preoperatively.

Schaeren et al. ⁽⁴⁾ examined patients suffering from spinal stenosis clinically or radiologically. Thirty-two patients (88.89%) had degenerative spondylolisthesis at the L4/L5 level. The mean listhesis grade due to Meyerding was 25.23% (range, -14% to 50%; SE -1.44, SD -6.28) which equals to G I spondylolisthesis. **Costa et al.** ⁽⁹⁾ recorded in his trial that 88.7 % the spondylolisthesis was of grade I, while in 6 (11.3 %) it was of grade II.

In our study, levels that were targeted for lumbar pedicle screw fixation and revised during imaging examination were mostly of lower lumbar vertebrae (L3-L4-L5) in 63.3% of cases. Single level disease was seen in 20% of cases. Multiple level disease was seen in 20%. All multilevel cases were double levels. All studies discussing spine problems included double levels with single level pathology ⁽¹⁰⁻¹³⁾. It is not surprise to find more prevalence of lower lumbar pathologies than L1 and L2 pathologies. The former are mobile segments and under stress of degenerative processes while the later are more susceptible to pathological fractures.

In our study, the accepted results of Odom's criteria were seen in 27 cases (90%). Accepted results is an umbrella term included all categories but "Poor" category. In **Son et al.** ⁽¹⁴⁾, the results were excellent in 6 patients (35.3%), good in 7 patients (41.2%), and fair in 4 patients (23.5%) at the 6-month follow-up. At the

last follow-up, the results were excellent in 7 patients (41.2%), good in 8 patients (47.0%), and fair in 2 patients (11.8%). Therefore, the clinical success rate according to Odom's criteria was 88.2%. **Kang et al.** (2) obtained 90.25% success rate during his study to compare unilateral versus bilateral pedicle screws in lumbar spine.

In majority of spine research projects, assessment of surgery success is evaluated by introducing Odom's criteria (which was originally instrumented in cervical spine and then propagated to whole spine surgery assessment) (14), Oswestry disability scale (2) or quality of life sheets (9, 15 & 16). In our study, high success rate according to Odom's criteria reflects our high selectivity of patients and absence of intraoperative complications due to higher experienced surgeons.

In our study, the mean and standard deviation of VAS for both leg and back were 5 ± 1.3 and 2.52 ± 1.08 respectively. The reduction in VAS score for both back and leg pain was about 32% and 68% respectively. The mean VAS for LBP and LP decreased significantly to around thirty percent and 19.58% combined with NASS-Pain scores respectively. The optimal surgical treatment of DLS has been advanced more in the recent decades (5). The present study revealed that PS technique is useful to reduce slippage of vertebrae and to maintain the restored alignment with significant neurological recovery for at least immediate recovery postoperatively. Loss of correction in 3 cases during the follow-up period was observed. Apparent loosening of PS was not found in these cases (17-19). Apparent nonunion was not encountered after the surgery evident as a clear as it takes long follow up. However, this never correlated with clinical symptomatology or biomechanical failure. It is difficult to directly compare the nonunion rate with other results because universally approved radiological criteria for interpedicular fusion have been established and discussed everywhere (20).

The clear zone around screws evident on CT is not our topic in this field. The possible impact of the screws inside pedicles was advocated (21). However, the exact mechanism remains unknown. Further studies are warranted to elucidate the pathoanatomical changes around screws (21 & 22).

We followed-up our patients to discover complete bony fusion. The optimal surgical treatment of DLS has been advanced more in the recent decades. Decompression surgery without spinal fusion has achieved fair clinical results in patients with DLS in the short term (5). However, it is not always indicated for patients with DLS (19). A variety of factors including instability and/or disc degeneration of the level of spondylolisthesis, spinal alignment, and severity of spinal canal stenosis can be present. Appropriate surgical treatments including spinal fusion surgeries should be indicated. Spinal balance, especially sagittal balance, is an important issue to be

considered for spinal surgeons. Several researchers suggested that correction of sagittal imbalance is critical step in short- and long-term outcomes in adult spinal deformity (23-25).

A positive correlation between improved local lordosis at the fused segment due to the reduction of slippage and recovery rate of Odom criteria of the patients with DLS managed by posterolateral fusion has been described (26 & 27). Biomechanical studies using cadaveric spines have shown that local sagittal alignment of fused segment after lumbar fusion surgery appreciably influences the adjacent levels (13, 28 & 29).

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