Original Article

Unilateral Transpedicular Screw Fixation with Cage Fusion. A Novel Technical Option for Management of Symptomatic Lumbar Foraminal Stenosis

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ABSTRACT

Background: Foraminal stenosis is usually associated with thickening of ligamentum flavum, bulging of intervertebral disc and hypertrophy of facet joint. Wide decompression may cause postoperative instability if weight bearing structures are compromised. Objective: to evaluate unilateral transpedicular screw stabilization with interbody fusion as a technical option for management of symptomatic lumbar foraminal stenosis. Patients and Methods: The study included fourteen patients who underwent unilateral posterior decompression with pedicle screw fixation and single-level interbody fusion from September 2012 to January 2014 with follow-up period up to 12 months later on. The Japanese Orthopedic Association Scale (JOA) was used for evaluation of back pain. The result of surgery was also evaluated with MacNab’s classification. Excellent or good outcome was considered as satisfactory. Results: The average JOA score of the fourteen patients was 6.5 (range, 4-9) before surgery and was 12.5 (range, 10-15) at the end of this study. Post-operative JOA score improved significantly (p < 0.05). There were two cases (14%) of post-operative cerebrospinal fluid (CSF) leak, only one case (7%) of wound infection and were treated conservatively. Satisfactory outcome was achieved in twelve cases (86%). Conclusion: Unilateral pedicle screw fixation with interbody cage fusion after posterior decompression for the unilateral symptomatic foraminal stenosis is an effective option for obtaining satisfactory clinical outcome. Good selection and meticulous surgical procedures give satisfactory outcome in over 85% of cases with follow-up period of 12 months.

INTRODUCTION

Chronic discogenic back pain caused by degenerative disc disease is a common ailment in the general population. This degeneration often results from arthritic changes in the intervertebral discs, facet joints, and ligaments surrounding the vertebral canal. In clinical practice, lateral recess stenosis and foraminal stenosis may induce nerve root compression which can cause unilateral symptoms. Stenosis of the intervertebral foramen is usually associated with decreased disc height, thickening of ligamentum flavum, bulging of intervertebral disc, hypertrophy of facet joint, and the growth of spur. Wide decompression may cause postoperative instability if weight bearing structures are compromised. Instrumented fusion is necessary when preexisting or surgically induced instability is present.

Unilateral lumbar spinal pathologies, such as the foraminal or extraforaminal disc herniations, spinal stenosis related to facet hypertrophy, and spinal cord tumors (e.g., neurinoma, menengioma), can be treated using a unilateral spinal approach. In these cases, removing one side of the total facet articulation(s), with or without performing a laminectomy, may allow access to the pathology. Trans-pedicular screw instrumentation is a popular method of strong fixation to achieve high fusion rate. Although the ideal stiffness of instrumentation is unknown, pedicle screw fixation proved to be very strong and showed high fusion rate.

The foraminal stenosis is the result of degenerative change of spinal segment. The radicular pain may be unilateral if the progression of stenosis is different in both sides. In that situation, there is no need to expose contralateral side for the decompression of the corresponding nerve root. If the unilateral pedicle screw fixation is strong enough to achieve acceptable fusion rate, the surgeon can get the advantage of reduced surgical extent by exposing only the symptomatic side.

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The facet joint carries an estimated sixteen to twenty five percent of the compressive load and provide torsional stiffness and resistance to shear and translational forces. According to the biomechanical perspective, the one-sided total lumbar facetectomy produces a significant increase in the range of motion (ROM) in flexion and in axial rotation to the opposite side. Hence, a total facetectomy, even when performed unilaterally while preserving the posterior ligaments, may create instability.

Because of the role of facet articulation, some authors prefer the more stable facet-sparing laminectomy procedure over the combined bilateral facetectomy and laminectomy procedure when spinal canal decompression is needed for the multilevel lumbar spinal segment.

There are some studies testing the effectiveness of unilateral fixation. The idea of unilateral fixation was initially proposed to decrease the stiffness of fixation, thereby to reduce the degree of adjacent segment degeneration and the decrease in mineral density of fused vertebra. The unilateral fixation may have some advantages such as a smaller surgical exposure, lower cost, and lower rate of screw-related complications.

However, the fusion rates of unilateral fixation were lower than bilateral counterpart. Posterior lumbar interbody fusion (PLIF) has proven successful for relieving motion-induced discogenic pain and was once considered standard treatment for degenerative disc disease.

A successful PLIF can restore disc height, decompress the dural sac and nerve roots, immobilize the unstable intervertebral disc, and maintain load-bearing to anterior structure.

**PATIENTS AND METHODS**

This retrospective study was conducted on fourteen patients between 25 and 55 years old at the time of diagnosis (mean age 40 years) among twenty three patients presenting with symptomatic foraminal stenosis in the Neurosurgery Department, Al-Menoufia University Hospitals from September 2012 through January 2014. There were nine males and five females with M: F ratio 1.8:1. The mean duration of the symptoms was 8.4 months. The confirmation of foraminal stenosis was done through Magnetic Resonance Imaging (MRI) scans as shown in Figure 1.

**Inclusion criteria:**
1. Unilateral radicular pain not responding to conservative treatment for more than three months.
2. Ipsilateral intervertebral foraminal stenosis evident on MRI.

**Exclusion criteria:**
1. High grade spondylolithesis associated with foraminal stenosis.
2. Patients presenting with bilateral neurogenic claudication.
3. Previous disc surgery at the same level.

After confirmation of diagnosis and patient's consent, fourteen patients (61% of total population) were included in the study and underwent unilateral posterior decompression, unilateral trans-pedicular screws with single-level interbody cage fusion shown in Figure 2.

Follow-up was done after 3, 6 and 12 months post-operative through both: Clinical follow-up: The clinical symptoms were assessed at each interval. The JOA score was determined via direct questioning to assess subjective symptoms, clinical signs and the restriction of activities of daily living. Radiological follow-up: Immediate post-operative Plain-X ray was done to confirm the accurate position of pedicular screws and interbody cage, 6 months post-operative and at the end of the study for evaluation of successful fusion as shown in Figure 3. An independent radiologist was invited to evaluate the status based on radiographic study. Surgical outcome was classified using MacNab's classification: Excellent: Complete relief of back/leg pain. Good: Occasional pain in back/leg. Fair: Some improvement in back/leg pain with occasional use of pain medication. Poor: Little or no change in pain or worse than before surgery with regular use of pain medication.

**Fig. 1:** Preoperative T2 weighted sagittal MRI showing left L5 root impingement in the intervertebral foramen by the protruded disc and collapsed disc space (arrow).
Fig. 2 a&b: Intra-operative interdisc dilator is inserted before impaction of interbody cage, after unilateral pedicle screw placement.

Fig. 3 a & b: Post-operative plain-X-ray. AP and lateral view showing optimum position of pedicle screw with interbody cage.

RESULTS

Regarding the age distribution among fourteen patients in our study, the peak incidence was between 35-45 years (28% in males and 14% in females) and the least incidence was between 25-35 years (14% in males and 7% in females), the mean age was 40 years. Most of patients in our study were males (nine patients, 65%), while only five patients (35%) were females with M: F ratio (1.8: 1) and this was due to the nature of the heavy work of males in the agricultural society and higher susceptibility to trauma as shown in table 1.

Table 1: Age and sex distribution among the studied group

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male</th>
<th>%</th>
<th>No.</th>
<th>Female</th>
<th>%</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-35</td>
<td>2</td>
<td>14</td>
<td>1</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35-45</td>
<td>4</td>
<td>28</td>
<td>2</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-55</td>
<td>3</td>
<td>23</td>
<td>2</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>65</td>
<td>5</td>
<td>35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The most common presenting feature in our study was unilateral sciatic pain in all patients, while partial unilateral foot drop was observed in only one patient (7%) as shown in table 2.

Table 2: Clinical presentations among the studied group

<table>
<thead>
<tr>
<th>Clinical presentations</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral sciatica</td>
<td>14</td>
<td>100</td>
</tr>
<tr>
<td>Sensory deficit</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Motor deficit</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

According to pre-operative MRI (investigation of choice), the most common level affected was at L4-5 in eight patients (58%), L5-S1 in four patients (28%), while L3-4 was found in only two patients (14%) as shown in table 3.

Table 3: Levels of lumbar foraminal stenosis included in the study

<table>
<thead>
<tr>
<th>Affected level</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3-4</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>L4-5</td>
<td>8</td>
<td>58</td>
</tr>
<tr>
<td>L5-S1</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>100</td>
</tr>
</tbody>
</table>

The commonest post-operative complications in our study were transient CSF leakage which was reported in two patients (14%) and were managed conservatively by absolute bed rest, compressed bandage and frequent aspiration until complete resolution with no collection. Superficial wound infection developed in only one patient (7%) and was treated conservatively by bed rest, antibiotics and daily dressing until complete healing as shown in table 4.

Table 4: Post-operative complications included in the study

<table>
<thead>
<tr>
<th>Complications</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient CSF leakage</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Wound infection</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>

According to the results achieved in our study, the mean JOA score showed significant improvement during the follow-up period as it increased from 6.5 on admission to 12.5 at follow up period up to 12 months post-operative as shown in table 5.
Regarding the outcome of patients in our study, it was excellent in three patients (21% of cases) with complete resolution of pre-operative symptoms and patients return to their daily activities at the end of the follow up period, good in nine patients (65% of cases) with improvement of pre-operative symptoms, had a sedentary life with restriction of heavy work, while only two patients (14% of cases) had fair outcome and continued on some medical treatment and physical therapy program due to long standing pre-operative manifestations and neglectation for long time before surgical interference as shown in table 6.

Table 6: Surgical outcome according to MacNab's classification

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Good</td>
<td>9</td>
<td>65</td>
</tr>
<tr>
<td>Fair</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

DISCUSSION

The foraminal stenosis is a common etiology of lumbar radicular symptoms. The incidence of foraminal stenosis is reported to be 8-11%. But, the diagnosis of foraminal stenosis is often difficult and when unrecognized, it is a frequent cause of failed back syndrome.

According to Jenis and An’s definition of intervertebral foramen, it is vertical interpedicular zone. The foraminal stenosis causes compression of the exiting nerve root. For the diagnosis of foraminal stenosis causing radicular pain, MRI may be the preferred imaging tool. The parasagittal images allow visualization of the contour and size of the intervertebral foramen with exiting nerve root. The placement of cage for decompression and arthrodesis was required for patients return to their daily activities at the end of the follow up period, good in nine patients (65% of cases) with improvement of pre-operative symptoms, had a sedentary life with restriction of heavy work, while only two patients (14% of cases) had fair outcome and continued on some medical treatment and physical therapy program due to long standing pre-operative manifestations and neglectation for long time before surgical interference as shown in table 6.

Table 6: Surgical outcome according to MacNab’s classification

<table>
<thead>
<tr>
<th>Time interval</th>
<th>JOA score</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Preoperative</td>
<td>4-9</td>
<td>6.5</td>
</tr>
<tr>
<td>3 months post-operative</td>
<td>6-11</td>
<td>8.5</td>
</tr>
<tr>
<td>6 months post-operative</td>
<td>9-14</td>
<td>11.5</td>
</tr>
<tr>
<td>12 months post-operative</td>
<td>10-15</td>
<td>12.5</td>
</tr>
</tbody>
</table>

As a result of involvement of the facet joint and pars interarticularis in foraminal stenosis, which are essential parts weight transmission between the vertebrae, best surgical method for its relief remains controversial. The decompression without fusion may have the advantage of preserving the segmental motion. But, Ozeki et al. in their series on thirty six patients concluded that it is often difficult to achieve enough decompression preserving the facet joint and this coincide with the results achieved in our short study.

Generally, bilateral pedicle screw fixation is accepted as a standard procedure for treating symptomatic spinal pathologies, such as degenerative spinal stenosis, spondylolisthesis, recurrent disc herniation, postlaminectomy instability, and deformity. Some authors have recently demonstrated that unilateral pedicle screw fixation is as effective for spinal fusion as bilateral screw fixation.

According to the biomechanical dynamics of the facet joints, unilateral total lumbar facetectomy produces a significant increase in the range of motion (ROM) in flexion and in axial rotation to the opposite side. Hence, a total facetectomy, even when performed unilaterally while preserving the posterior ligaments, may create instability in the lumbar motion segment.

That is the reason why we chosen unilateral facetectomy with trans-pedicular screws and cage fusion for the surgical procedure in our short study. The fixation with pedicle screws allows enough facetectomy to decompress the nerve root. The placement of cage for interbody fusion distracted the disc space, and this correlates with Suk et al. who also widened its application to multilevel fixation.

The effectiveness of unilateral pedicle fixation was investigated by several authors. The clinical results of unilateral pedicle screw fixation were nearly identical with that of bilateral fixation in Kabins et al.14 who restricted unilateral fixation to single level. The unilateral fixation had several advantages due to its less invasiveness such as shorter operative time, hospital stay and lower medical expenses.

In our study, we restricted this procedure to selected patients presented with unilateral symptoms as we believed that only ipsilateral decompression and screw fixation could relief symptoms and this correlates with Henderson et al. who reported that ipsilateral decompression and arthrodesis was required for improvement of unilateral symptoms.

In the literature, some reports found that unilateral fixation had drawbacks as a result of the decreased strength which can result in nonunion. Looking into the Yücesy et al. series, the unilateral fixation provided significantly worse stabilization. Goel et al.11 also concluded that the unilateral screw system was less rigid and was likely to reduce stress shielding of the vertebral body compared with the bilateral model.

In our study, in order to overcome the decreased stiffness caused by reduced number of pedicle screws in unilateral fixation, we strengthen the strut by placement of interbody cage impacted with laminectomy bone.
We preferred posterior interbody fusion rather than posterolateral fusion as posterior interbody fusion had higher strength than posterolateral fusion because it provided anterior column support. Good fusion was achieved in our study at the end of the follow-up period and was diagnosed by dynamic X-ray study that showed lack of motion, lack of lucencies and development of anterior bridging bone. There was no fusion failure or pseudoarthrosis during the follow-up period and this was identical with similar high fusion rate of posterior interbody fusion reported in previous reports. 25

The mean duration of hospital stay in our study was four days. The average follow up duration was 6.5 months (range: 1-12 months). JOA score improved in all patients after the surgery with statistical significance and the improvement maintained during the follow-up period as it increased from (4-9, mean 6.5) pre-operative to (10-15, mean 12.5) at the end of the follow up period. Satisfactory outcome (both excellent and good) by MacNab’s classification was achieved in twelve cases (86%) and was statistically significant (P <0.05) and this correlates with Kabins et al. who reported significant improvement of outcome score after unilateral fixation.

According to the results in our study, there were low incidence of post-operative complications (21% of cases) and this correlates with Henderson et al. who reported 25% of post-operative CSF leak in their series. The commonest post-operative complications in our study were transient CSF leakage which was reported in two patients (14%) and were managed conservatively by absolute bed rest, compressed bandage and frequent aspiration until complete resolution with no collection till the end of the follow-up period. Superficial wound infection developed in only one patient (7%) and was treated conservatively by bed rest, antibiotics and daily dressing until complete healing.

The limitations in our study were the relatively small number of cases and short follow-up duration. Therefore, there is a possibility that the clinical or radiological outcome can change in longer follow-up. Larger scale study is required to further investigate the effectiveness of this operative option.

CONCLUSION

Unilateral pedicle screw fixation with interbody cage fusion after posterior decompression for the unilateral symptomatic foraminal stenosis is an effective option for obtaining satisfactory clinical outcome. Good selection and meticulous surgical procedures give satisfactory outcome in over 85% of cases with follow up period of 12 months.

REFERENCES

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