Clinical Outcomes Of Minimally Invasive Intersegmental Bilateral Decompression Via A Unilateral Approach For Degenerative Lumbar Spine Stenosis

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Abstract

Purpose

We report one of the largest series of patients treated for lumbar spinal stenosis using a minimally invasive technique. The purpose of this study was to evaluate the results and efficacy of minimally invasive intersegmental bilateral decompression via a unilateral approach for the treatment of degenerative lumbar spinal stenosis.

Materials and Methods:

This is a retrospective review of prospectively collected data, from a group of one hundred-eight patients, who underwent minimally invasive surgical treatment for lumbar stenosis. All patients were operated by single surgeon, consecutive series (n=108). Informed consent was obtained from all patients. All patients were assessed using Visual Analogue Scale (VAS) for pain and Oswestery disability index (ODI) preoperatively as well as postoperatively. The preoperative diagnoses were lumbar spinal stenosis without instability. The indications for surgery were moderate to severe stenosis in patients who had persistent, leg dominant, claudicant/radicular pain. All patients underwent minimally invasive intersegmental bilateral decompression via a unilateral approach. Patients with radiological signs of instability were not offered this type of surgery.

Results

The majority of the patients (88%) had a single level decompression. The length of stay in hospital was just one day for over 85% of patients. At medium term follow up of at least 36 months the average clinical improvement in ODI was 29.9%. VAS was measured for leg pain and improved from 8.35 preoperatively to 2.55 at follow up. The walking distance improved in 95% of patients. There were no cases of postoperative instability.

Conclusions

Degenerative spinal stenosis can be treated successfully with minimally invasive intersegmental decompression, preserving the posterior elements thus preventing iatrogenic instability. We believe it offers a significant advantage over open decompression particularly in elderly patient population.

INTRODUCTION

Spinal stenosis is the progressive narrowing of the spinal canal and lateral recesses caused by any combination of prolapsed intervertebral discs, hypertrophic ligamentum flavum, hypertrophic facet joints and thickened posterior longitudinal ligament and bony spurs. Resultant neural compression can lead to sensory and motor symptoms with variable severity. Lumbar canal stenosis is the most common reason for lumbar spine surgery, particularly in elderly patients [16, 25, 31]. Lumbar decompressive surgery offers similar results in elderly population as any younger age group [3, 26, 30]. Therefore, development and evaluation of different types of minimally invasive procedures are relevant for treatment of degenerative lumbar stenosis.

The aim of surgical treatment of lumbar stenosis is to achieve adequate neural decompression while keeping

iatrogenic trauma to a minimum. Lumbar spinal stenosis treatment via a traditional standard posterior midline approach involves periosteal dissection of paraspinal musculature from the underlying spinous process and lamina with subsequent removal of the bony elements and underlying ligamentum flavum. It offers good clinical outcomes to date and has shown to be superior to conservative therapy for patients with moderate to severe stenosis [2, 5, 6, 7, 8, 15, 34]. However newer, less invasive techniques encompassed in the rapidly expanding genre of minimally invasive spinal surgery allows for a shorter postoperative recovery and fewer complications [4, 17] which is especially relevant when faced with treating an aging population. Although the range of complications in MIS is near about same as the open surgery but recent comparative studies have suggested that the rate of these complications are lesser as compared to open surgery, for instance, less operative blood loss and shorter postoperative stays in patients undergoing MIS for treatment of lumbar stenosis compared to traditional surgery [11, 25]. Minimally Invasive Surgery for both spinal decompression and fusion has evolved quite rapidly over the last two decades. The main principles of minimally invasive decompression include avoiding a wider tissue dissection and disruption of tendinous attachments, especially the multifidus attachment to the spinous process and limiting the amount of osseous resection thereby maintaining the normal biomechanics of the lumbar spine and lessening postoperative spinal instability which happens to be one of the major concerns leading to deterioration of symptoms in the long run [9, 13, 14]. In the degenerative setting, the majority of neural compression occurs at the level of the interlaminar window. In 1988, Young et al [35] described a microscopic technique to achieve this. Their technique involved a bilateral fenestration of the laminae and subarticular fenestration, removing the medial third of the facet joints, without removing the midline structures, where the dural sac and bilateral nerve roots were decompressed with preservation of the supraspinous and interspinous ligament complex. The technique was subsequently modified by Poletti in 1995 [24] and McCullouch in 1998 [19] who reported excellent functional outcomes in thirty patients after two years. Magnetic resonance imaging allows for precise delineation of both soft tissue and bony stenosing elements. Intersegmental decompression can be performed in a minimally invasive fashion, whereby the main stenosing element is addressed specifically without creating additional iatrogenic trauma [32]. The purpose of our study was to examine the efficacy of this minimally invasive intersegmental decompression technique.

MATERIALS AND METHODS

A retrospective review of prospectively collected outcome data from a consecutive series (n=108) of patients (48 males and 60 females; age range 38-91; mean age 69.5 years), operated on by the senior author was undertaken. Patients were taken from a portion of a single years practice, 2007. Duration of symptoms ranged from 6 to 40 months before surgery. Preoperative symptoms and signs included low back pain (89%), leg pain (90%), neurogenic claudication (99%), sensory changes (pareasthesia) (60%) motor weakness in 14% and sphincter disturbance in 8% (Table 1).

Radiological evaluation included plain radiographs and magnetic resonance imaging. Patients with previous spine surgery, instability, trauma, or developmental spinal deformities were not included in the study. All patients had moderate to severe stenosis and the clinical indications for the surgical procedure were leg pain and/or numbness including intermittent claudication rather than back pain. Those patients who had correlation of symptoms with stenosis on MRI had intersegmental decompression performed. The significant segment of stenosis was decompressed as assessed by clinical criteria. In cases where the degenerative changes were particularly extensive and there was doubt as to which segments were symptomatic, a nerve root block was routinely used to verify the symptomatic level. Patients with spondylolisthesis grade 2 or greater were not included in this study. ODI, VAS and walking distance assessments were performed independently of the operating surgeon by the department of physiotherapy; both preoperatively and at 36 month minimum follow up.

SURGERY

Minimally invasive intersegmental, bilateral decompression via a unilateral approach was performed. Preoperative imaging was used in all cases to identify the correct level. A midline incision of less than 2 cm was performed. The multifidus muscle on the side of approach was elevated gently to the medial border of the facet joint. A narrow self-retaining retractor was inserted and the operating microscope was then used to gain full view of the superior and inferior laminae as far lateral as the facet joint, exposing the interspinous ligament and ligamentum flavum medially. It was ensured that the disruption of multifidus muscle was kept to a minimum and not to completely detach it from the

spinous process as it is the largest of the paraspinal muscles and plays a crucial role in stability of lumbar spine. Ligamentum flavum was also preserved as long as possible so that the dural sac and nerve root stay protected during the drilling of medial part of facet joint.

The ligamentum flavum was opened on the ipsilateral side using a knife and then punch dissector, the resection was extended superiorly and inferiorly to complete the decompression in the midline. In case of severe stenosis or if there was shingling of adjacent laminae, high speed 6mm diamond burr was used to remove bone for sufficient exposure of the underlying ligament. Usually trimming of less than 1/3 of the laminae above and below was adequate.

At this stage the microscope was angled 10 degrees towards the surgeon to achieve an adequate view beneath the ipsilateral facet joint which was then undercut in a cone shaped manner until the ipsilateral nerve root was identified and was completely decompressed. The microscope was then angled to 15 degrees medially, into the contralateral gutter; the basal portion of the spinous process needed to be removed in some cases where space offered by ligamentum flavum resection was inadequate. The contralateral nerve root was then decompressed without removing the interspinous ligament or the spinous process, ensuring minimal bony removal.

Outcome Measures and Statistical Analysis.

Patient records were reviewed for operative time, length of postoperative hospital stay, operative blood loss, rate of complications, and rate of reoperation and deterioration of symptoms. Clinical outcomes were evaluated by comparing their preoperative Oswestry Disability Index, VAS leg pain scores and walking distance with their scores at medium term follow up, (minimum of 36 months). Pre and post-operative clinical assessments were performed independently of the operating surgeon.

RESULTS

The vast majority of patients (95) underwent a single level decompression and 13 patients had two levels decompressed (Table 2). The significant level of stenosis was identified with clinical correlation of the distribution of symptoms and signs with MRI. In case of conflict between symptomatic level and level of maximum compression on MRI, the symptomatic level was decompressed.

Clinical Analysis

The mean blood loss per level was 55mls; the mean 'theatre time' was 66 minutes +/- 16.6 min (the time between the patient entering and leaving the theatre was recorded at the institution). The average length of stay was 1.5 days; the mode was 1 day (ie. within 24 hours). There were no perioperative deaths. Four patients underwent redo surgery for repeat decompression at the same level because of progressive restenosis or residual stenosis and inadequate neural decompression at operated levels. Complications included 7 cases incidental durotomy, these were repaired at time of surgery using a fat graft and fibrin glue, two of these patients required formal reopening to repair the leak due to post op pseudomeningocoele formation. There were no cases of post-operative CSF leak. Two patients developed superficial wound infections, which were treated successfully with a course of oral antibiotic therapy. Significantly, no patient required spinal fusion for instability following decompression during the follow up period.

Assessment of Outcome

At medium term follow up of at least 36 months (36- 48 months) the average clinical improvement in ODI was 29.9%; 57.8% +/-19.1 before surgery to 24.8% +/12.6 after surgery. VAS was measured for leg pain and also improved from 8.35 +/-1.2 preoperatively to 2.55 +/-0.3 at follow up (Table 3). The walking distance improved in 95% of patients, 46% of patients reported unlimited walking distance after surgery whose average preoperative assessment was <100meters or <15 minutes. Preoperatively grade 1 degenerative spondylolisthesis was observed, these were assessed by preoperative X-ray and no abnormal movement on the sagittal plane was identified. These patients had repeat X-rays in the late postoperative period and no radiographic evidence of an increase in the degree of spondylolisthesis was detected. None of these patients developed postoperative instability requiring instrumented fusion.

Table 1

Preoperative symptoms

Preoperative Symptoms	Percentage of patients
Low back pain	89%
Leg pain	90%
Neurogenic Claudication	99%
Sensory disturbance	60%
Motor disturbance	14%
Sphincter disturbance	8%

Table 2

Level of stenosis

Number of patients	Level operated
45	L4/L5
32	L3/L4
13	L5/S1
4	L2/L3
1	L1/L2
8	L3/L4, L4/L5
3	L4/L5, L5/S1
1	L1/L2, T12/L1

Table 3

Preoperative & postoperative comparison for ODI and VAS.

Parameter	Preoperative	Postoperative
ODI	57.8% +/- 19.1	24.8% +/-12.6
VAS (Leg pain)	8.35 +/-1.2	2.55 +/-0.3

DISCUSSION

The development of minimally invasive surgery aims to improve on the shortcomings of a traditional wide laminectomy in the treatment of lumbar spinal stenosis. These shortcomings include the morbidity associated with significant tissue trauma which occurs during a standard posterior midline decompression; Mayer et al [18]and Airaksinen et al [1] demonstrated a decrease in paraspinal muscle strength, extensors more affected than flexors, with associated muscular atrophy was on postoperative CT scan after elevation and wide retraction of multifidus muscle. Iatrogenic instability after decompression is another aspect of traditional decompression surgery that minimally invasive techniques aim to lessen [25]. Stability in flexion is altered with loss of the supraspinous and interspinous ligament complex and overall extensive posterior element resection has resulted in up to 16% of patients requiring subsequent fusion [10, 15, 21, 29]. The Scoliosis Research Society has recently reported morbidity of 5.8% versus 7.6% in 10,000 patients undergoing minimally invasive verses open decompression.

The MIS techniques described to date include unilateral intersegmental microdecompression, tubular retractor system microdecompression, microendoscopic laminotomy and foraminotomy. Young [35], in 1988 and McCulloch [19] in 1991 first began to explore less invasive means of surgically decompressing patients with lumbar stenosis. In 2002 Khoo and Fessller [17] followed up on their cadaveric studies with a clinical series of 25 patients who underwent decompression for LSS using a minimally invasive microendoscopic decompressive laminotomy (MEDL) technique. They compared a group of 25 patients who underwent MEDL and with an open laminectomy group and reported on short term outcomes. The results for the MEDL group showed a slightly longer operative time, 109 minutes per single level, versus 88 minutes, but significantly the postoperative stay for the MEDL group was 42 hours verses 94 hours for the control group. Also, with regard to postop recovery, the MEDL group needed significantly less narcotic medication after surgery. Overall, 16% of the MEDL patients reported resolution of their back pain, 68% improved symptomatically, and 16% remained unchanged.

In 2009 Pao et al [23] published results on MEDL, or microendoscopic decompressive laminectomy, they studied 60 patients, and excluded patients with segmental instability, which they defined as greater than 4mm translation or intervertebral angle reversal on dynamic radiographs. They performed unilateral laminotomy and foraminotomy for patients with unilateral symptoms and performed unilateral laminotomy for bilateral decompression (ULBD) using the METRx, Medtronic retractor system. Decompression of the ipsilateral lateral recess was achieved by medial facetectomy, the retractor tube was then tilted and the central canal and contralateral lateral recess was decompressed by excising the ligamentum flavum and undercutting the lamina with straight narrow osteotomes, their mean operating time was 126.7 minutes +/- 38.3 minutes, their estimated blood loss was 104.5 +/-26.2 ml per level. There were no cases of postoperative instability and no progression of those who had pre-existing spondylolisthesis or scoliosis.

In 2005 Ikuta et al [12] published results on 44 patients who underwent microendoscopic posterior decompression, (MEPD). The mean follow-up duration was 22 months. The mean rate of improvement was 72% based on the Japanese Orthopaedic Association score, and good results were obtained in 38 patients. Although the rate of morbidity decreased in the MEPD group, the incidence of complication was slightly higher. In 2006 Oertel et al [22] published long term follow up results of 102 patients who underwent unilateral laminotomy for bilateral decompression (ULBD) for the treatment of LSS without instability. They found that 85.3% of patients had an excellent-to-fair operative result. Repeat surgery for spinal instability was necessary in just two patients. In 2007 Rosen et al [27] retrospectively

examined the outcomes of patients over the age of 75 who underwent microendoscopic decompression for LSS. Fifty-seven patients with a mean age of 81 years were followed up for 10 months, they found that no major complications or deaths occurred VAS, ODI and SF-36 scores all showed statistically significant improvements after surgery ($P < 0.05$). These improvements were maintained on longitudinal analysis. The median length of hospital stay was only 29 hours.

The minimally invasive technique can also be used in patients with degenerative spondylolistheseis [33]. In 2008 Sasai et al [28] compared MBDU in patients with degenerative spondylolisthesis and patients with stenosis alone and found that both groups had satisfactory results after two years and radiographically the surgery did not result in dynamic instability in those who had spondylolisthesis. In their study the NCOS increased from an average of 30 points to 71 points and the ODI decreased from 24 to 7 points. Patients with spondylolisthesis also benefitted, their ODI dropped from 21 to 9, their NCOS increased from 35 to 66. Back pain was also found to be improved in this study, thereby allaying fears that low back pain may indeed increase after decompressive surgery. No patient required subsequent fusion during the follow up period. In 2012, Musluman et al [20] described patients with grade 1 degenerative spondylolisthesis and spinal stenosis, 84 patients underwent unilateral approach + bilateral decompression, 2 year follow up, NCOS demonstrated significant improvement, neutral and dynamic slip did not significantly change post op, one patient required fusion.

CONCLUSION

In agreement with the published literature our report demonstrates the favorable results using a minimally invasive method when treating patients with lumbar stenosis. The use of an undercutting facetectomy together with angulation of the operating microscope allows excellent visualization of the traversing and exiting nerve root and thus complete decompression of the affected nerve root. The microdecompression procedures do require extensive knowledge of microanatomy and experience with the operative microscope but is worthwhile in this patient population with degenerative spine.

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