Minimally invasive surgical treatment of lumbar spinal stenosis: Two-year follow-up in 54 patients

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Abstract

Objective: Minimally invasive surgery has seen increasing application in the treatment of spinal disorders. Treatment of degenerative spinal stenosis, with or without spondylolisthesis, with minimally invasive technique preserves stabilizing ligaments, bone, and muscle. Satisfactory results can be achieved without the need for fusion in most cases.

Methods: Fifty-four consecutive patients underwent bilateral decompressions from a unilateral approach for spinal stenosis using METRx instrumentation. Visual Analog Scale (VAS) pain scores were recorded preoperatively and patients were interviewed, in person or by phone, by our office nurse practitioner (LD) to assess postoperative VAS scores, and patient satisfaction with the clinical results 21–39 months postoperatively (median 27 months).

Results: Fifty-four patients underwent decompression at 77 levels (L4/5 = 43, L3/4 = 22, L5/S1 = 8, L1/2 = 4, L2/3 = 4), (single = 35, double = 16, triple = 2, quadruple = 1). There were 39 females and 15 males. The average age was 67 years. The average operative time was 78 minutes and the average blood loss was 37 ml per level. Twenty-seven patients had preoperative degenerative spondylolisthesis (Grade 1 = 26, Grade 2 = 1). Eight patients had discectomies and four had synovial cysts. Patient satisfaction was high. Use of pain medication for leg and back pain was low, and VAS scores improved by more than half. There were three dural tears. There were no deaths or infections. One patient with an unrecognized dural tear required re-exploration for repair of a pseudomeningocele and one patient required a lumbar fusion for pain associated with progression of her spondylolisthesis.

Conclusions: Minimally invasive bilateral decompression of acquired spinal stenosis from a unilateral approach can be successfully accomplished with reasonable operative times, minimal blood loss, and acceptable morbidity. Two-year outcomes in this series revealed high patient satisfaction and only one patient progressed to lumbar fusion.

Key Words: Lumbar spinal stenosis, minimally invasive surgery, spondylolisthesis
INTRODUCTION

The initial description of the surgical treatment of spinal stenosis was given by Sacks and Fraenkel in 1900. Bailey and Casamajor published work linking the findings of osteoarthritis of the lumbar spine with compression of the spinal cord and nerve roots in 1911. Traditional surgical treatment of spinal stenosis has been with bilateral laminectomy, partial facetectomy, and foraminotomies with or without fusion. Interest in less invasive options has led to direct decompressions limited to bilateral foraminotomies and unilateral approaches to bilateral decompression.

Minimally invasive approaches to spinal surgery have been described utilizing chemical, mechanical, laser, and endoscopic techniques. Sequential dilatation of tissues of the back followed by placement of a tubular or similar retractor was introduced by Foley and Smith (METRx) (Medronic, Memphis, TN, USA) Since then, multiple companies have marketed substantial similar systems, attesting to its increasing popularity. METRx techniques were originally applied to microdiscectomies but have been found to be useful in approaching many types of spinal pathology. Palmer et al. and Khoo and Fessler initially described the bilateral decompression of acquired spinal stenosis from a unilateral approach utilizing minimally invasive techniques.

MATERIALS AND METHODS

The 54 consecutive patients who underwent bilateral METRx decompression from a unilateral approach for spinal stenosis, by a single surgeon, were included in this study. A total of 77 levels were decompressed. Procedures were done as out-patients or in-patients. All patients underwent the procedures under general anesthesia. Prospective Visual Analog Scale (VAS) pain scores were recorded preoperatively and at 2, 6, 12, 26, and 52 weeks postoperatively. Patients were interviewed, in person or by phone, by our office nurse practitioner (LD) to assess long-term VAS scores, and patient satisfaction was assessed utilizing a patient satisfaction questionnaire developed by PhDx (Albuquerque, NM, USA) at 21–39 months postoperatively (median 27 months).

The average age was 67 years (range 43–84 years) and there were 39 females and 15 males. Twenty-seven patients had degenerative spondylolisthesis (Grade 1 = 26, Grade 2 = 1). All patients were studied with preoperative magnetic resonance imaging (MRI) scans and lumbar X-rays with flexion/extension views. Further radiological testing was performed as necessary. Eight patients had concomitant discectomies and five had synovial cysts.
Surgical procedure
Patients were prepared and positioned as for standard laminectomy. The procedure is a modification of the microendoscopic discectomy (MED) procedure previously described in detail by Foley and Smith.\textsuperscript{[11]} The level of interest was localized with fluoroscopy and then a 20-mm paramedian skin incision was made. The muscle was sequentially dilated followed by placement of an 18-mm working channel of the shortest length that would allow adequate depth of access (usually 50–70 mm). The operative microscope was moved into the field and the laminar edge was identified. A laminotomy was performed extending cephalad above the insertion of the ligamentum flavum on the inferior surface of the superior lamina (to ensure adequate resection of ligamentous compressive elements) and caudally to include a smaller portion of the superior aspect of the inferior lamina exposing the pedicle. Partial resection of the medial facet complex was performed as necessary to adequately decompress the lateral recess and the foramina.

The working channel was then angled medially exposing the anterior aspect of the spinous process, which was then removed utilizing a power drill with a diamond burr [Figure 3]. This exposed the lateral recess on the contralateral side where residual lamina and ligamentum flavum could be resected using the drill, Kerrison punches, and curettes. The angle of approach is the same as that commonly taken during an open laminectomy that allows undermining of the contralateral facets, making the anatomy familiar to most spine surgeons. Satisfactory decompression of the lateral recess and foramina is achieved under direct vision. Palpation of the pedicle and foramina, with a blunt ball-tipped nerve hook, ensures correct orientation and complete decompression [Figure 4].

Bupivacaine 0.25% with epinephrine 1:200,000 was infiltrated into the soft tissues prior to closure. The incision was closed in layers with Vicryl (Johnson and Johnson/Ethicon, Somerville, NJ, USA) followed by Steristrips (3M Corporation, St. Paul, MN, USA) and a bioocclusive dressing or, more recently, Dermabond (Johnson and Johnson, Somerville, NJ, USA) on the skin edge. The patients were encouraged to use ice postoperatively and were given only oral analgesics (usually hydrocodone). Patients with preoperative spondylolisthesis were placed in a chair back brace for 6 weeks as a precautionary measure whether or not they were stable to preoperative flexion/extension lateral radiographs. Physical therapy was begun at 6 weeks, and thereafter increased activities were encouraged.

RESULTS
A total of 77 levels were decompressed in the 54 patients. There were 35 single-level procedures, 16 two-level procedures, 2 three-level procedures, and 1 four-level procedure. The level of decompression was L4/5 in 43, L3/4 in 22, L5/S1 in 8, L1/2 in 4, and L2/3 in 4 patients. Eight patients had concomitant discectomies at the index level and one patient had a discectomy at a non-stenotic level. Five patients had an associated synovial cyst. Average operative time was 78 minutes per level and average estimated blood loss was 35 ml per level. There were three durotomies that were not primarily repaired but covered with gelfoam. These three patients were admitted for 48 hours of bed rest and did not have adverse consequences. One pseudomeningoecele developed in a patient with an unrecognized dural tear. She required re-exploration for repair of the pseudomeningoecele. There were no neurologic injuries and infections. One patient from the entire group of 54 patients went on to require fusion at 16 months postoperatively with a progressive spondylolisthesis.
VAS pain scores were followed prospectively at pre-op, 2, 6, 12, 26, and 52 weeks. The results were followed separately for back pain and for leg pain. The average preoperative VAS pain score was 6 for back pain and 8 for leg pain. The score decreased to 2 for back pain and 1 for leg pain at 2 weeks (n = 52), 2 for back pain and 1 for leg pain at 6 weeks (n = 52), 1 for back pain and 1 for leg pain at 12 weeks (n = 52), 3 for back pain and 3 for leg pain at 26 weeks (n = 27), and 5 for back pain and 4 for leg pain at 52 weeks (n = 22). VAS pain scores were also assessed at an average of 27 months postoperatively by phone interview and the average results were 3 for back pain and 2 for leg pain (n = 45) [Figure 5].

Patients’ use of analgesic medications was followed prospectively. Patients were queried as to their use of narcotics, non-narcotic analgesics, or no analgesics. Preoperatively 18 patients used narcotics, 20 patients used non-narcotic analgesics, and 14 used no analgesics (n = 52). The analgesic usage was 18 narcotic, 4 non-narcotic, and 30 none at 2 weeks (n = 52); 7 narcotic, 8 non-narcotic, and 38 none at 6 weeks (n = 52); 7 narcotic, 15 non-narcotic, and 30 none at 12 weeks (n = 52); 3 narcotic, 9 non-narcotic, and 15 none at 26 weeks (n = 27); and 4 narcotic, 4 non-narcotic, and 14 none at 52 weeks (n = 22) [Figure 6].

Analgesic usage was assessed at an average of 27 months postoperatively (range 22–39 months) by phone interview. It was assessed separately for back pain and for leg pain. Seventeen patients had no back pain, 10 patients had back pain but did not use analgesics, 2 patients had bad back pain but did not use analgesics, 1 patient used analgesics with complete relief of back pain, 9 patients used analgesics with moderate relief of back pain, 6 patients used analgesics with little relief of back pain, zero patients used analgesics with no relief of back pain [Figure 7]. Thirty-two patients had no leg pain, three patients had leg pain but did not use analgesics, two patients had bad leg pain but did not use analgesics, zero patients used analgesics with complete relief of leg pain, six patients used analgesics with moderate relief of leg pain, two patients used analgesics with little relief of leg pain, and zero patients used analgesics with no relief of leg pain [Figure 8].
Patient satisfaction with the care they received and the results of the surgery were also assessed by questionnaire at an average of 27 months postoperatively (range 22–39 months). Approximately 80% of patients thought it was definitely true or mostly true that they were pleased with the care they received and the results of the surgery. Thirty-seven of 44 patients thought it was definitely or mostly true and only 7 of 44 patients thought it was definitely or mostly false that, “All things considered, I would have the surgery again for the same condition” [Figure 9].

**DISCUSSION**

The goal of any surgical treatment of spinal stenosis is to decrease pain and increase the functional capacity of the patient while limiting surgery-related morbidity and mortality. Limiting the extent of surgical invasiveness with the preservation of preexisting spinal elements has been utilized to try and optimize the clinical benefit of surgery.[4,8,15,16,20,22,25,29,32] This may limit the risk of iatrogenic spondylolisthesis, postoperative pain and disability, and hospital and rehabilitation costs, and thereby improve patient outcomes.

We have previously demonstrated the feasibility of performing minimally invasive bilateral decompression for spinal stenosis from a unilateral approach.[25] The lack of a direct correlation of degree of stenosis on MRI and signs and symptoms has led to the questions of what degree of stenosis is necessarily symptomatic and what degree of decompression is necessary to adequately relieve symptoms. Satisfactory decompression on MRI follow-up has been shown to be achieved in most patients using minimally invasive technique.[22] Hitselburger and Witten, in an early myelographic study, showed that stenosis of up to 45% can be found in asymptomatic patients.[13] Aryanpur and Ducker suggested that complete decompression may not be necessary to achieve symptomatic relief.[4] Furthermore, Thomas et al. found a statistically significant increase in dural sac size after laminotomy or laminectomy, but they found no statistical relationship between the extent of decompression and clinical outcome.[29]

The biomechanics of the normal spine, as it relates to spinal stenosis and spondylolisthesis, have been extensively studied and previously reported. The salient work by Adams, Risannen, and Cusick will be reviewed here. Adams and Hutton showed that the tendency to anterolisthesis is resisted by multiple spinal elements. The facet joints have been shown to resist 33% of the shear forces, with the disk resisting 67%.[1] The supraspinous and interspinous ligaments resist 19% of flexion forces, with the facet capsular ligaments resisting 39% and the disk resisting 29%.[1,2] Adams et al. also suggested that the muscular attachments to the posterior arch and the insertions of the muscular slips on the facet capsule braced the facets, improving their ability to resist displacements.[1] The muscular and truncal soft tissue offers contributions to resisting flexion, which are critical since the force exerted on the spine in physiologic flexion by the trunk is more than double that required to injure the facet joints. The facet joints would fail if unaided by other supporting tissues.[1,2] The supraspinous/interspinous ligamentous complex has the greatest mechanical advantage being furthest from the axis of rotation. It is also the first to fail in flexion.[1] Rissanen found, in an anatomic study, that 20% of adult spines had ruptures of the ligamentous complex and many specimens had tears in the attachments to the spinous processes.[26] This is an anatomic verification of the biomechanical results.

Cusick et al. designed a biomechanical study of sequential sectioning of the posterior ligaments and facets using a two-motion segment model.[7] They noted the importance of the intact motion segment in stabilizing the altered segment, which, thus more closely simulated the clinical situation than a single-motion segment model. Though other biomechanical studies have shown only a small contribution of the posterior ligaments to overall stability, once the facet joints and the facet capsule have been altered surgically, the relative contribution of the posterior ligaments to stability probably changes.[6] The importance of the supraspinous/interspinous ligamentous complex was emphasized. They progressively surgically altered the lumbar facet complex and found that the effects were controllable until the supraspinous/interspinous ligaments and associated residual tendinous, midline muscle, and fascial attachments were violated. This experimental model closely mimics the post-surgical status of patients and stresses the contribution of the entire posterior musculo-ligamentous complex in resisting the development of postoperative spondylolisthesis. Nevertheless, the rationale that saving as many of these

![Figure 9: Long-term patient satisfaction](http://www.surgicalneurologyint.com/content/3/1/41)
elements as possible during the decompression will limit the development of iatrogenic spondylolisthesis remains controversial.\[6,10,21,32]\]

Many authors have questioned the effectiveness of treating patients with spinal stenosis complicated by spondylolisthesis without the use of fusion.\[6,12,14,16]\] Iatrogenic postoperative spondylolisthesis has a very large variation in the reported incidence of 0–100%, with the common range being 10–12%.\[11]\] Johnsson et al. found a 56% rate of increased postoperative slip in their patients with preoperative spondylolisthesis. In their patients with degenerative spinal stenosis, they had a 32% rate of postoperative slip.\[16]\] Whether or not iatrogenic spondylolisthesis is necessarily symptomatic is also debated. Mullin et al. reported that patients with postoperative spinal instability had a lower ambulatory status.\[19]\] Thomas et al. did not find a significant correlation of spondylolisthesis and poor clinical results.\[20]\] Routine postoperative dynamic X-rays were not done in our patients unless postoperative symptoms developed. One patient went on to require fusion at 16 months postoperatively with a progressive symptomatic spondylolisthesis. Iatrogenic spondylolisthesis requiring secondary fusion in this minimally invasive series was only 2%, which appears to be substantially less than that reported in the literature. However, only long-term follow-up of a larger group of patients would be able to establish the reproducibility of this result.

Lumbar spinal stenosis is not commonly a disease of younger patients. Surgery in an older patient is commonly complicated by multiple co-morbidities. It is particularly attractive to have a minimally invasive surgical treatment option for this older group. This allows for early consideration of surgical options without waiting for potentially irreversible neurological morbidity before entertaining fusion surgery. This also allows for an earlier return to an active lifestyle, often limited by the symptoms of lumbar spinal stenosis. Rehabilitation is quicker with minimally invasive surgery with the avoidance of the complications related to postoperative immobility of more extensive procedures. We utilized general anesthesia in all patients, but spinal or epidural anesthesia has been utilized successfully by others. The surgery can be performed with the patient as an inpatient or an out-patient depending on medical, social, and economic factors.

**CONCLUSION**

Minimally invasive bilateral decompression of acquired spinal stenosis from a unilateral approach can be successfully accomplished with reasonable operative times, minimal blood loss, and acceptable morbidity.

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