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Minimally Invasive 360 Degrees Decompression for Ligamentous, Bony and Discogenic Lumbar Canal Stenosis

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Abstract

Background: For decades, traditional open surgical techniques were used to treat lumbar disc herniation and lumbar canal stenosis (LCS). However, seeking for better outcomes for patients and avoiding extensive bony loss with its sequences had raised minimally invasive technique for treating these disorders as an alternative surgery. **Methods:** This is a retrospective study in which 54 patients of LCS were operated upon via unilateral minimally invasive technique to decompress the canal in a 360 degrees fashion through laminotomy, deroofing of opposite laminar side, sublaminar ligamintectomy, bilateral foraminotomies and discectomy. We used VAS scores and ODI to assess clinical outcomes with a period of one year follow-up. **Results:** Our results demonstrated that minimally invasive techniques for treating these disorders are effective procedures. Minimally invasive 360 degrees decompression for treating LCS had better outcomes regarding postoperative back pain, smaller incisions, less bony loss and early ambulation. **Conclusion:** Minimally invasive techniques for treating lumbar canal stenosis of different causes could be considered a better option instead of traditional full laminectomy with better outcomes as regards respecting the anatomical layers such as posterior spinal integrity and musculature, postoperative pain, accompanied with less blood loss, shorter hospital stays, and shorter recovery periods.

Keywords

Lumbar Decompression, Minimally Invasive Surgery, 360 Degrees, Lumbar Canal Stenosis

1. Introduction

Lumbar discectomy and/or decompression for lumbar canal stenosis (LCS) are the most common and well known traditional operations in spine surgery. Although the pathophysiology and etiology of these disease entities differ, they both essentially involve compression of the spinal canal and neural elements located in the thecal sac and also affect nerve roots. Ischemia of nerve roots is also believed to be involved in the pathogenesis of neurogenic claudication in lumbar stenosis [1]. LCS can be classified according to etiology or anatomical causes, etiological classification may be congenital stenosis or acquired (degenerative), while anatomical classification is according to the site of compression either central, lateral recess or foraminal stenosis [2]. The compressive elements may include bony stenosis either congenital or degenerative facet hypertrophy. Also compression may be due to herniated discs ventrally and ligamentum flavum dorsally or laterally or both [3]. Patients of LCS differ in their complaint according to the site of compression of neural elements; in central LCS, patients usually experience neurogenic claudication pain, while patients with lateral recess stenosis usually present with radicular pain [4]. Through decades of scientific progression especially in radiological tools, assessment of LCS and its types became easier. Magnetic resonance imaging (MRI) is still the golden tool in diagnosis of LCS types and severity [5]. Despite recent technology and advances in spine surgery, the gold standard for treatment of LCS remains direct decompression of the neural elements by removing the bone structures including the lamina plus or minus the medial facet, ligamentum flavum, and the herniated fragment of the intervertebral disc which together can cause LCS either central and/or lateral recess stenosis [6] [7]. Many researchers studied the effective management of LCS with different outcomes and recommendations. Conservative management is usually tried in the beginning including medications and physiotherapy before surgery [8]. In near a century Mixter and Barr (as detailed in Robinson) described in details the technique of lumbar decompression and discectomy. The traditional surgical approach for LCS was a full decompressive laminectomy through posterior approach with resection of the medial portion of the facet joints to decompress neural foramina [9] [10] [11]. However, for its efficacy to decompress stenosis and improve symptoms, some side effects were reported including intraoperative excessive blood loss, postoperative back pain due to disruption of posterior support band composed of supra-spinous, inter-spinous ligaments and muscle detachment from bony elements [12] [13]. Also tissues fibrosis and weak muscles may cause load over adjacent segments causing instability, and the possibility of iatrogenic instability by excision of excess bone rather than medial facet [14] [15]. Various modifications were made over years to this approach to avoid these complications. Minimally invasive techniques have been introduced. Forty years later with introducing the microscope to spine surgery, microsurgical procedures for discectomy were then introduced by Yasargil, Caspar, and Williams [16]. These interventions were associated with less bleeding, more satisfactory outcome with less postoperative pain and shorter recovery period. Despite the fact that decades have passed, traditional posterior approach for lumbar discectomy, microdiscectomy and micro-decompression as described by these pioneers has not significantly changed and still considered the treatment of choice for patients who require surgery complaining of symptoms associated with LCS or lumbar disc herniation after failed medical and conservative measures [7] [17]. Various surgical techniques seek to adopt new art of minimizing traumatizing tissues without affecting the aim of the surgery. Current trends in spine surgery favor minimally invasive yet maximally effective surgical techniques in the order to limit surgery-related morbidity and mortality. Spine surgery is one of the subspecialties in which minimally invasive techniques (MIS) are constantly being developed and modified [2] [17]. Some of the MIS techniques which were introduced to treat LCS and lumbar disc herniation include chemonucleolysis, percutaneous lumbar discectomy, microscopic laminotomy or hemi-laminectomy, and transforaminal or inter laminar endoscopic techniques [6] [18]. Although there are a number of different MIS techniques for treatment of LCS and lumbar disc herniation, all these techniques seem to be inferior to the traditional gold standard direct posterior microsurgical approach. The MIS direct lumbar decompression/discectomy favors a "muscle splitting" rather than a subperiosteal dissection technique as is used in traditional methods [2] [6] [19].

2. Methods

This is a retrospective study in which 54 surgically indicated patients of LCS were operated upon via unilateral minimally invasive technique to decompress the canal in a 360 degrees fashion in the period from June 2018 to June 2021. This study included 33 females and 21 males, ranging in age from 25 years to 68 years. Patients with lumbar canal stenosis either bony, ligamentous or discogenic were included in this study. Patients with instability or spondylolisthesis grade 2 or more were excluded from our study. Thorough history taking, general and neurological examination, routine preoperative labs and radiological assessment in form of Magnetic resonance imaging (MRI) lumbo-sacral spine (LSS) to assess the compromised neural elements with detailed visualization of neural canal components, facet joint hypertrophy or arthropathy and intervertebral disc degeneration signs with extent of compression of thecal canal, X-Rays LSS dynamic views to assess stability and Computed tomography (CT) of affected spine was done in selected cases to assess bony stenosis. It provides more details for bony anatomy, bony canal diameter and useful for assessment of deformities and loss in vertebral height. Pain was assessed before &after surgeries using Visual analogue scale (VAS) & Oswestry disability index (ODI). Follow up was done for patients in inpatient wards for less than 24 hours then follow up at outpatient clinic bases. Early follow-up included post-operative back pain, residual radicular pain, neurogenic claudication distance, neurological status, radiological evaluation with X-Rays, MRI and CT to assess the extent of decompression, any residual canal compromise and ifiatrogenic instability was suspected. Late follow-up included 3, 6, 9 and 12 months clinical and also radiological assessment when needed or indicated through clinical examination in outpatient clinics.

3. Statistical Analysis

Data were collected, coded, and entered into Microsoft Access. Data analysis was performed using Statistical Package of Social Science (SPSS-Version 20). The mean and standard deviation (SD) of assessed variable were presented. Categorical variables were expressed as numbers and percentages. Qualitative data were tested for normality using One-Sample Kolmogorov-Smirnov test. Mann-Whitney test was used to compare two independent groups and Chi square test (χ^2) was used to compare more than two groups. P-value of ≤ 0.05 was considered the cut-off point for statistical significance.

4. Surgical Technique

Midline lumbar incision, after which unilateral sub-periosteal para-spinous muscles detachment from the spinous processes and laminae, then retracted laterally as much as we could, especially in multicomponent lumbar canal stenosis. The extent of removal of posterior spinal elements, including supraspinous and inter-spinous ligaments, spinous processes laminae, medial facets, varies based on the severity of spinal canal stenosis. We start the 360 degrees lumbar canal decompression fashion in the following steps (**Figure 1**). The drill and/or Kerrison rongeur were used to perform ipsilateral laminectomy, remove the base of the spinous process posterior to the ligamentum flavum then introducing a McDonald dissector to detach the ligamentum flavum from the contralateral lamina, deroofing of the contralateral lamina either with drill or Kerrison rongeur with a dissector protecting underlying theca. After the deroofing maneuver was accomplished, the ligamentum flavum was dissected from the theca and any remaining bony attachments and removed ipsilateral and contralateral side (**Figure 2**). The operative microscope was then introduced and used to visualize the operative field. The Kerrison rongeur was then used to do foraminotomies by decompressing both foramina by resecting a superior bony part from the superior articulating process as much as needed with excision of lateral recess ligamentum flavum to decompress both exiting nerve roots. The decompression adequacy was then confirmed by using small blunt dissector or ball ended hook. Discectomy was done also when needed using straight and angled punch rongeurs with adequate excision of all degenerated material in ipsilateral and contralateral side. A dissector was then used anterior to theca to push any underneath disc fragment inside the empty space created through discectomy.

5. Results

In our study, the mean age was (46.8 ± 15.5) years old ranged between 25 years to 68 years, as regards to sex distribution, 33 females (61%) and 21 males (39%). Regarding co-morbidities, higher percentage 37% (20 patients) were free of comorbidities, diabetes mellitus (18.5%), Hypertension (20%), other comorbidities included renal, hepatic and asthmatic patients (**Table 1**). Different levels of stenosis were determined by MRI with higher percentage for L4, 5 level (83%) 45

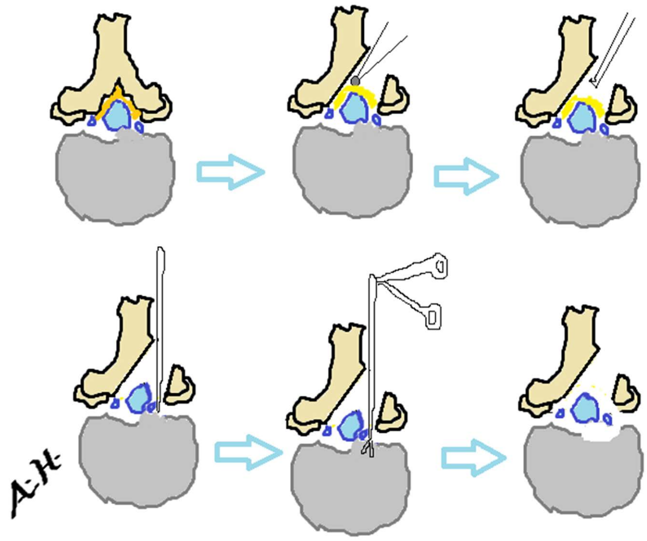

Figure 1. Steps for 360 degrees decompression for LCS.

Figure 2. Post-operative CT showing minimally invasive 360 degrees decompression from the ipsilateral side.

Table 1. Age, sex and comorbidities.

	Age	
25:35	7	(13%)
35:45	12	(22%)
45:55	16	(30%)
55:68	19	(35%)
	Sex	
Males	21	(39%)
Females	33	(61%)
	Co-morbidities	
Free	20	(37%)
Hypertension	11	(20%)
Diabetes	10	(18.5%)
Hepatic	8	(15%)
Renal	3	(6%)
Asthma	6	(11%)

patients followed by L5, S1 level (39%) 21 patients then L3, 4 level (26%) 14 patients. The majority of cases (25 cases, 46.3%) were operated upon by single level decompression followed by 2 levels of decompression (20 cases, 37%) with a mean 2.3 ± 0.9, and 3 levels of decompression (9 cases, 16.7%) with a mean 2.7 ± 1.4 (**Table 2**). As regards pre-operative clinical assessment 76% of patients were full motor power, 83% of patients had radiculopathy in sensory assessment, while 15% of patients showed sphincteric affection especially in the form of precipitancy. All patients complained of pain either back or lower limbs or both, mean VAS score for lower limbs pain was (8.7 ± 1.3) while for back pain was (6.2 ± 1.6) with average ODI 54.7% ± 8.7%. For clinical outcomes, on comparing pre and postoperative clinical condition assessment for patients in our study group, it revealed significant improvement of both ODI and lower limbs pain VAS score with p-value < 0.05, the mean ODI decreased from 54.7% ± 8.7% to 24.1% ± 7%, and the mean VAS score for lower limbs pain decreased significantly from (8.7 ± 1.3) to 2.4 ± 1.5, while the mean VAS score for back pain decreased non-significantly from 6.2 ± 1.6 to 3.9 ± 1.2 (**Table 3**). Regarding the duration of surgery needed for our technique a mean operative time was 1.7 ± 0.6 hours. The estimated blood loss was an average of 150 ± 102 ml. Average hospital stay was 1.1 ± 1.4. According to incidence of complications, we've found four patients complicated with incidental dural tears which were primarily repaired intraoperative with primary stitches followed by putting a fat graft, blood patch and gel foam over it with no CSF leak after intraoperative Valsalva or postoperative leakage related complications. Also three patients developed superficial wound infection which was managed conservative by repeated dressings with povidone iodine, local and systemic antibiotics. Only one patient developed iatrogenic instability one month postoperatively and he needed posterior lumber fixation.

6. Discussion

Neurogenic claudication related to lumbar canal stenosis is a common complaint in the adult population. Degenerative lumbar canal stenosis is also considered a common cause for low back pain in elderly. Although many conservative measures have been tried times and times in the past, their efficacy in curing this condition is limited [20]. Decompressive surgery offers an advantage over conservative treatment. Therefore, it is critical to choose the optimal method of treating those individuals according to patients' complaints and requirements with proper counseling for patients [15]. Traditional laminectomy plus or minus fusion remains the standard operative technique for LCS. However, traditional bilateral laminectomy is accompanied by many postoperative complications, such as blood loss, iatrogenic instability, dural tears, atrophy of paraspinal muscles, and epidural scarring, which can lead to poor results [5] [8]. Instead of operating those patients by decompression with or without fusion and after which maximizing associated intra and post-operative risks, other operative options which are less invasive, such as microscopic hemi-laminectomy, unilateral or bilateral

Table 2. Different levels of stenosis and number of levels of decompression.

Level of stenosis		
L4, 5	45	(83%)
L5, S1	21	(39%)
L3, 4	14	(26%)
Number of levels		
One	25	(46.3%)
Two	20	(37%)
Three	9	(16.7%)

Table 3. Pre-operative and postoperative VAS score and Oswestry disability index (ODI).

VAS score	**Pre-operative**		**Post-operative**		**P-value**	**Significance**
	Mean	**SD**	**Mean**	**SD**		
Lower limbs pain	8.7	0.6	2.4	1.3	**<0.001**	**S**
Back pain	6.2	1.3	3.9	1.8	0.12	NS
ODI	**Pre-operative**		**Post-operative**		**P-value**	**Significance**
	Mean	**SD**	**Mean**	**SD**		
	54.7%	12.3%	24.1%	5.9%	**<0.001**	**S**

SD: stands for standard deviation, **S:** stands for significant, **NS:** stands for non-significant.

laminotomy and, in particular, the unilateral laminotomy for bilateral decompression (ULBD), and endoscopic interlaminar or transforaminal discectomy have been introduced during the past years. Those minimally invasive techniques was believed to minimize perioperative risks of traditional wide laminectomies and decompression even with their own complications like miss level, inadequate decompression, incidental dural tears, root injury, residual disc fragment or iatrogenic instability [21] [22]. Our study results demonstrate that those minimally invasive surgeries could be an effective and reliable treatment option when used for wisely selected and indicated LCS patients, especially our technique which using unilateral laminectomy to decompress the whole thecal sac and affected roots in a 360 degrees fashion.

When we analyze the number of decompression levels in our study, the majority of cases were operated upon by single level decompression followed by two levels of decompression while Bradley K. *et al.* described in their study which included thirty cases that the majority of their patients were operated upon by two levels decompression [23]. In our study, nine cases were operated upon by 3 levels decompression. Some authors excluded long segments decompression more than two levels from their studies because of difficulty of operating these cases by microscopic minimally invasive technique. Our study results revealed significant postoperative improvement in both leg VAS score and also ODI score. This goes with Seok WK *et al.* study which revealed significant improvement in VAS, ODI score and also in SF-36 physically function score [24]. Our results also matches with Mobbs *et al.* who showed that postoperative VAS leg scores and ODI scores showed statistically significant improvements in each group. However, there was no significant difference between both groups as regard postoperative VAS scores and ODI [25]. In contrary, Thomas *et al.* compared outcomes of fourteen patients with laminotomies and twelve patients with laminectomies and showed a higher reduction of back and leg pain in the full laminectomies group [5]. Regarding the duration of surgery in our technique the mean operative time was 1.7 ± 0.6 hours. Khoo *et al.* who reported an operative duration of 109 minutes for a single level micro-endoscopic unilateral laminotomy and 88 minutes for open laminectomy [21]. Contrary to Rahman *et al.* who documented that ULBD approach involves shorter operating times than open decompressive technique. [26] Although there is a list of potential complications with minimally invasive decompression but it is not different from standard open surgery, the rate of those certain complications is significantly lower with minimally invasive techniques. For instance, blood loss, wound infection, iatrogenic instability, and medical deterioration following lumbar decompression using microscopic techniques are lower compared to open laminectomy [1] [21] [27]. However our great outcomes in back and lower limbs claudication pain improvement, there was four cases (7.4%) of incidental dural tears which is not a low percentage in LCS surgeries, even though all of them were managed intra-operative by primary repair and only conservative management measures for post-operative CSF leak. It's believed that this incidence will decline throughout future cases by improving the learning curve of manipulating instruments through this narrow working field. One report by Khoo *et al.* found the incidence of durotomy to be 16%, although no long-term sequelae were noted [21]. Also Seok WK *et al.* mentioned dural lacerations as a frequently faced complication with their unilateral laminotomy for bilateral decompression technique in LCS cases [24].

7. Conclusion

Minimally invasive techniques for treating lumbar canal stenosis of different causes could be considered a better option instead of traditional full laminectomy with better outcomes as regards respecting the anatomical layers such as posterior spinal integrity and musculature, postoperative pain, accompanied with less blood loss, shorter hospital stays, and shorter recovery periods. Although it needs a learning curve to ensure patient safety, less complications and less operative time. However, it is difficult to compare the effectiveness and possible superiority of this technique with traditional decompression.

Conflicts of Interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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