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Outcomes of Surgical Decompression Approaches in Patients with Lumbar Spinal Stenosis: Conventional VS Minimal Invasive VS Addition of Fixation

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Abstract: *Background:* Lumbar spinal stenosis is one of the commonest causes of patients' disability due to degenerative disorders. Surgery have been found to be a more effective in relieve of patients' symptoms and improvement of physical disability after failure of conservative management for 6 months. A variety of surgical techniques are available for management of this condition. We present our experience with conventional laminectomy, decompressive laminectomy with fixation and microscopic laminotomy via unilateral approach as 3 different surgical options regarding patients' outcomes and complications. *Methods:* This is a retrospective study of patients with lumbar spinal stenosis operated in our institute in the period from January 2018 to December 2019. We included 69 adult patients and were subdivided into 3 groups according to the intervention done, either Lumbar decompression and fixation (group A) or conventional laminectomy (group B) or microscopic decompression (group C). Postoperative Disability changes via ODI, Back pain and leg pain via VAS were compared in the three groups. *Results:* Patient's pain and disability significantly improved in all patients of the 3 groups. There was no significant difference in patients' leg pain improvement compared in the 3 groups. Patients in the fixation group had significant back pain improvement (median improvement of 6) in comparison to both other groups (median improvement of 3 and 3). Patients in fixation groups had more amount of blood loss (median of 200 ml) and longer operative time (median of 180 minutes) compared to both other groups however this was not statistically significant. *Conclusion:* Conventional decompressive laminectomy with or without fixation and microscopic decompression would provide sufficient pain and disability improvement for patients with lumbar spinal stenosis. Further research is recommended to conclude evidence in favor of specific surgical technique. We suggest a significant improvement in postoperative back pain for patients with lumbar spinal stenosis receiving decompression and fixation in comparison to those who receive conventional laminectomy or microscopic decompressive laminotomy.

Keywords: Lumbar Spinal Stenosis, Lumbar Canal Stenosis, Minimal Invasive Spine Surgery, Lumbar Decompression and Fixation

1. Introduction

Management of degenerative Lumbar Spinal Stenosis (LSS) can be challenging and needs the incorporation of patients' symptoms, clinical results, and diagnostic imaging. The rationale of the management is to regulate intraspinal pressure, blood flow, and metabolic status of neural structures by decompression of the neural elements and reducing the inflammatory process. Basically, this should be started with conservative treatment and preferably with a multimodal approach (medical treatment, bed rest, and physiotherapy), but in cases of severe pain with extensive neurogenic claudication symptoms, surgical interference is indicated. There is rising evidence that decompressive surgery offers a priority over nonsurgical management for particular patients with continual severe signs despite conservative treatment for up to six months [1–4].

The primary goal of surgical intervention in LSS is to decompress the neural structures that are being encroached upon, to relieve the symptoms, and improve the function. The surgical approach may vary according to the location of the stenosis, the number of segments affected, associated deformity or spinal instability, history of previous surgery, patient's general condition, and the surgeon's preferences [5]. Classic surgical treatment of LSS involves wide laminectomy, foraminotomy, discectomy, and medial facetectomy if needed. However, decompression surgery can further destabilize a pathological motion segment, and some patients develop symptomatic spinal instability [6].

Alternatives to conventional decompression by laminectomy have been developed to minimize the damage on posterior structures of the lumbar spine. Minimally invasive decompressive techniques used to treat lumbar spinal stenosis include unilateral or bilateral laminotomies and spinal process-splitting laminectomy. These techniques are also frequently performed with the use of an endoscope or microscope. The bilateral laminotomy technique preserves the neural arch of the vertebrae and protects the dura. In multi-segmental stenosis this technique allows the reattachment of the paravertebral muscles to the spinous processes [7].

However, for severe lumbar central canal and lateral recess stenosis, minimal invasive surgery and traditional laminotomy are technologically difficult and may not decompress the spinal canal completely. Therefore, open surgical removal of the inferior 2/3 lamina, inferior articular process, and partially hypertrophic and cohesive superior articular process may be necessary [8]. Additionally, as spinal instability is a frequent finding following bony decompression, surgical fusion has been recommended in addition to decompression of the spinal canal for the management of some patients with spinal stenosis [9].

One of the major controversies about surgery for spinal stenosis is the role of spinal fusion. Spinal arthrodesis to achieve spinal fusion has generally been recommended for spinal stenosis associated with degenerative spondylolisthesis, recurrent stenosis after previous decompression, instability, or scoliosis [5]. Guidelines from the North American Spine Society recommend that in the absence of associated scoliosis or spondylolisthesis, “decompression alone is suggested for patients with predominant leg symptoms without instability”. As of now, no conclusive guidelines are indicating whether treating these patients would be more effective with or without fusion [5, 10].

Many surgical techniques are available for the management of lumbar Spinal stenosis, and the lack of evidence to support the rapid evolution of surgical techniques has led clinicians to rely on their own opinions and experiences to choose the surgical technique for their patients, which leads to practice variation. More high-quality trials comparing the effectiveness between techniques are needed to decide the best surgical option for this condition [11, 12].

We aim to compare the efficacy of three different surgical modalities for management of LSS, and to evaluate their outcome on patients’ pain and disability.

2. Methods

This is a retrospective chart review study of patients with lumbar spinal stenosis operated in our facility in the period from January 2018 to December 2019. All preoperative, operative, and post-operative clinical and radiological patients’ data were reviewed. We included 69 adult patients and were subdivided into 3 groups according to the intervention done, either Lumbar decompression and fixation (group A) or conventional laminectomy (group B) or microscopic decompression (group C), there was no randomization for the patients, decision of type of surgical intervention was according to the surgeon and patient preference. Different surgeon was operating for each group, all of them was completely qualified neurosurgeon. All included patients had a trial of conservative management of at least 6 months before surgery.

2.1. Our Exclusion Criteria Were

1) Patients older than 75 years or younger than 18 years at time of presentation.
2) Patients presented with significant comorbidity affected decision making for type of intervention e.g., Morbid obesity Body mass index > 40 or medical condition which significantly restrict possible time of safe elective general anesthesia.
3) Patients with spondylolisthesis (Dynamic translation instability > 3 mm).
4) Patients with destructive or infiltrating lesions of the spine.
5) Previously operated patient with recurrence of symptoms.
6) Patients with significant degenerative scoliosis or sagittal spine imbalance.

2.2. Data Collected Included

1) Preoperative clinical and radiological data: Patient’s demographics, patients’ comorbid medical condition, Duration of presenting symptoms and Patient Visual analogue scale VAS for back pain and leg pain with Patient Oswestry disability index ODI [13, 14]. Patient preoperative MRI LSS and PXR LSS Dynamics were reviewed, number of levels of stenosis or presentation of spondylolisthesis were reported.
2) Operative details: Type of intervention, Time of surgery, Blood loss, complications were reported.
3) Postoperative follow-up and outcomes: Duration of hospital, Postoperative complications, ODI, VAS for Back pain and leg pain at 3 months follow up were reported.

2.3. Surgical Technique

Patient received either Decompression and pedicular fixation (Group A) or Conventional Laminectomy without fixation (Group B) or microscopic decompression (Group C). Choice of the technique was dependent on the surgeon opinion and experience. A midline skin incision and bilateral muscle separation was used in Group A and B. When fixation was decided exposure of the facet joint and transverse process was done. We used trans pedicular screws and posterolateral autograft for bone fusion. Preservation of the facet joint was done whenever possible. Bilateral laminotomy via unilateral approach was used in patients of group C, this was done with the Aid of microscopic drilling of the under surface of the contralateral lamina and tilting of the operating table [15, 16].

2.4. Statistical Analysis

Sample characteristics were analyzed with descriptive statistics. Pre-post-comparisons for VAS scores and ODI score were executed using Wilcoxon's rank signed test for paired samples. All numeric variables in the dataset were not-normally distributed. To test for differences among the three groups in case of ordinal or non-normally distributed data Kruskal Wallis test was used. And in these cases, the values for each group were summarized as medians and interquartile ranges. In case of a statistically significant result from Kruskal Wallis test, post-hoc (pairwise) comparisons were conducted using Dunn Test after correcting for multiple testing using Bonferroni correction method.

To test for difference in complications rate (binary data), Pearson chi-square analyses were used. In general, type one error was set to alpha = 0.05 and two tailed p-values were used to assess statistical significance. All statistical analyses were conducted by R 4.1.1 software used through RStudio Version 1.4.1717.

3. Results

This study included 69 patients. Patients were divided into 3 groups according to the intervention done. Group A (Decompression and Fixation) included 25 patients, Group B (Laminectomy) included 24 patients and Group C (microscopic decompression) included 20 patients. This study included 41 male and 28 female patients. Most of the patients had single level (36/69) or double level (28/68) Spinal stenosis. Four patients had 3 levels Spinal stenosis and a single patient had 4 levels Spinal stenosis in Group C. *Table 1.*

Table 1. *General Characteristics of the sample (n = 69).*

	Fixation (n= 25)	**Laminectomy (n= 24)**	**Micro (n = 20)**
Age (mean ±SD)	53.6 (± 11.1)	48.5 (± 12.2)	54.8 (± 11.03)
Gender			
Male	17 (68%)	13 (54%)	11 (55%)
Female	8 (32%)	11 (46%)	9 (45%)
Number of levels			
1	11 (44%)	14 (58%)	11 (55%)
2	11 (44%)	10 (41%)	7 (35%)
3	3 (12%)	0 (0%)	1 (5%)
4	0 (0%)	0 (0%)	1 (5%)

Leg pain, back pain and ODI was significantly improved post-operative in patients of all the three groups. Table 2.

Table 2. *Comparison of the preoperative VAS and ODI scores vs. postoperative VAS and ODI scores in each group.*

Fixation			
	Preoperative Score median [IQR]	**Postoperative Score median [IQR]**	***P*-value**
VAS leg	10 [9-10]	2 [1-3]	< 0.001
VAS back	9 [7-9]	3 [2-3]	< 0.001
ODI	60 [43-65]	15 [10-23]	< 0.001

Laminectomy			
	Preoperative Score median [IQR]	**Postoperative Score median [IQR]**	***P*-value**
VAS leg	9 [8-9]	2 [2-3]	< 0.001
VAS back	6 [5-7]	2 [2-3]	< 0.001
ODI	55 [40.75-60]	20 [12.25-28]	< 0.001

Micro			
	Preoperative Score median [IQR]	**Postoperative Score median [IQR]**	***P*-value**
VAS leg	8 [8-9]	2 [2-3]	< 0.001
VAS back	6 [6-7]	3 [2-3]	< 0.001
ODI	58 [55-60]	26.5 [24-28.5]	< 0.001

Comparing the improvement of Leg pain and back pain in between the 3 groups (*Figure 1*), we compared postoperative change or difference in VAS of pain from preoperative VAS values. Patients in Fixation group had improvement of leg and back pain VAS values in comparison to both other groups, Median change in leg pain for patients of Group A, B and C was 7, 6 and 6 respectively. The were no statistically significant differences among the groups except when comparing fixation and microscopic decompression, however, it is not considered clinically significant. Regarding the median change (improvement) in back pain, it was much higher in Fixation group in comparison to laminectomy and microscopic decompression group; 6, 3 and 3 respectively. Post hoc (pairwise) analysis found this change statistically significant with p- value < 0.001. Postoperative improvement in ODI for Group A, B and C was 37, 30 and 32 respectively which was statistically non-significant. *Tables 3 and 4.*

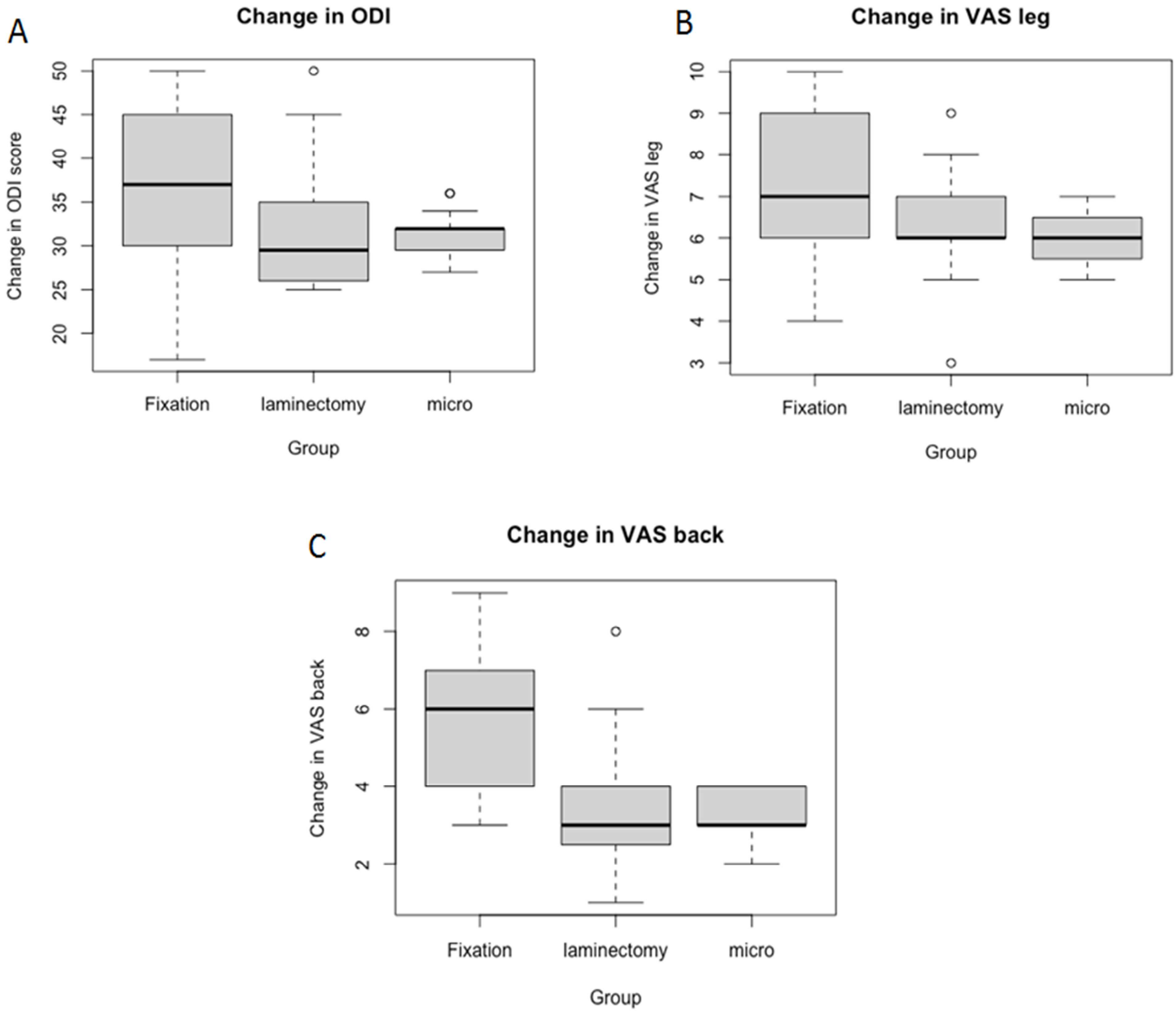

Figure 1. *Box plot of Postoperative improvement in ODI, VAS leg and VAS back pain compared among 3 groups of patients.*

Median improvement of ODI was insignificantly higher for patients in fixation group in comparison to both other groups. B) Median improvement of VAS leg pain for fixation group was statistically significantly higher (median change of 7) compared to both other group (median improvement of 6 and 6). However, this value would be considered of insignificant clinical value. C) Median improvement of back pain VAS was significantly higher for patients in fixation group (median improvement of 6) compared to both other groups (median improvement of 3 and 3. which can be considered clinically significant.

Table 3. *Comparison of the measured outcomes among the three groups.*

	Fixation Median [IQR]	Laminectomy Median [IQR]	Micro Median [IQR]	*P*-value
Change in VAS leg	7 [6-9]	6 [6-7]	6 [5.75-6.25]	0.007
Change in VAS back	6 [4-7]	3 [2.75-4]	3 [3-4]	< 0.001
Change in ODI	37 [30-45]	30 [26-35]	32 [30-32]	0.052
Blood loss (ml)	200 [150-220]	135 [100-200]	200 [180-250]	0.015
Operation time (min)	180 [120-210]	80 [70-121]	122 [110-140]	< 0.001
Hospital stay (days)	3 [3-4]	2 [1-2.25]	2.5 [2-3]	< 0.001

Table 4. *Post-hoc (Pairwise) comparisons for the outcomes with statistically significant differences among the three groups.*

	Fixation vs Laminectomy (Adjusted P-value)	Fixation vs Micro (Adjusted *P*-value)	Laminectomy vs Micro (Adjusted *P*-value)
Change in VAS leg	0.13	0.006	0.75
Change in VAS back	< 0.001	< 0.001	>0.999
Blood loss (ml)	0.073	>0.999	0.02
Operation time (min)	< 0.001	< 0.001	< 0.001
Hospital stay (days)	< 0.001	< 0.001	< 0.001

We also compared improvement in leg and back pain between the three techniques in four subgroups based on age (either < 50 years or ≥ 50 years) and number of operated levels (either single or multiple level). We found significant superiority of the fixation technique in improving leg pain in older patients (≥ 50 years) and patients with multiple levels (more than one operated level). The difference was insignificant in younger patients and patients with one level only. Regarding improvement in back pain, the fixation group remained consistently and significantly better than the other two techniques among all the studied subgroups.

Older patients (≥ 50 years) had statistically significant more improvement of their ODI after decompression and fixation, however it is not considered clinically significant (37 compared to 27 and 30 in the laminectomy and microscopic decompression techniques). Improvement in ODI remained insignificant among the 3 surgical techniques either in the single or multiple levels subgroups. *Tables 5 and 6.*

Table 5. *Change in VAS leg, VAS Back pain and ODI according to number of levels among the 3 groups.*

	Fixation	Laminectomy	Micro	
One level	n= 11	n=14	n=11	
Multiple levels	n= 14	n=10	n=9	
	Median [IQR]	**Median [IQR]**	**Median [IQR]**	***P*-value**
Change in VAS leg	7 [6-9]	6 [6-7]	6 [5.75-6.25]	0.007
One level	8 [5-9.5]	6 [6-7]	6 [5-6]	0.175
Multiple levels	7 [6.25-8]	6 [6-7]	6 [6-7]	0.03
Change in VAS back	6 [4-7]	3 [2.75-4]	3 [3 - 4]	< 0.001
One level	6 [4.5-7.5]	3.5 [3-4]	3 [3-3]	< 0.001
Multiple levels	5.5 [4.25-7]	3 [2.25-3]	3 [3-4]	< 0.001
Change in ODI	37 [30-45]	29.5 [26-35]	32 [30-32]	0.052
One level	35 [27-48.5]	28.5 [26.25-38.75]	32 [28.5-32]	0.61
Multiple levels	38.5 [31.25-42.25]	30 [26.5-32.75]	32 [30-32]	0.06

Table 6. *Change in VAS leg, VAS back pain and ODI according to subgroups of age among of 3 groups.*

	Fixation	Laminectomy	Micro	
Age < 50 yrs	n =10	n=13	n=6	
Age >= 50 yrs	n=15	n=11	n=14	
	Median [IQR]	**Median [IQR]**	**Median [IQR]**	***P*-value**
Change in VAS leg	7 [6-9]	6 [6-7]	6 [5.75-6.25]	0.007
Age < 50 yrs	7 [6-8]	7 [6-7]	6 [6-6.75]	0.5
Age >= 50 yrs	7 [7-9]	6 [5.5-6.5]	6 [5.25-6]	0.005
Change in VAS back	6 [4-7]	3 [2.75-4]	3 [3 - 4]	< 0.001
Age < 50 yrs	5.5 [4-7.5]	3 [2-4]	3 [3-3]	< 0.001
Age >= 50 yrs	6 [5-7]	3 [3-4]	3 [3-4]	< 0.001
Change in ODI	37 [30-45]	29.5 [26-35]	32 [30-32]	0.052
Age < 50 yrs	36 [26.25-46]	31 [27-40]	32 [32-32]	0.8
Age >= 50 yrs	37 [30-44]	27 [25.5-33.5]	30 [28.25-32]	0.014

We also compared the blood loss; operation time and hospital stay for patients in three groups of our study (Figure 2). Median blood loss was 200, 135 and 200 ml for group A, B and C respectively, with patients in the laminectomy group (B) having the lowest amount of blood loss compared to both other groups. However, blood loss in the laminectomy group was only statistically significant lower when compared to the microscopic decompression group. Median operation time was 180, 80 and 122 minutes for Group A, B and C respectively. Operation time was higher in fixation followed by micro and the lowest time was in laminectomy. All differences are statistically significant p value < 0.001. Patients in the Fixation Group (A) had the longest hospital stay of a median of 3 days, followed by microscopic decompression group (C) of a of 2.5 days and the lowest hospital stay was for patients in the laminectomy group (b) of 2 days. All differences in hospital stay were statistically significant. *Tables 3 and 4.*

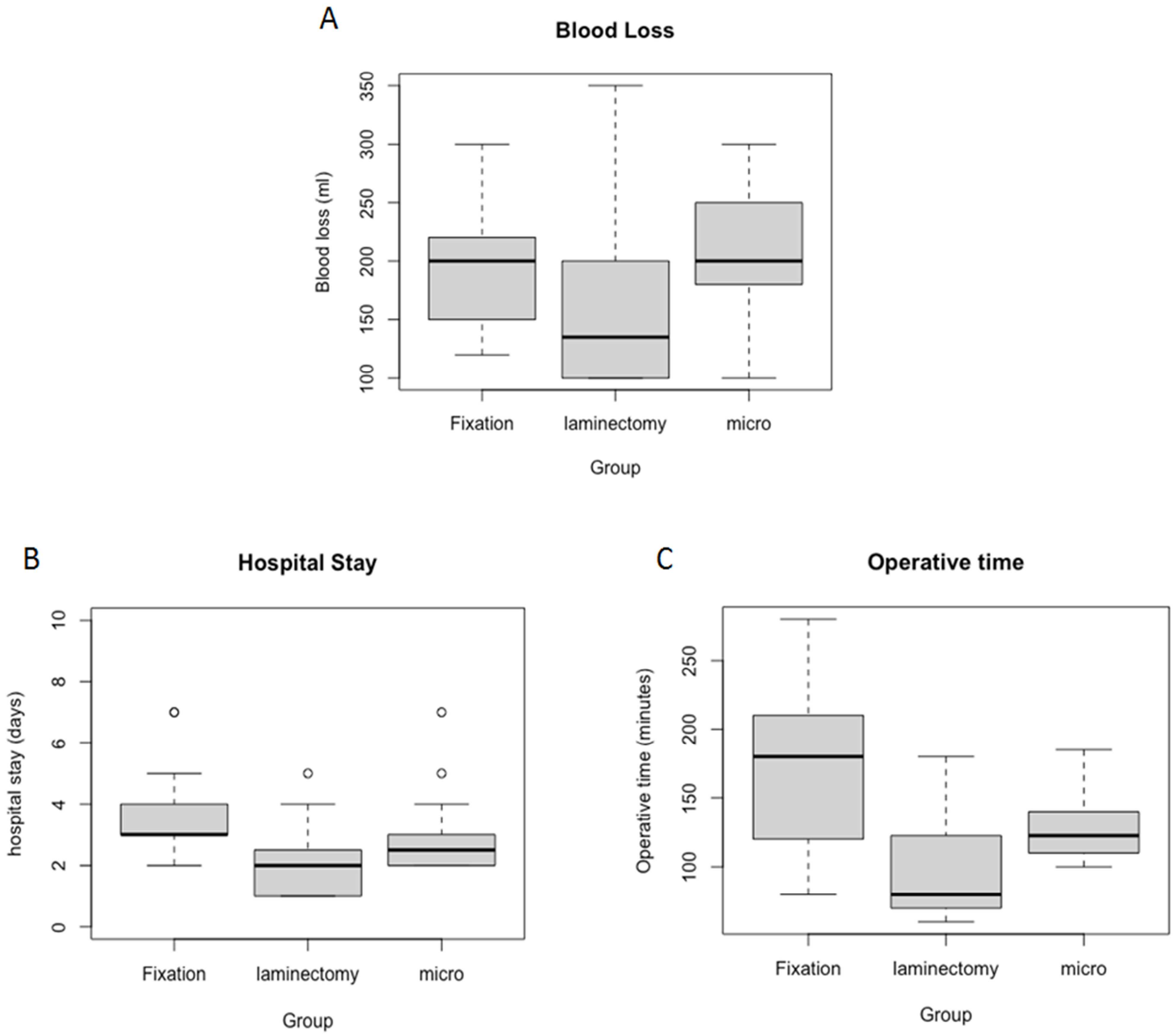

Figure 2. *Box plot of Blood loss, operative time and hospital stay compared across the 3 groups of patients.*

A) Patients in fixation group had statistically insignificant higher blood loss (median of 200 ml) than the laminectomy group (median 135ml) and the same median blood loss of patients in microscopic group. B) Patients in the fixation group had statistically insignificant longer hospital stay (median 3 days) compared to both other groups. C) Patients in fixation group had statistically longer operative time (median 3 hours) compared to both two other groups.

The only reported complication for patients of this study was unintended durotomy, it was reported in 9/69 patients for the three groups with no statistically significant difference. *Table 7*.

Patients with intraoperative unintended durotomy was managed with dural repair with muscle graft and postoperative bed rest for 3 days. None of the patients in our study had persistent Postoperative CSF leak or CSF infection.

Table 7. *Comparison of the complications rate between the three groups.*

	Number of cases with complications (%)	**X^2**	***P*-value**
Fixation (n = 25)	3 (12%)		
Laminectomy (n = 24)	2 (8.3%)	1.34	0.51
Micro (n= 20)	4 (20%)		

4. Discussion

A variety of surgical techniques are available for the management of lumbar spinal stenosis, up to date there is no strong evidence supporting one technique over the other and surgical decision is tailored according to surgeon experience and patient preference [11]. We present a retrospective report of our patients with lumbar spinal stenosis comparing 3 different techniques: Conventional laminectomy, minimal invasive unilateral approach for bilateral decompression and Decompression with fixation using transpedicular screws. Our results showed superiority of Lumbar fixation in improvement of back pain compared to micro decompression or conventional laminectomy groups, there was no significant difference in improvement of leg pain or physical disability of patients received either of the 3 techniques.

The most commonly used surgical technique for patients with lumbar spinal stenosis is open laminectomy and decompression and is considered a gold standard technique [11]. A recent report on 500 patients with lumbar spinal stenosis with an average follow up of 4 years showed statistically significant post-operative improvement in back pain, Leg pain and weakness in all their patients [17]. Intraoperative durotomy was reported in 10.00% of the patients; only, 1.60% experienced a postoperative cerebrospinal fluid leak [17]. Reoperation due to disease progression was needed in 14.40% of their patients [17]. All of our patients had statistically significant improvement in their presented symptoms. Intraoperative durotomy was reported in 13% (9/69) of our patients in all the 3 groups with no significant difference between groups, this results fall within same range reported by other literature [18, 19].

The idea of adding different fixation techniques in addition to lumbar spinal canal decompression was evolved to guard against the possibility of iatrogenic instability following conventional lumbar laminectomy especially if there is associated spondylolisthesis or there was intraoperative disruption of the facet joint [5]. Iatrogenic instability is reported in the literature in the range of 10-20% of cases [20–23].

It was previously concluded by a group of authors that clear indications for fusion include iatrogenic instability, isthmic spondylolisthesis, kyphosis, stenosis that develops at a previously decompressed segment or adjacent to a previously fused lumbar region, dynamic instability with neurologic findings and mechanical back pain. They also stated that Fusion is rarely indicated in the setting of discectomy or degenerative disc disease, failed back surgery, or stable spinal stenosis [5, 24]. A randomized control trail conducted on 44 patients with lumbar spinal stenosis to compare outcomes of decompression alone versus decompression with fusion, showed there was improvement in low back pain and neurologic claudication pain and significant improvement of postoperative physical disability in all groups. However there was no significant added benefit of fusion concluded by this study [25]. Other group compared decompression laminectomy to decompression with fixation outcomes of 184 patients with lumbar spinal stenosis, they concluded in there results that patient in fixation group had much significant improvement in their pain and function compared to the laminectomy only group [26]. A Cochrane review of surgical options for lumbar stenosis showed a paucity of evidence that decompression with fixation or interbody spacer provide significant improvement in patients pain or disability than conventional laminectomy for patients with lumbar spinal stenosis [7]. Our results showed clinical and significant improvement of back pain in patients of fixation with decompression group in comparison to patients in conventional laminectomy or microscopic decompression group, although improvement in leg pain and post-operative disability index was in favor of fixation group but it was not statistically significant.

A study reported that the reoperation rate was high after the conventional laminectomy because of postoperative back pain [27]. Other studies reported that wide laminectomy induces postoperative instability of the spine in more than half of the population. [28, 29]. Drive increased in 2000s for developing less invasive decompressive procedures for lumbar spinal stenosis. The unilateral approach for bilateral decompression (ULBD) was introduced by spetzger et al [16], other study on ULBD suggested superiority on bilateral laminotomy in preservation of spinal stability after surgery, with better improvement in postoperative patients' symptoms and function [30]. Our results go on agreement with the previously reported results as all the patients in the microscopic decompression group had postoperative improvement in pain and function with no significant additional benefit for patients in conventional laminectomy. Although other studies [31–33] comparing different surgical techniques for patients with lumbar spinal stenosis provided no evidence of benefit for fixation and fusion on minimal invasive or conventional laminectomy techniques, however our study results showed significant improvement of back pain for patients in fixation group in comparison to other 2 groups with a slight significant improvement of leg pain for patients in fixation group in comparison to microscopic decompression group. Of note our results showed significant higher improvement of back pain for patients in fixation group even when compared to the microscopic decompression group, this can be attributed to our follow up point which is 3 months follow up post-surgery, this allowed enough time for healing from surgical trauma of decompression and fixation surgery. Although most of the literature reported better improvement in back pain with minimal invasive spine technique related to lower bony anatomical disruption, on the other hand it is reported that lumbar fixation improves micro instability as a cause of back pain in patients with lumbar spinal stenosis, even some authors argue for minimal invasive fixation techniques in addition to compression to improve post-operative back pain [34–36]. However, we cannot have a solid conclusion from our study regarding improvement of back pain with fixation in comparison to microscopic decompression because of our modest number of patients and retrospective nature of the study.

Authors reported lower operative time, less blood loss and fewer complications for the minimal invasive decompression techniques [37, 38]. Our results showed median blood loss of 200 ml, median operative time of 122 minutes and median hospital stay of 2.5 days for patients in the microscopic decompression group. These rates are higher than previously reported rates by other authors [32, 35, 39–41]. We attribute this as it was a new technique developed in our institute with developing learning curve.

Patients in the fixation group and conventional laminectomy group in our study was found to have within average reported blood loss, operative time and hospital stay [42–46]. There was no statistically significant increase in any of these outcomes for patients in the fixation group in comparison to conventional laminectomy group or microscopic decompression group except for the operative time which was as expected higher for patients in the fixation group.

The present study suggests a tendency for improvement of back pain for patients who had decompression with fixation in comparison to conventional laminectomy and microscopic decompression techniques without addition of significant operative time, blood loss or hospital stay, however we cannot conclude which would be the best surgical option for patients with lumbar spinal stenosis, further research is recommended especially with the rapidly developing minimal invasive techniques, relatively few numbers of patients in our study and its retrospective nature.

5. Conclusions

Debate continues, what is the best surgical option for patients with lumbar spinal stenosis, especially with the rapidly evolving recent surgical techniques. Our results augmented what is previously stated in the literature that is, Conventional decompressive laminectomy with or without fixation and microscopic decompression provide sufficient pain and disability improvement for patients with lumbar spinal stenosis, with no statistically significant difference between groups regarding physical disability or leg pain, however addition of fixation showed significant improvement of back pain compared to both other groups. We suggest a significant improvement in postoperative back pain for patients with lumbar spinal stenosis receiving decompression and fixation in comparison to those who receive conventional laminectomy or microscopic decompressive laminotomy, with no added statistically significant complications.

6. Recommendations

Further research is recommended to conclude solid evidence in favor of specific surgical technique. A multicenter study with long term follow-up is highly recommended.

List of Abbreviations

LSS: Lumbar spinal stenosis;
VAS: Visual analogue scale;
ODI: Oswestry disability index;
UBLD: Unilateral approach for bilateral Laminotomy decompression.

Conflicts of Interest

The authors declare that they have no competing interests.

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