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Surgical Modalities for Management of Degenerative Lumber Canal Stenosis

Abdelwhab Mohammed Abdelwhab Deabs *; Shehab M. Al Khadrawy; Ahmed Adel Ayad

Department of Neurosurgery, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.

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*Corresponding author

Email: dr.abdulwahab.neuro@gmail.com

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ABSTRACT

Background: Lumbar canal stenosis is defined as a narrowing of any part of the lumbar spinal canal. Several surgical techniques for lumbar spine decompression have been described; but there is no agreement about the best method.

Aim of the work: To assess the outcome of the different approaches in the surgical management of degenerative lumbar canal stenosis.

Patients and methods: This randomized clinical trial had been conducted. In this study; fifty patients with lumbar canal stenosis were divided into 3 groups; 20 patients subjected to laminectomy, 20 patients have undergone lamino-foramenotomy, and 10 patients received endoscopic lamino-foramenotomy. period of research varied from six-twelve months. The primary outcome was the improvement score of low back pain developed by the Japanese Orthopedic Association Lumbar Score, and the outcome was classified as excellent at more than 75.0% improved score; good, 50.0–75.0%; fair, 25.0–49.0%; and poor, 0.0–24.0% or less.

Results: There was no variation in improvement score at three and six months of different procedures. There was no variation in pain score at three and six months of different procedures. There is no variation in the operative outcome of different procedures.

Conclusion: Different approaches in the surgical management of single and multiple degenerative lumbar canal stenosis have similar effects. They are good surgery to treat degenerative lumbar canal stenosis, with reasonable outcomes.

Keywords: Lumbar Stenosis; Decompression; Laminectomy.

INTRODUCTION

Two types of lumbar stenosis are present [congenital and acquired]. In acquired lumbar canal stenosis, the progressive narrowing is attributed to acquired degenerative changes such as thickened laminas, medially impinging arthritic facets, hyperlordosis with laminar shingling, in folding of hypertrophied yellow ligament and ossification of the posterior longitudinal ligament [1].

Radiculopathy and neurogenic claudication [which may be unilateral or bilateral with or without low back pain] associated with spinal stenosis have been attributed to either direct mechanical compression or indirect vascular insufficiency leading to lack of adequate blood flow and oxygenation of lumbar nerve roots or cauda equine [2].

MRI [magnetic resonance imaging] has evolved to be the single imaging modality of choice in lumbar canal stenosis because of its ability to delineate soft tissue, CSF [cerebrospinal fluid] spaces, the severity of neural compression, and disc disease. CT [computed tomography] scanning is excellent for bone resolution. The combination of MRM followed by a CT scan is excellent for assessing the degree of foraminal stenosis and nerve root compression [3].

Studied cases with progressive neurological symptoms or those who do not respond to a suitable trial of non-operative treatment after 6 months should consider lumbar spinal stenosis surgery. the primary objective of all surgical interventions suggested is neural element decompression [4].

Decompressive laminectomy is used as the “gold standard”, through this approach the laminae and the ligamentum flavum at the involved levels are removed for central canal decompression and the laminectomy may be extended laterally to allow visualization and decompression of the nerve roots within the neural foramina if foraminal stenosis is detected on preoperative imaging [5].

Lumbar instability following decompressive laminectomy has been rare, only about 1.0-2.0% of all laminectomies for stenosis will develop progressive subluxation; therefore, fusion has been rarely required to prevent the progression of sublaxation with degenerative stenosis [6].

Laminoforaminotomy and decompression without total laminectomy for lumbar spinal stenosis is a safe and gentle method for decompressing the spinal canal with excellent possibilities [7].

In contrast to conventional techniques, MIS direct lumbar decompression/ discectomy favors the "muscle splitting" methodology. para spinous is not separated from the spinous process as in conventional procedures and lateral, as opposed to midline skin incision, is employed in earlier methods [8].

THE AIM OF THE WORK

The goal of this work is to assess the result of the different approaches in the surgical management of single & multiple degenerative lumbar canal stenosis.

PATIENTS AND METHODS

Study population: In this prospective research, fifty patients with degenerative lumbar canal stenosis were evaluated. Patients were recruited from the Department of Neurosurgery, Al-Azhar University Hospitals during the period from April 2021 to April 2023.

Inclusion criteria: Patients diagnosed with degenerative lumbar canal stenosis, who presented by neurogenic claudication [unilateral or bilateral] with or without low back pain, after failure of conservative measures for six months, and MRI or CT lumbar spine demonstrating central and foraminal stenosis.

Exclusion criteria: Sequestrated disc herniation, grades 2, 3, and 4 spondylolisthesis, and previous lumbar spine surgery.

Patients’ classification: Patients were randomly classified into one or these groups: **Group 1** included 20 patients subjected to Laminectomy; **Group 2:** included 20 patients subjected to Lamino-foramenotomy; **Group 3:** included 10 patients subjected to endoscopic lamino-foramenotomy.

Data collection: Full detailed systemic history including [sex, age, body mass index [BMI], occupation, smoking, and co-morbid medical conditions], current history of the condition [duration of illness, site and level of lesions and symptoms in details]. Reported symptoms include bache ache, leg ache, intermittent claudication, lower limb weakness, bladder dysfunction and paresthesia. Details about drug history were also obtained. Past history of chronic diseases, early postoperative and 6 months postoperative follow-up.

Surgical procedures:

Group 1 and 2 [Open surgery]:

After administering general anesthesia, the patient was placed face down. A small incision was made in or near the center using a preincision needle localization film to determine the correct size of the exposure. Subcutaneous dissection and hemostasis were achieved using Bovie electrocautery. Monopolar electro-cautery was used to dissect through subcutaneous fat to the lumbodorsal fascia, and then to elevate the paraspinal muscles sub-periosteally. Retractors were used as needed. To expose neural structures, the lower half of the lamina above and upper third of the lamina below were removed, allowing for complete removal of the ligamentum flavum while leaving the central portion of the neural arch intact to minimize spinal instability.

The interspinous and supraspinatus ligaments were preserved. To access the medial aspect of the superior facet, the inferior facet was partially removed medially. The superior facet was undercut and removed with a Kerrison rongeur. The nerve root was then checked to ensure that it had been decompressed.

The contralateral side was addressed by undermining the spinous process and tilting the table to bring the zone of the foramen and lateral recess into view. The contralateral portion of the ligamentum flavum was sequentially resected until the nerve root was seen exiting freely into the foramen, and then the lateral recess was cleaned.

Undercutting of the spinous process with a rongeur provided excellent visibility of the contralateral side. Decompression of the nerve root was confirmed by sliding a blunt instrument along its course.

Discectomy is usually necessary when treating LCS caused by a disc or when a disc herniation is present that could compress the root. If a free fragment is visible in the canal, it can be removed with rongeurs. If it is located under the thecal sac, nerve hooks can be used to bring the fragments into view and then removed with a rongeur.

Bipolar electrocautery is used to cauterize the annulus over the disc space, and any crossing epidural veins are also cauterized and divided. The

annulus is then incised with a No. 11 scalpel to make either a rectangular or parallel cut to the nerve root. Nerve hooks are used to free any subligamentous fragments, and disc fragments are removed with a rongeur.

Hemostasis is achieved with cautery, gel foam, and gentle pressure with cottonoid as needed, and a Hemovac may be used if necessary. Fascia is closed with one Vicryl suture, and subcutaneous tissue is closed with 0 Vicryl suture. The skin is then reapproximated and closed with either 2.0 prolene or running 4/0 subcuticular stitches.

Group 1 [Laminectomy]: During a conventional laminectomy [CL], we removed the spinous process, supraspinous ligament, and interspinous ligament, along with complete removal of the lamina to enable the complete removal of the hypertrophied ligamentum flavum beneath it.

Group 2 [Lamino-foramenotomy]: We removed the lateral recess through performing medial facetectomy and checking the neural foramen to ensure that the nerve root has been adequately decompressed through foraminotomy.

Group 3 [Endoscopic Laminoforaminotomy]: Microscopic bilateral decompression is achieved under general anesthesia with the knee–thorax position, with the surgical opposite side of the body blocked for later "over-the-top" decompression. After confirming level localization, a 25–30-mm skin incision was made approximately 10–15 mm from the midline on the side of the approach typically at the lower part of the back [L4 to S1]. With a retractor that expands the soft tissue, step-by-step expansion tubular retractors are placed in the operation area. Finally, the working tube is placed in the target area. Intraoperative X-rays was used to confirm the correct targeting site for the placement of the tubular retractor. The surgical microscope is then used to identify the boundary between the LF and inferior rim of the lamina. A ball-tipped dissector is used to identify the cranial insertion of LF. The ipsilateral LF is removed caudally and thus the dura is decompressed. The tube is angled medially with the operating table tilting against the side of the surgeon, achieving a working and viewing angle of approximately 30° to conduct over-the-top decompression. With intact contralateral LF, the contralateral lamina is drilled while neural structures are protected by a 9-French Frazier suction tube. Kerrison rongeurs are used for complete resection of the contralateral LF carefully to expose the underlying dural sac. Subsequently, the resection of the ipsilateral LF and hyperplastic articular process was performed.

All surgical data [operative time, blood loss, intra-operative and early post-operative complications] were reported.

Follow up: For at least six months by: Clinical [pain score] and radiologically

1. Early post-operative follow-up for complications [infection, hematoma, CSF leak, Dural tear and root injury] were all checked for and reported if present. Residual defects and activity were also checked.

2. **Clinical evaluation for improvement scores**: The scoring system for pain and disability by the Japanese Orthopedic Association [JOA score] [9] was used. This evaluation form comprises subjective symptoms [0–9 points] and objective findings [0–6 points]. Preoperative clinical evaluation data and JOA scores were obtained, and postoperative final scores were obtained by blind follow-up examinations. The rate of the improved JOA score [RIS] was defined according to the following calculation: [[postoperative score 2 preoperative score]/ [15 2 preoperative score]] 3 100.0%. The overall result was classified as excellent at more than 75.0% of RIS; good, 50.0–74.0%; fair, 25.0–49.0%; and poor, 0.0–24.0% or less than the preoperative score.

3. **Pain score**: After three and six months, the Oswestry Disability Index [ODI] [10] was conducted. The ODI assesses symptoms in ten areas, which include pain intensity, personal care, lifting, walking, and sleeping, among others.

4. Radiological follow-up was performed for all patients to check radiological fusion.

Ethical considerations:

The study was designed according to the Declaration of Helsinki. All contributors signed an informed consent form. An approval of the Institutional Review Board [IRB] was obtained from the ethical committee of Faculty of Medicine, Al-Azhar University.

Statistical analysis:

Statistical Package for the Social Sciences [SPSS] version 24 was used to analyze the data. Summaries of quantitative information were provided as means ±SD. Numbers and percentages were used to illustrate patterns in the qualitative data. The Chi-square test was used to compare categorical variables, while one-way ANOVA test or Kruskal Wallis tests were used to compare between continuous variables of the three studied groups. P-value < 0.05 indicated statistical significance.

RESULTS

Table [1] showed that there is no statistical variation in demographic data of different procedures. However, there were female sex predominance in laminectomy and Laminoforaminotomy, while male sex predominance was observed in endoscopic lamino-foramenotomy. The majority of patients were in their sixth decade of age and were mainly obese or overweight. The manual worker was the commonest occupation among study groups.

Table [2] found that there is no statistical variation in clinical data of different procedures. The mean duration of illness was 7 years and the majority were unilateral, especially in Laminoforaminotomy and endoscopic Laminoforaminotomy groups. L4, 5 and S1 were the commonest levels in laminectomy and Laminoforaminotomy, while L3, 4,5 were the commonest in the endoscopic Laminoforaminotomy group. Backache was the commonest symptom among study groups, especially in the endoscopic group [100% of patients had backache].

Table [3] found that there is no statistical variation in the operative outcome of different procedures. The commonest complications were infection [one patient in laminectomy and lamino-foramenotomy groups] and hematoma [one in the Laminoforaminotomy group]. The residual neurological defects were presented in [15.0%, 25.0% and 20.0% in laminectomy, Lamino-foramenotomy and Endoscopic lamino-foramenotomy groups, respectively], while residual pain presented in 15%, 5% and 10.0% with the same order. The improvement was good or poor in 80.0%, 20.0% in laminectomy procedure, compared to 65.0% and 35.0% in Lamino-foramenotomy and 80.0% and 20.0% Endoscopic lamino-foramenotomy.

Table [4] found that there is no statistical variation in the radiological outcome of different procedures. Table [5] showed that there is no statistical variation in improvement scores at three & six months of different procedures. Table [6] showed that there is no statistical variation in pain score at three & six months of different procedures.

Table [1]: Comparison between study groups regarding demographic data

Variable		Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	One-way ANOVA test/ chi-square test	
		N= 20	N=20	N=10	f/x2	p-value
Sex	Male Female	9 [45.0%] 11 [55.0%]	8 [40.0%] 12 [60.0%]	7 [70.0%] 3 [30.0%]	2.524	0.283
Age [years]	Mean ± SD	52.06 ± 4.11	51.50 ± 5.47	50.08 ± 6.39	0.491	0.615
BMI	Mean ± SD	30.55 ± 1.03	32.25 ± 3.02	31.17 ± 2.82	2.600	0.085
Occupation	Manual worker Farmer Employee Housewife	9 [45.0%] 2 [10.0%] 5 [25.0%] 4 [20.0%]	5 [25.0%] 2 [10.0%] 5 [25.0%] 8 [40.0%]	3 [30.0%] 4 [40.0%] 1 [10.0%] 2 [20.0%]	8.268	0.219

Table [2]: Comparison between study groups as regard to clinical data

Variable		Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	Significance	
		N= 20	N=20	N=10	f/x2	p-value
Duration of illness [years]		7.00 ± 1.09	7.67 ± 1.43	7.50 ± 2.02	1.127	0.333
Side of lesion	Unilateral Bilateral	9 [45.0%] 11 [55.0%]	12 [60.0%] 8 [40.0%]	7 [70.0%] 3 [30.0%]	1.907	0.385
Level of lesion	L3,4-5 L4,5-S1 L5,S1	9 [45.0%] 10 [50.0%] 1 [5.0%]	8 [40.0%] 10 [50.0%] 2 [10.0%]	6 [60.0%] 3 [30.0%] 1 [10.0%]	1.658	0.798
Symptoms	Bache ache Leg ache Intermittent claudication Lower limb weakness Bladder dysfunction Paresthesia	14 [70.0%] 11 [55.0%] 16 [80%] 8 [40%] 5 [25%] 12 [60%]	15 [75.0%] 13 [65.0%] 9 [40%] 10 [50%] 9 [45%] 7 [35%]	10 [100.0%] 6 [60.0%] 5 [50%] 2 [20%] 3 [30%] 8 [80%]	3.671 0.417 5.625 2.500 1.872 5.918	0.159 0.812 0.060 0.287 0.392 0.052

F: On-way ANOVA test; X^2 : chi-square test

Table [3]: Comparison between different procedures regarding operative outcome

Variable		Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	Significance	
		N= 20	N=20	N=10	X^2	p-value
Complications	Infection Hematoma	1 [5.0%] 0 [0.0%]	1 [5.0%] 1 [5.0%]	0 [0.0%] 0 [0.0%]	0.750	0.687
Residual defect	Pain Neurological defect	3 [15.0%] 3 [15.0%]	1 [5.0%] 5 [25.0%]	1 [10.0%] 2 [20.0.%]	1.500	0.472
Activity	Good improvement Poor/no improvement	16 [80.0%] 4 [20.0%]	13 [65.0%] 7 [35.0%]	8 [80.0%] 2 [20.0%]	1.403	0.496

Table [4]: Comparison of radiological outcome of different procedures

Variable		Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	Chi-square test	
		N= 20	N=20	N=10	x2	p-value
Radiological fusion	Complete Incomplete	16 [80.0%] 4 [40.0%]	18 [90.0%] 2 [10.0%]	10 [100.0%] 0 [0.0%]	2.652	0.266

Table [5]: Comparison of improvement score of different procedures

		Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	Chi-square test	
		N= 20	N=20	N=10	X^2	p-value
At 3 months	Poor Fair Good Excellent	0 [0.0%] 6 [30.0%] 8 [40.0%] 6 [30.0%]	1 [5.0%] 3 [15.0%] 11 [55.0%] 5 [25.0%]	0 [0.0%] 5 [50.0%] 4 [40.0%] 1 [10.0%]	6.176	0.404
At 6 months	Poor Fair Good Excellent	0 [0.0%] 4 [20.0%] 9 [45.0%] 7 [35.0%]	1 [5.0%] 1 [5.0%] 7 [35.0%] 11 [55.0%]	0 [0.0%] 3 [30.0%] 2 [20.0%] 5 [50.0%]	6.517	0.368

Table [6]: Comparison of pain score of different procedures

	Laminectomy	Lamino-foramenotomy	Endoscopic lamino-foramenotomy	Chi-square test	
	N= 20	N=20	N=10	F	p-value
Pain score before the operation	7.14 ± 3.108	8.92 ± 2.15	8.17 ± 0.83	2.696	0.078
Pain score at 3 months	21.31 ± 1.89	22.42 ± 2.83	21.75 ± 0.45	1.316	0.278
Pain score at 6 months	24.50 ± 2.19	24.25 ± 5.45	23.08 ± 2.99	0.448	0.641

DISCUSSION

With this criterion, lumbar laminectomy is deemed required because all other probable causes of pain are ruled out, radiological scans show nerve root compression that is consistent with clinical outcomes of the afflicted nerve root, and Member has not followed cautious management for at least six weeks. Daily activities were limited by ongoing back pain that traveled down to the lower leg. On examination, neurological affection is still present & is associated with nerve root that is affected [e.g., positive straight leg raising test, sensory loss, altered response, weakness] [11].

The main goal of this research was to assess the result of the different approaches in the surgical management of single & multiple degenerative lumbar canal stenosis. This randomized clinical trial was conducted. In this study, fifty patients with lumbar canal stenosis were the subject of this clinico-surgical work. The period of research varied from six-twelve months.

As regard demographic data, the current study included 50 patients, whose age ranged between 43 – 60 years with a mean value of 51.300 ± 5.209. 52.0% were females and 48% were males. 34.0% were annual workers, 28.0% were housewives, 22.0% were employees and 16.0% were farmers. Our findings had been proven by the research of **Ebrahim *et al***. [12] as they informed that They worked with fifteen studied cases [ten females & Five males]. median age, which ranged from thirty to fifty-five years old, had been 42.8 +/- 6.0. Seven housewives, four workers, two farmers, & two employees had been there. Also, in the study of **Ige *et al***.[13], a total of thirty-two studied cases had been followed up over a 24-week study period. The baseline characteristics of patients showed a mean age of 64.3 ± 8.4. Fifteen of the participants had been male [46.5%], whereas the remaining 17 had been female [53.1%]. About 68.8% of the study population had a formal education; the entire population was married as may be expected.

The present study showed that as regard clinical symptoms; Among our studied population, 56.0% have unilateral lesion while 44.0% have bilateral lesion, most of them have backache 78.0% followed by leg ache and claudication in 60.0% for each then parathesis in 54.0% weakness n 40.0% then and bladder dysfunction in 34.0% of them. Our findings had been proven by the research of **Islam *et al***. [14] as they stated that motor weakness affected sixty percent of studied cases & that practically all had low back pain along with radiation to the back of the leg & thigh. Of the studied cases, 83.3 percent exhibited neurogenic claudication, while about 66.6 percent had sensory impairment. At the time of presentation, in most of the studied cases, eighty percent had been in pain for twelve months or more. average number of months of suffering had been 14.7±5.1. thirty-six percent of studied cases could walk on their tiptoes, & over fifty-five percent could walk on their heels. 53.3 percent of studied cases & almost fifty-seven percent of studied cases, respectively, experienced sensory deficits along the first sacral nerve's distribution & lumber five nerves. Similarly, **Kariya *et al***. [15] stated that the mean period of symptoms had been 53.9±15.9 months. 15 [thirty percent] studied cases complained of backache without radicular pain however thirty-five [seventy percent] had backache related to radiculitis. Ninety percent of studied cases complained of neurogenic claudication. The neurological deficit appeared in thirty-five cases [seventy percent]. In the research of **Ige *et al***. [13], all research population had severe leg pain and spinal claudication at presentation, average VAS score for the leg was 8.5. Only two patients had severe back pain at presentation. 17 weeks were on average spent experiencing symptoms before the presentation. Magnetic resonance imaging results of patients have been outlined. Stenosis was seen at two levels, 15 [46.9%] of the study population and the involvement of L4/L5 level in 25 [75.1%] were the most common findings.

The current study showed that regarding surgical intervention, 40.0% have Laminectomy and Laminoforaminotomy procedure for each while endoscopic Laminoforaminotomy were done in 20.0% for each. 74.0% have good improvement; 20.0% have residual neurologic defects and 10.0% have residual pain. In the study of **Islam *et al***. [15], Laminectomy, laminectomy & discectomy, & laminectomy, discectomy, & foraminal decompression were performed on 43.3%, thirty percent, 26.7% of studied cases, respectively. In twenty-five [83.5 percent] of the studied cases, the symptoms were relieved. According to Oswestry Disability Index, more than 76.7 percent of studied cases had a low disability and 23.3% had moderate disability, whereas according to MacNab criteria, in most studied cases eighty percent scored excellent, ten percent good, & another ten percent fair. mean Oswestry score considerably dropped from 54.5 percent at baseline to twenty-two percent at the end of a year, according to repeated measure ANOVA statistics [p< 0.001]. Also, **Hawis and Gabriel** [16] revealed that Traditional laminectomy & discectomy is primarily used in group A, endoscopic unilateral decompression lamino-foramenotomy without discectomy is primarily used in group B, & bilateral microscopic laminectomy without discectomy is primarily used in group C.

In the study in our hands, there is no statistical variation in demographic data of different procedures. Our results were supported by the study by **Rodrigues** and **Natour** [17] as they reported that they used a forty-eight-week follow-up period for their research. Using electronic randomization, 63 studied cases of both sexes, aged fifty to seventy-five, had been chosen from the outpatient clinic & randomly assigned to the intervention group or control group.

Current research found that there is no statistical variation in clinical data of different procedures. In the study of **Eissa *et al***. [18] patients were treated with conventional laminectomy without posterolateral fusion, conventional laminectomy with posterolateral fusion [CLPF], or unilateral laminectomy with bilateral decompression [ULBD]. Twenty patients were subjected to conventional laminectomy [CL] surgery. Single-level decompression was performed for one case, double-level decompression was performed for eight cases, triple-level decompression was performed for eight cases, quadruple-level decompression was performed for three cases and the total levels were 53 levels.

According to **Zhao *et al***. [19], a retrospective analysis of seventy-eight studied cases that met the criteria resulted in the division of studied cases into two groups, 1 for endoscopic transforaminal lumbar interbody fusion [Endo-TLIF; forty cases] & other for minimally invasive transforaminal lumbar interbody fusion [MIS-TLIF; thirty-eight cases]. studied cases' different disease courses had not been statistically different [P > 0.05], indicating comparability.

The present research showed that there is no statistical variation in the operative outcomes of different procedures. There is no statistically significant difference in the radiological outcome of different procedures. There is no statistical variation in improvement score or pain score at 3 and 6 months of different procedures. In the study of **Hawis** and **Gabriel** [16], Group A had the highest mean operation length across the board for both genders, followed by Group B and Group C. most frequent intraoperative complication in the entire research, particularly in Group A, had been unintended durotomy. Group A had the highest average blood loss for both genders, followed by Group B, and then Group C. Group A had the most postoperative problems in its studied cases [33.3 percent], followed by Group B [8.5 percent], & group C [two percent].

In addition, **Zhao *et al***. [17] stated that at three months & a year following surgery, VAS scores of the Endo-TLIF group had been statistically superior to those of the MIS-TLIF group [P <0.05]. At any of the remaining time intervals, there had been no statistically significant score variations among the 2 groups [P > 0.05]. the intervertebral altitude of 2 groups did not differ significantly at three-month [11.36 ± 0.23, 11.21 ± 0.42, respectively] or final follow-up [10.88± 0.64, 10.81± 0.39, respectively] [P > 0.05]. There were no dural tears, cerebrospinal fluid leaks, infections, or neurologic injuries. At the most recent follow-up, both groups displayed excellent intervertebral fusion.

The study has some limitations. The small sample size is the main limitation. Also, it is a single-center study. The relatively short follow-up duration and that present work represented initial clinical experience & add to the literature about efficacy & safety of surgical management of lumbar spinal canal stenosis are also other limitations.

Conclusion: Different approaches in the surgical management of single and multiple degenerative lumbar canal stenosis have similar effects. They are good surgery to treat degenerative lumbar canal stenosis, with reasonable results.

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