Comparative study between microscopic bilateral decompression via unilateral approach and standard total laminectomy for treatment of degenerative lumbar canal stenosis

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Abstract

Background: The better patient outcomes is driving to the development of minimally invasive spine surgical techniques. There are several evidences on the use of microscopic decompressive surgery for degenerative lumbar canal stenosis; however, few of these studies compared their outcomes with the classic laminectomy and laminotomy techniques.

Objectives: The aim of our study was to compare outcomes following microsurgical bilateral decompression via unilateral laminotomy approach for bilateral decompression (ULBD) of the lumbar spinal canal to the standard open laminectomy for cases with single and multiple degenerative lumbar canal stenosis.

Material and methods: Cases were divided in two groups. Group (A) cases were operated by microscopic decomressive laminotomy via unilateral approach and bilateral decompression; Group (B) cases were operated by standard classical decompressive laminectomy technique. Results from both groups were compared regarding duration of surgery, blood loss, perioperative complication, and postoperative outcome and patient satisfaction.

RESULTS: Statistical difference noted between the improvement rate of the two groups .Group A had higher rate of improvement than Group B. Unilateral laminotomy for bilateral micro-decompression : single and multiple levels had 88% improved VAS, 0.8% instability compared to Clinical results of decompressive laminectomy. Postoperative clinical improvement in (Group A) as regard back VAS, leg VAS, modified ODI and PSI could lead to a significant improvement of symptoms during the follow-up period. The pre- and postoperative JOA scores of the multiple level cases were significantly lower than those of the single level cases; however, there was no significant difference in the recovery rate (RR) between the groups. There is statistically significant difference between the mean VAS score for leg pain pre-operatively and post-operatively, at 3rd month ,6 th month and 12 th months follow up. Patient satisfaction varies from 57% to 81% with regard to excellent to good results. surgery met their expectations and patients were satisfied from the outcome.

CONCLUSIONS: Comparing ULBD with classic laminectomy showed the efficacy of the minimally invasive technique in obtaining good surgical outcome and patient satisfaction. Unilateral laminotomy with bilateral micro-decompression technique preserves posterior midline structures with sparing of spinous process, opposite side lamina , paraspinal muscles and provides an adequate and safe bilateral decompression at multiple levels. This procedure has smaller incision, minimal perioperative blood loss, postoperative posterior scarring and back pain, less length of hospital stay and it promotes early mobilization with early return to normal routine life than classic laminectomy technique.

Keywords Lumbar canal stenosis, Laminectomy, Laminotomy, degenerative Spondylolisthesis ,Micro-decompression.

Introduction

Lumbar canal stenosis is a reduction in the diameter of the spinal canal, lateral nerve canals, or neural foramina, due to a progressive degenerative process of the lumbar spine, leading to symptoms and disability caused by the reduced space available for the nerve roots and cauda equinae (1)(2)(3).

Causes of degenerative LSS include broad base disc bulging, ligamentum flavum hypertrophy, and degenerative facet joint disease. It significantly impacts the quality of life in performing the daily activities and can lead to progressive disability.The classical symptom of lumbar canal stenosis is neurogenic intermittent claudication. Patients suffer from radicular symptoms in the lower extremities during walking, and more persistent radicular symptoms may also occur Patients have often already had back pain before leg pain. Most patients treated surgically have only subjective symptoms, mainly pain (1)(3).

The main line of treatment of lumbar canal stenosis in many patients is the conservative treatment. Surgery should be reserved for when medical treatment fails and leg symptoms are severe and functionally disabling. Lumbar canal stenosis is the most common indication for lumbar spine surgery in adults aged over 65 years (4).

In addition to advances in surgical techniques, improvement of the outcome could be achieved through better knowledge of outcome predictors, and with postoperative rehabilitation (5). The treatment of lumbar spinal canal stenosis (LSCS) has become an important issue, especially in older people. The aim of surgery for LSCS is to relieve lower leg pain, and regain the walking capacity by decompressing the canal stenosis (6). Usually, the classical (standard total laminectomy) operation was a dissection of the paraspinal muscles, and the posterior elements such as the spinous process and interspinous ligaments were removed during the procedure. Such an operation is regarded to be highly aggressive, especially for elderly people. Rarely recoveries to normal activities are very important for such patients (7).Recently, microscopic decompressive laminotomy via a unilateral approach has been performed as minimally invasive surgery This procedure is very useful for preservation of the spinous process and interspinous ligaments as well as the preservation of facet joints to prevent postoperative spinal instability. (8).Minimally invasive surgical techniques are recently gaining popularity; The objective of this study was to evaluate the efficacy and safety of microscopic unilateral laminotomy for bilateral decompression of degenerative lumbar canal stenosis and to compare the outcome with classic total laminectomy.Unilateral laminectomy and bilateral decompression (ULBD) surgery is considered a viable option for the treatment of LCS since the popularity of minimally invasive surgery has increased. With its aim of preserving normal anatomy and minimizing surgical morbidity, the utility of ULBD has been widely accepted (18)(19).

The learning curve cumulative summation test (LC-CUSUM) is an analytical tool, which was specifically designed to focus on the learning period of a procedure.Quantitative and statistical process-control methods of LC-CUSUM monitor individuals' medical performance during the learning period, and may help determine when an individual achieves a predefined competent level of medical performance.To date, only a few studies on the learning curve for ULBD have been reported, and to our best knowledge, there is no previous study reporting a learning curve of ULBD using a LC-CUSUM(18) (19).The purpose of this study was to determine the learning curve of ULBD for LSS using a LC-CUSUM analysis and to provide information on how many cases of ULBD were required to achieve competency for performing the procedure efficiently and safely.

Subjects and methods

This is a proospective study conducted on data of 72 patients, who were indicated for surgical decompression for degenerated lumbar canal stenosis. Cases were managed in the period between September 2017 and October 2019.

Degenerated lumbar canal stenosis was diagnosed clinically by presence of low back pain, neurogenic claudication pains, and/or radiculopathies. Diagnosis was confirmed by the presence of bony, ligamentous, facet hypertrophy or discogenic canal stenosis in lumbar spine MRI. All cases had an initial period of conservative therapies for at least 3 months. Cases with spinal deformities and instabilities, as well as recurrent cases, were excluded from the study group.Cases included in this study were divided into two groups. Group (A) cases, Microscopic unilateral laminotomy and bilateral decompression (ULBD) was performed for single, double, segmental and multiple level stenosis. In group (B) Classic total or partial (fenestration) laminectomy cases were operated by bilateral total or partial laminectomy and medial facetectomies single, double, segmental and multiple level stenosis. Microscopic ULBD technique was performed under general anesthesia, in prone position. C-arm fluoroscopy was utilized to identify the desired level before skin incision. Subperiosteal muscle separation followed till reaching the desired lamina. Ipsilateral microscopic laminotomy is then performed by karrison rongeur or drilling, followed by excision of the ligamentum flavum and trimming of the medial aspect of the facet joint, decompressing the ipsilateral foramen and inspecting for any disc fragments. The operating table and the surgical microscope were then tilted to the opposite side followed by the removal of the base of the spinous process to allow direct vision to the contralateral side. We then undermined the opposite lamina, removed the ligamentum flavum, and did the medial facetectomy and the foraminotomy directly from the opposite side. The classic open laminectomy technique was performed under general anesthesia. Subperiosteal muscle separation was performed bilaterally till reaching the desired laminae. Total laminectomy was then performed, including the hypertrophied ligamentum flavum. Finally bilateral medial facetectomy, foraminotomy, and inspecting the intervertebral discs were performed.

Results from both groups were compared regarding duration of surgery Level of affection (single, douple segmental or multiple), blood loss, perioperative complication, and postoperative clinical outcome and patient satisfaction using visual analogue scale (VAS) pain score for back and leg pain (0-10),neurogenic claudication outcome score (NCOS). the Modified Oswestry Disability Index (MODI): ,The Japanese

Orthopedic Association score (JOA) score (full score 29) and the Macnab's criteria (9)(10).

Results

This study included seventy two cases with degenerated lumbar canal stenosis, divided into two equal groups. Group (A) cases were operated upon by microscopic unilateral laminotomy and bilateral decompression, while group (B) cases were operated upon by bilateral total laminectomy.

In group (A), the mean age of cases was 64.81 years (7.2 SD), and the male to female ratio was 55.5:44.4. In group (B) cases, the mean age was 65.36 (6.5 SD), and the male to female ratio was 62.5: 36.1. Multivariate analysis of age and postoperative improvement of the NCOS showed no statistically significant effect of the mean age and sex on the postoperative NCOS ($p > 0.05$).

The most common presenting symptoms were claudication pain, LBP and radicular pain (sciatica) in both groups. Least common presentation between two groups was motor weakness and sphincter (bowel and bladder) disturbance. In group A claudication pain was present In 94% ,back pain in 92%, radiculopathy in 86%,motor abnormalities in 8% ,sensory abnormalities in 78% , and bowel and bladder abnormalities in 4 patients 11% ,While in group B claudication pain was present in 90% ,back pain in 90% , radiculopathy in 80% ,motor abnormalities in 11% ,sensory abnormalities in 70% ,and bowel and bladder abnormalities in 15%. Most of cases presenting with signs of limited lumbar extension, decreased SLR, Absent Ankle reflexes, Sensory changes and absent knee reflexes in both groups.The group (A) had higher percentage of cases presenting with limited lumbar extension in 72.2%, decreased SLR in 83.3%, absent Ankle reflexes in 75%, Sensory changes in 58.3% and Absent knee reflexes in 41.6% than group (B). The mean duration of symptoms till the operation was 27.2 months and 19.1 months (SD 14.5, 13.4) for group A and group B, respectively. No statistical significance was detected in any of these demographic data in both groups.

The most common affected single level was L4-5 followed by L5-S1 then L3-4 then L2-3 levels separately all levels present with segmental and multiple levels in both groups.L4-5 (66.6%), L3-4 (59%), L2-3 (50%), L5-S1 (41%) in both groups.Two levels of the spine needed decompression in 22 cases (35%), while one level needed decompression in 18 cases (25%), and three levels were decompressed in 16 cases (22.2%). The commonest level affected was L4-L5 it was affected in 48 cases (66.6%) while the least was L1-L2.

Decompression levels in Group A were L4–5 level 26 patients (72.2%), L2–3 level 18 patients (50%), L3–4 level 18 patients (50%) and L5–S1 level 15 patients (41.6%) in both single and multiple levels. Decompression levels in Group B were L4-5 level 26 patients (72.2%), L3-4 level 23 patients (63.8%), L2-3 level 22 patients (61.1%), L5-S1 level 15 patients (41.6%) in both single and multiple levels. Decompression in single and double levels in Group A were treated 10 patients at L4–5 level (27.6%),7 patients (19.4%) at L5–S1 level, 6 patients (16.6%) at L2–3 level, and 6 patients (16.6%) at L3–4 level while decompression single and two level in Group B were L4-5 level 10 patients (27.7%),L3-4 level 6 patients (16.6%), L2-3 level 6 patients (16.6%), L5-S1 level 7 patients (19.4%) in both single and multiple levels.

The level of stenosis at multiple level sites between two groups:23 patient (31.9%) decompressed at one Level, 15 patient (20.8%) decompressed at two Levels, 20 patient(27.7%)decompressed at three to four levels and 14 patients (19.4 %) above four levels. Mean surgery time for classic laminectomy was less than the group A. The intergroup difference was found to be statistically significant, average surgery time per level in group A, was 59.4 minutes (minimum 50, maximum 70 minutes). The mean operation time in multiple level patients was 120 min (range 60–260 min) and in single level patients was 90 min (range 50–240 min),In group B , surgery time per level was minimum 30, maximum 50 minutes, while the average was 45 minutes.

The mean blood loss in multiple level patients was 60 ml (range 10–280 ml) and in single level patients was 40 ml (range 5–270 ml). The blood losses were also significantly larger in the multiple level patients than those in the single level patients, but there was no significant difference in the blood losses, operation level between the groups ($P > 0.05$). Estimates blood lost per level was 250 ml (minimum 200 ml, maximum 300 ml). By comparing amount of bleeding in both groups amount of blood lost was higher for classical laminectomy than bilateral laminectomy via unilateral approach.

There was no statistically significant difference between both groups regarding the occurrence of complications as there was no complications in 25 cases (69.4%) in group (A) and 26 (72.2%) in group (B).

The postoperative assessment of back, leg VAS, neurogenic claudication and modified ODI in group A microscopic decompression procedure could leads to a significant improvement of symptoms and it lasted during the follow up period. In the multiple level patients (Group A), the preoperative JOA scores averaged 11 points (range 3–22) and the postoperative scores averaged 21 points (range 4–29) with significant improvement after surgery ($P < 0.05$), and the recovery rate (RR) at the follow up period averaged (mean) 61% (range 0–95 %). The JOA scores significantly improved after surgery ($P < 0.05$), In the single level patients (Group A), the preoperative JOA scores averaged 13 points (range 3–22) and the postoperative scores averaged 22 points (range 4–29) with significant improvement. The RR averaged (mean) 60 % (range 20 to 100 %)(table.1).

Table (1): Showing the clinical improvement of the patients with LCS following microscopic decompression procedure (Group A)

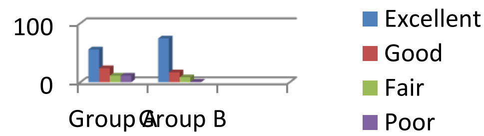
	Preop. (mean VAS)	**Postop.**	**Postop (6mon)**	**Postop (12mon)**
Back VAS	7 (4-8)(SD = ±1.05)	3 (2-5) ± 1.14	2 (1-4) ± 0.72	1 (0-2) ± 0.68
P value	-	< 0.05	< 0.05	< 0.05
Leg VAS	8 (SD = ±1.05)	2 ± 1.14	3 ± 0.72	3 ± 0.68
P value	-	< 0.05	< 0.05	< 0.05
Disability index	60%	< 20%	< 20%	< **2**0%
P value	-	< 0.05	< 0.05	< 0.05

In Group B, there was statistically significant difference between the mean VAS for leg pain preoperatively, postoperatively (hospitalization) up to 3rd month, 6th months and 12 months follow up. The preoperative leg pain, neurogenic claudication and back pain VAS score was mean VAS = 8.94. (SD = ±1.04). There was a rapid decrease in the leg pain scores from 8.94 in the preoperative period to 1.36 (SD ±1.13) after the operation. At one month follow up patients with no pain (VAS = 0) were 8 (23.00%). On follow up at three months the mean leg pain VAS score 0.36 (SD = ±0.76) with no pain in 24 (66.6%) patients (VAS = 0). However at six months follow up, the mean leg pain VAS score was 0.11 (SD = ± 0.66) and the difference in leg pain score was significant ($p < 0.05$) and at twelves months follow up almost all patients reported no leg pain (VAS = 0) or some slight pain (VAS = 1) with the exception of two patients who complained of moderate leg pain (VAS = 4) no pain in 34 pts. (94.4%).The mean leg pain VAS score was 0.11 (SD = ± 0.66) at 12months follow up and the score was statistically significant ($p < 0.05$)(table.2).

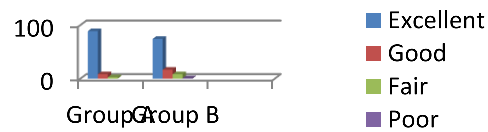
Table (2): Showing the clinical improvement of the patients (VAS) score with LCS following (Group B)

	VAS	**P value**	**Disability index**	**P value**
Preoperative	8.94 ± 1.04	-	60%	-
Postoperative (hospitalization)	1.36 ± 1.13	0.6261	< 20%	< 0.05
At 6th month	0.36 ± 0.76	0.067	< 20%	< 0.05
At 12th month	0.11±0.66	0.008	< 20%	< 0.05

The outcome of treatment in both groups in postoperative evaluation. Group A had higher rate of improvement than Group B. Excellent outcome had been reported in 46 cases (%66), good outcome in 14 cases (%20), fair outcome in 7 cases (10%) and poor outcome in 5 cases (4%)(fig1(a)



(a)



(b)

(b)

Figure (1): Showing comparison of (s) general outcome (improvement rate) among both groups (b) follow up periods postoperative up to 3 months, 6 and 12 months**.**

During follow up period with improvement of VAS of back and leg pain postoperative, 3,6,9 and 12 months and other clinical features with treatment of complications group A hade maximal rate of improvement of VAS than Group B. Excellent outcome had been reported in 58 cases (80.5%), good outcome in 9 cases (12.5%), fair outcome in 4 cases (1.5%) and poor outcome in 1 case (1.3 %)(fig.1(b)).

Discussion

Lumbar canal stenosis is a common indication for decompressive spine surgery. Decompression is indicated for cases who fail to respond to medical management or cases with severe clinical symptoms.

We have presented our results of the randomized controlled prospective study to compare the outcome of microscopic unilateral laminotomy (group A) for bilateral decompression of degenerative lumbar canal stenosis with classic laminectomy (group B), lumbar canal and neural foramina decompression was adequately achieved in all cases of both groups.

The main advantages of this microscopic approach are a reduction of the surgical trauma and the avoidance of induced instability. The facet joints are preserved, because only the compressing hypertrophied ligamentum flavum in medial parts are resected. Midline structures (interspinous and supraspinous ligaments) are completely preserved. The contralateral supporting lumbar musculature with its physiological attachment to the spinous process and lumbar fascia are also preserved, and the integrity is left intact. The most important surgical point is to make sure that spinous process bleb (under surface) is adequately undercutted which allows direct visualization of contralateral side microscopicaly insuring adequate decompression and help in minimizing time needed for surgery.

All operative procedures were performed under microscope as described previously (18).With the patient prone on a Wilson frame or on a Jackson table, the surgery level and the incision position were identified by a fluoroscopy. A small 3 cm of midline incision was made for unilateral approach to expose the surgery level. The approached side was determined by the patient's symptom: the more symptomatic side was chosen as the approached side. If the patient symptom was similar bilaterally, the left side approach was chosen (18).

Under microscope, the inferior aspect of the superior lamina of the surgery level was identified. Dissection of lamina was started at the spinous process-lamina junction of upper level on the approach side using 3-mm matchstick headed high-speed burr and Kerrison punch. Once removal of the proximal lamina was done at the attachment site of the ligamentum flavum, the distal lamina and the hypertrophied ligamentum flavum were excised using Kerrison punch and a freer periosteal elevator with dural sac identification. Ipsilateral subarticular zone and lateral recess were examined for additional decompression (18).

After ipsilateral partial hemilaminectomy and decompression, undercutting of spinous process was performed for decompression of the contralateral side. The proximal lamina of the contralateral side was removed by high-speed burr and Kerrison punch. With dural sac identification, contralateral ligamentum flavum was removed completely for decompression. Contralateral subarticular zone and lateral recess were also assessed for additional decompression. Complete neural decompression was examined by dural pulsation. Bleeding control was achieved using bone. In every patient, drain was inserted before wound closure (18).

Figure 1: After well decompression, thecal sac as seen through a microscope:

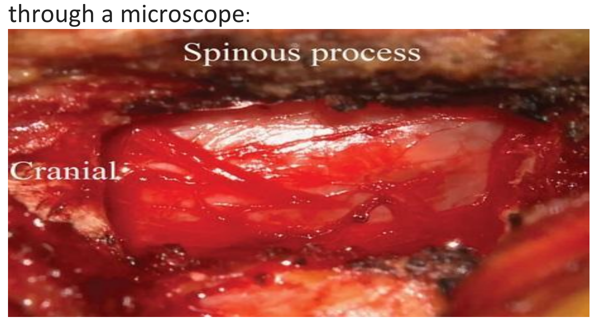


Figure 2: Showing preoperative (A,C) and postoperative (B,D) CT LCS radiologic finding markedly widening dural sac (B,D) only decompression.

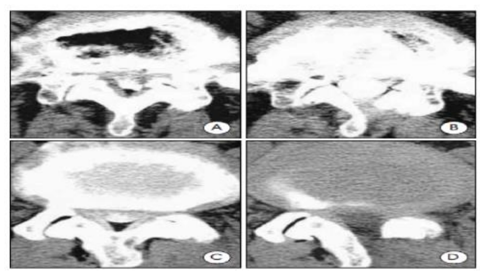
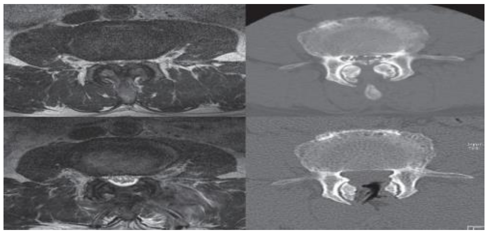


Figure 2: Showing Preoperative CT scan images demonstrating lumbar spinal stenosis at the level of L4–5 and Postoperative CT scan image with minimal facet resection at right side(Lt. sided). Preoperative axial T2-weighted MR and Postoperative axial MR image (Rt. sided) demonstrates the extent of decompression afforded by the microscopic decompression procedure with the preservation of tendinous attachment of the multifidus muscle at the spinous process at right side.



As regard the level of decompression in our study 23 patient (31.9%) decompressed at one Level, 15 patient (20.8%) decompressed at two Levels, 20 patient(27.7%) decompressed at three to four Levels and 14 patients (19.4 %)above four levels. The most affected level was L4-5 (58%) followed by L3-4 (26%) and L5-S1 (16%) respectively. 15 patients (20.8%) required discectomy. The most common stenotic site of single level in both groups is L4-5 followed by L3-4 then L5-S1 then L2-3 levels separately all levels present with segmental and multiple levels in both groups L4-5 and this is coincide with **Dutton JJ 1994 and by Sasaki K 1995** and **Johnsson K.1995** who reported that the most common site is L4-5, followed by the L3-4.**Ideguchi M, et al., 1998** report that L1-2 is one of the least common single location of this stenosis (12). **Haba K et al** noted that degenerative lumbar stenosis is most frequently observed in the L4-L5 and noted that microcirculation in nerve roots is damaged due to compression. In **Elmorshidy, et aL** series, (36.8%) patients were decompressed at one Level, (39.6%) patients at two Levels, (19.8%) patients at three Levels, and four (3.8%) patients at four Levels. In 17 patients, an associated disc herniation was removed (16%).The most affected Level was L4–L5 (82.1%). In **Alimi et aL** series, common level of surgery was L4–5 (50.3% of cases). The L3–4 level made up 29% of cases; L5–S1, 11.2%; and L2–3, the remaining 9.5% (13).

As regard the operative time in both groups the length of operation was significantly higher In group A than B, where mean surgery time per level was 59.4 minutes (minimum 50, maximum 70 minutes).The mean operation time in multiple level patients was 120 min (range 60–260 min) and in single level patients was 90 min (range 50–240 min), Coincide with Nakamura M, et al. 2009 and Abumi K, Panjabi MM, Kramer KM, Duranceau J, Oxland T and Crisco JJ.1990 (14).The operation times in Group A were significantly longer in the multiple level than in the single level patients; however, those of each operation level in the multiple level patients were significantly shorter than the single level patients ($P < 0.05$),However in group B operative time for multiple levels was not significantly longer than single level.

Sasai, et al reported 191 min/level for microsurgical decompression of spinal degenerative stenotic group (Sasai, et al 2008). Contrary to Rahman et al, Bilateral decompression of lumbar spinal stenosis via a unilateral approach involves shorter operating times than open decompressive techniques (15).In group B, surgery time per level was ranged between 30 and 50 minutes, while the average was 45 minutes. Mean surgery time for classic laminectomy was less than the group A. The intergroup difference was found to be statistically significant compared to Nancy e.Epestien 1997 who found that formal laminectomy group, surgery time per level was ranged between 35 and 50 minutes, while the average was 44.7 minutes.

In other studies, The LC-CUSUM was developed to analyze the learning curve by modifying CUSUM the criteria for success of the learning curve were set to operation time. It was set as the operation time written on the anesthesia record, and this was defined the time from skin incision to skin closure time. The reference operation time was set to 75 minutes, which is the operation time of our senior professor (H.-J.K). Inadequate performance (failure) was defined as an operation time more than 75 minutes. other studies applied LC analysis according to previous literatures (20) with the following parameters: the acceptable and unacceptable failure rates for “in control” and “out of control” processes, respectively, were a priori set at 20 and 40% by expert discussion in our department. These resulted in a decrease of 0.262 units for each successful measurement and an increase of 0.738 for each failure. With the optimizing type I error (0.05) and type II error, the decision limit h was set as -2.086. After LC-CUSUM analysis, standard CUSUM analysis was applied to the surgeon once his demonstrated adequate performance level. A decision limit h 2.524 was chosen for the CUSUM analysis. For calculating LC-CUSUM and CUSUM score, Excel software (Excel 2020, Microsoft, Redmond, WA). Other statistical analyses were performed using Stata/MP 15.0 (StataCorp LLC, College Station, TX). A 2-sided P value < 0.05 was considered to indicate statistical significance (20).

As regard the blood loss in both groups the estimated blood loss was significantly lower among group A 40 ml (range 5–270 ml/level) than group B 250 ml (minimum 200 ml, maximum 300 ml/level) (P value < 0.05) similar but lesser amount than results described by **Thomé,et al** where estimated blood loss in laminectomy group more than microscopic laminotomy group: (227 ± 154 ml /level) versus (212 ± 147 ml/level) respectively. (16). Comparing our results to Macnab’s criteria preoperatively, at 3 month and 6 months and 12 months postoperatively follow ups to evaluate the functional outcome of patients.The preoperative Macnab’s score was fair in

13.89% and poor in 86.11%. The Macnab's criteria on 1 month postoperative follow up was poor in 2.27%, fair in 11.11% and good in 86.33%, on 3 month of follow up was fair 2.27%, good in 8.33%, excellent in 88.88%, with no patients reported poor results and on 6 months of follow up good in 5.55% and excellent in 94.44%, with no patients reported fair or poor.

By the end of follow up all patients had favourable outcome and had returned to their original job. Similarly in the study done by **Hoogland et al ,** which showed significant improvement in the functional ability of the patients according to the Macnab's criteria. Also in 2002, **Yeung et al**, reported favourable outcome in the functional ability of almost all patients. Almost all patients were able to return to previous occupation by the end of the follow ups (17).

Conclusion

Minimally invasive surgical techniques for degenerated lumbar canal stenosis decompression are gaining more popularity as life expectancy increases and the increased focus on improving the quality of life of the elderly above 65 years.

Standard open classic wide laminectomy has been used for many years as the standard surgical technique for decompression of the lumbar canal stenosis.Comparing microscopic unilateral laminotomy and bilateral decompression with traditional classic wide laminectomy showed the efficacy of the minimally invasive microscopic technique in obtaining good surgical outcome and patient satisfaction.

The microscopic technique was found to respect the posterior spinal integrity and musculature, accompanied with less blood loss, shorter postoperative hospital stays, decreased postoperative complications and shorter recovery periods in single, double, segmental and multiple levels than the classic open laminectomy technique

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