

Endoscopic Fenestration in Management of Monosegmental Degenerative Lumbar Spinal Canal Stenosis: A Clinical Cohort Study

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ABSTRACT

Background Data: Minimally invasive fenestration has evolved recently to become the modern standard surgical solution for degenerative lumbar spinal canal stenosis (DLCS).

Purpose: To investigate the safety and the efficacy of the endoscopic fenestration for patients with monosegmental degenerative lumbar spinal canal stenosis.

Study Design: Prospective clinical cohort study.

Patients and Methods: Thirty-five consecutive patients with DLCS were treated with endoscopic fenestration. Patients were treated with METRx system (Medtronic Sofamor Danek, Inc., Memphis, TN, USA), at Orthopedic Department, Zagazig University, between May 2012 and June 2015. Primary outcomes parameters included Numerical Rating Scale (NRS) for back and leg symptoms and Oswestry Disability Index (ODI) to quantify pain and disability, respectively. Secondary outcomes parameters included operative time, blood loss, preoperative and 3-month postoperative lumbar dynamic radiographs, and modified McNab criteria. Only patients who completed 36 months of follow-up were included in the final analysis of this study. Follow-up data were obtained from outpatient clinic follow-up visits by two independent physicians.

Results: At the final follow-up, the improvement in claudicant leg pain and disability was statistically significant, and the endoscopic fenestration procedure did not affect the stability of the motion segment. The total success rate according to McNab criteria was 85.7% (30/35), fair 5.7% (2/35), and poor 8.6% (3/35). The mean NRS leg score significantly decreased from 7.3 ± 1.5 preoperatively to 0.8 ± 0.67 ($P=0.001$) postoperatively. The mean ODI score significantly decreased from 72.34 ± 4.6 % preoperatively to 13.71 ± 3.46 % postoperatively. There were no reported serious complications in any of our patients' study.

Conclusion: Endoscopic fenestration is a safe and effective technique in patients with degenerative lumbar stenosis. It allows adequate decompression of the neural elements and preserves spinal stability. (2018ESJ145)

Keywords: endoscopic; fenestration; lumbar canal stenosis; degenerative spine

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INTRODUCTION

Degenerative lumbar spinal canal stenosis (DLCS) is the most common cause for spinal surgery in the geriatric population.⁹ Decompression is the logical procedure to relieve the neural elements and so the neurogenic claudications. However, stability of the motion segment must not be affected by decompression.⁵ Unfortunately, seven to ten years after open laminectomy for DLCS, 23% of patients had undergone reoperation and 33% had severe back pain due to extensive removal of the posterior elements.²¹ The fact that significant stenosis of up to 45% has been found in asymptomatic patients¹⁵ has led Aryanpur and Ducker² in 1990 to the suggestion that complete decompression may not be necessary to achieve symptomatic relief.

Subsequently, open unilateral and bilateral fenestrations have evolved to become the modern standard surgical solution for DLCS.^{2, 12, 41} This fenestration technique is characterized by ipsilateral and contralateral decompression performed under the midline posterior structures. It has been successfully used with proven efficacy in treatment of DLSS patients with good outcomes in 87% of the patients.^{6, 25} Serial tube dilators and retractors were designed to minimize disruption of the paraspinal musculature utilizing a muscle splitting approach and provide direct and focal access to the stenosed motion segment.^{11, 33, 36}

The goal of this study was to investigate the safety and the efficacy of the endoscopic fenestration for patients with monosegmental DLSS.

PATIENTS AND METHODS

We enrolled in our study 35 patients with clinically symptomatic DLCS who fulfilled the inclusion criteria for our study and completed at least 36 months of follow-up. Patients were treated with endoscopic fenestration utilizing METRx system (Medtronic Sofamor Danek, Inc., Memphis, TN, USA), at Orthopedic Department,

Zagazig University, Egypt, between May 2012 and June 2015.

Determination of the general indication for surgery was made by 2 spinal surgeons who were not involved in this study. In preoperative MRI studies, the T₂-weighted axial MR images were graded with regard to the degree of stenosis through measuring the AP diameters in the axial images; the spinal canal was classified into three grades: Grade 0, normal or mild changes (ligamentum flavum hypertrophy and/or osteophytes and/or disk bulging without narrowing of the central spinal canal); Grade 1, moderate stenosis (central spinal canal is narrowed but spinal fluid is still clearly visible between the nerve roots in the dural sac and/or less than 15 mm in the AP diameter); and Grade 2, severe stenosis (central spinal canal is narrowed and there is only a faint amount of spinal fluid or no fluid between the nerve roots in the dural sac and/or less than 10 mm in the AP diameter).^{9, 24}

Preoperative lumbar dynamic (flexion-extension) radiographs were reviewed for evidence of instability (AP translation more than 3 mm and/or angulation more than 10 degrees). All participants gave their written consent in accordance to the Helsinki Declaration.⁴³

Patients (1) with neurogenic claudications as expressed by the patients as leg pain and/or heaviness limiting standing, walking, or both, (2) with a history of walking intolerance, (3) with magnetic resonance imaging (MRI) confirmation of a monosegmental central canal stenosis (central sagittal diameter less than 10 mm) with or without lateral recess stenosis (lateral recess diameter less than 3 mm) (Figure 1), (4) with failure of >3 months of conservative therapy, and (5) who completed 36 months of follow-up were included in this study. Patients with (1) previous spinal surgery at the same level, (2) spinal instability determined by the presence of sagittal vertebral translation greater than 3 mm and angulation more than 10° on a dynamic radiograph, (3) isthmic spondylolisthesis, and (4) cauda equina syndrome (CES) were excluded from this study.

The outcome data of 18 men and 17 women were analyzed in this study. The mean age was

58.8±4.9 years (range, 45–66). The mean duration of symptoms was 17.8±3.7 months (range, 16–19). The most common symptoms were neurogenic claudications (93.3%) either unilateral (14.2%) or bilateral (85.8%) sciatica. All patients had failed conservative treatment prior to surgery in the form of limited duty: NSAIDs, muscle relaxants, neurotrophics, opioid analgesics, and a comprehensive course of 30 sessions of physiotherapy (mean 6.5 months). Patient characteristics are listed in Table 1. Reported comorbidities in this series showed that 95% of our patients had one or more of the following problems: obesity (85%), hypertension (55%), and diabetes mellitus (25%).

Outcomes Parameters:

Primary (clinical) outcomes parameters included Numerical Rating Scale (NRS) (range, 0–100)⁷ for back and leg pain and Oswestry Disability Index (ODI).⁸ The final score is calculated and presented as a percentage (0% represents no pain and disability and 100% represents the worst possible pain). Secondary (objective) outcomes parameters included (1) all patients having pre- and a 3-month postoperative lumbar dynamic (flexion-extension) radiographs that were reviewed for evidence of instability; a single radiologist who was not involved in this study blinded to the procedure and the clinical results of decompression reviewed all pre- and postoperative studies; (2) operative time, surgical wound size, blood loss, and hospital stay; and (3) modified McNab criteria.²⁵ Reoperation at the same level for any reason was considered a poor result, regardless of the ultimate level of function.

Endoscopic Fenestration Technique:

Patients were prepared in prone position over spine surgery frame for standard laminectomy. The stenotic level was localized by fluoroscopy. After making an 18-30 mm paramedian skin incision a guide wire was directed to the superior lamina of the desired level, the paraspinal muscles were dilated by sequential dilators, an 18 mm tubular retractor was inserted over the last dilator, and then the rigid endoscope was inserted into the tubular retractor (Figure 2). The surgeon looks at the monitor in front of him (Figure 3). A unilateral

laminotomy was performed by partial resection of the inferior aspect of the cranial hemilamina till the bare area of the ligamentum flavum was reached; then excision of the ligamentum flavum was done caudally along with the superior edge of the caudal hemilamina. A careful medial facetectomy was performed enough to deroof the lateral recess and the foramen's entrance zone to decompress the exiting nerve root (Figure 4). At this stage, a discectomy could be performed if the bulging disc is one of the stenosing elements (Figure 5). The endoscope was then directed medially to visualize the volar surface of the spinous process which was undercut by the drill. The contralateral hemilaminae together with hypertrophied medial facet were partially resected after bilateral flavectomy. The nearly 2-3 cm incision was closed in layers by using Vicryl (Figure 6). All the patients had intramuscular NSAIDs injection for pain control on recovery from anesthesia; then they were given oral NSAIDs medications. Patients were instructed to wear a back brace for 6 weeks as a precautionary measure. Patients were encouraged to increase their activities one week after operation.

Follow-up:

Patients were followed-up at postoperative day one, 2 weeks, and then 3, 12, 24, and 36 months with mean 36.4±0.65 months (range, 36–38). Postoperative X-rays were reviewed for evidence of instability. Follow-up data were obtained from outpatient clinic follow-up visits by two independent physicians: before surgery, after surgery at day 1 (40 patients in hospital before discharge), 3 months (40 patients), 12 months (38 patients), and 24 months (37 patients), and at the final follow-up visit at 36 months (35 patients) (87.5 %). Five patients were lost for the following reasons: 2 surgery-unrelated deaths and 3 patients not attending the OPC follow-up visits.

Statistical Analysis:

All statistical analyses were carried out using the SPSS (Statistical Package of Social Sciences, Chicago, IL, USA) for Windows software program version 17.0. A P value of less than 0.05 was considered statistically significant. The results were expressed as mean±SD. One-sample *t*-test

was used to express the mean values of patients' characteristics. Paired-samples *t*-test was used to test for significant differences between baseline band and final follow-up measurements.

RESULTS

We analyzed only the results of the 35 patients out of total of 40 who completed 36 months of follow-up. The mean operative time was 88.5 ± 15.6 minutes (range, 65–130) (early 20 procedures, 118 ± 12.5 minutes, and the late 15 procedures, 70.6 ± 10.4 minutes). The mean estimated blood loss was 31.6 ± 15.1 ml (range, 20–40). The mean length of hospital stay was 12.46 ± 2.6 hours (range, 10–16). The mean wound size was 25mm (range 20–30 mm). The percentage of patients who received narcotic analgesics was 20% (7/35 patients). The mean time to resume the preoperative level of daily activities was 12.5 ± 2.6 days (range, 12–14) (Table 2).

By the end of the 36-month follow-up period, the relief of neurogenic claudicant leg pain was statistically significant. The mean NRS leg score significantly decreased from 7.3 ± 1.5 preoperatively to 0.8 ± 0.67 postoperatively ($P=0.001$). Again by the end of the 36-month follow-up and regarding LBP, in 14.3% (5/35) of the patients, LBP was not a preoperative problem and none of those 5 patients reported back pain during the follow-up period. In the other 30 patients it was shown that, in 16.7% (5/30) of these patients, the LBP improved, in 80% (24/30) of these patients there was no change in their level of back pain, and only in one patient (3.3%(1/30)) the pain was worse than before operation and patient was referred to the pain clinic. The NRS of low back pain insignificantly changed from 3.8 ± 0.75 to 3.9 ± 0.74 postoperatively ($P=0.865$) (Table 3 and Table 4).

The disability improvement was statistically significant and the mean ODI score significantly decreased from 72.34 ± 4.6 % before operation to 13.71 ± 3.46 % at final 36-month follow-up ($P=0.001$) (Table 3).

According to McNab criteria, the overall results were good to excellent in 85.7 % (30/35) of the patients, who reported high satisfaction and reported that they would have the endoscopic procedure again if offered to them; the rest of the results were fair in 5.7 % (2/35) and poor in 8.6% (3/35). If the excellent and good categories were regarded as successful and fair and poor were considered failures, the total success rate of the endoscopic fenestration was 85.7 % at the end of the 36-month follow-up period (Table 5).

The postoperative lumbar dynamic (flexion-extension) radiographs showed no evidence of instability in all of the 35 patients who were operated upon (Figure 7). Postoperative MRI of one of our patients showed the minimal amount of fibrosis in the multifidus paraspinal muscles (Figure 8).

There were no serious complications such as nerve root injury, cauda equina syndrome, spondylodiscitis, or deep vein thrombosis. Dural tears were encountered in 2 patients (5.6 %) and were managed using Surgiseal and tailored patch from dorsolumbar fascia without residual postoperative CSF leakage. Transient postoperative dysesthesia developed in one patient (2.8 %). Transient urinary retention developed in one patient (2.8 %). One patient (2.8 %) had superficial wound infection.

During the follow-up period, 3 patients (8.6%) underwent reoperation; two patients underwent repeated decompression at previously operated levels due to residual stenosis or restenosis and one patient for recurrent disc herniation at the operated level. The patients partially recovered after repeat surgery but remained in the poor outcome group during the long-term follow-up.

Table 1. Patients characteristics.

Parameters	Values
Patients no.	35
Age (year)	58.8±4.9 (range, 45–66) *
Sex (male/female)	18/17
Duration of symptoms (month)	17.8±3.7 (range, 16–19)*
Decompressed levels	
-L2-3	1
-L3-4	6
-L4-5	25
-L5-S1	3
Mean follow-up (month)	36.4±0.65 (range, 36–38)*

*Assessed by one-sample *t* test

Table 2. Objective outcomes parameters.

Parameters	Values*
-Operative time (min)	88.5±15.6 (range, 65–130)*
-Early 20 patients (min)	118.0±12.5
-Late 15 patients (min)	70.6±10.4
-Blood loss (ml.)	31.6±15.1 (range, 20–40)*
-Hospital stay(hrs)	12.46±2.6 (range, 10–16)*
-Patients received analgesics	20%(7/35)
-Time to resume preoperative daily activities (day)	12.5±2.6 (range, 12–14)*

*Assessed by one-sample *t*-test.

Table 3. Subjective outcomes measures (pain and disability) of patients after endoscopic fenestration.

Parameters	Preoperative	Final postoperative	Differences in group (95% CI)	P value*
NRS of back pain	3.8±0.75 (range, 3–5)	3.9±0.74 (range, 3–5)	0.685±0.17	0.865
NRS of leg pain	7.3±1.5 (range, 7–10)	0.8±0.67 (range, 1-2)	6.45±1.77	0.001
ODI	72.34±4.6 % (range, 60–90)	13.71±3.46 % (range, 9–25)	58.6±4.2	0.001

*Assessed by paired-samples *t*-test (NRS= Numerical Rating Scale, ODI= Oswestry Disability Index, and CI= confidence interval; the mean ODI score is multiplied by 2 to give the mean disability score which is expressed in the table. Difference in group is expressed as the difference between preoperative and postoperative means values at the end of follow-up period).

Table 4. Neurological functions outcomes at the final interview (36 months).

Parameters	Preoperative	Final postoperative
Leg numbness (improved)	77.14% (27/35)	96.3% (26/27)
Leg Weakness (improved)	51.4% (18/35)	61.1% (11/18)
Back pain (improved)	85.7% (30/35)	16.7% (5/30)
Back pain (unchanged)		80% (24/30)
Back pain (worsened)		3.3% (1/30)

Table 5. McNab criteria.

Parameters		Two-week postoperative	At final interview
McNab criteria	Excellent and good	34.3% (12/35)	85.7 % (30/35)
	Fair	65.7% (23/35)	5.7 % (2/35)
	Poor	0% (0/35)	8.6%(3/35)

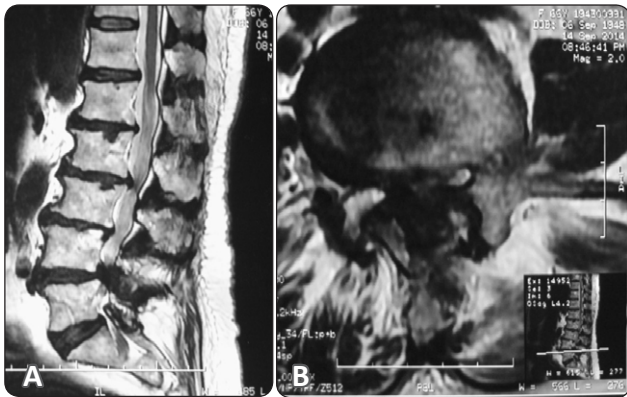


Figure 1. MRI of a patient with severe degenerative lumbar spinal canal stenosis. (A) Sagittal T2 MRI view showing stenosis at L4-5 disc level. (B) Axial view shows hypertrophied ligamentum flavum and facets that almost close the spinal canal.

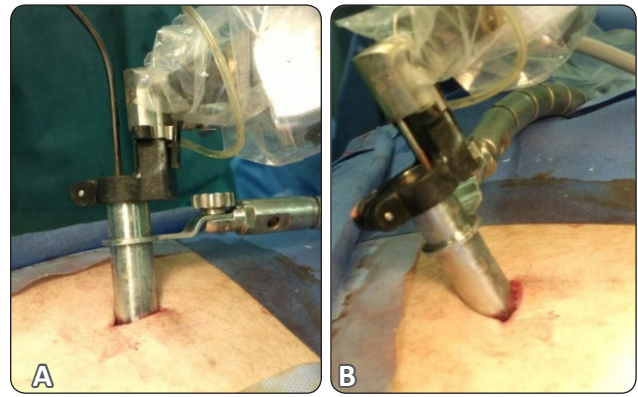


Figure 2. Endoscopic fenestration: note the angle of the tubular retractor to decompress midline and contralateral structures.



Figure 3. Endoscopic fenestration: surgeon looking at the monitor that is mounted over the tower which carries the video integrator and the light source.

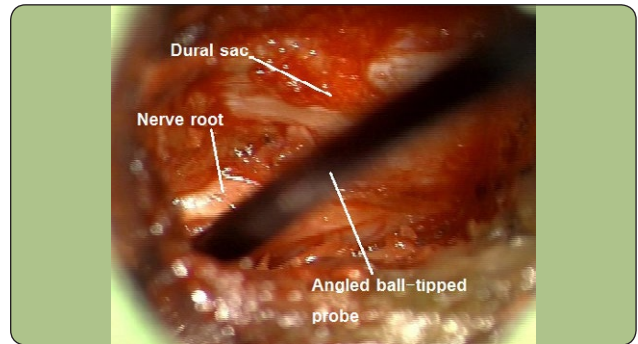


Figure 4. Endoscopic view: passing the angled ball-tipped probe through the intervertebral foramen to ensure nerve root decompression.

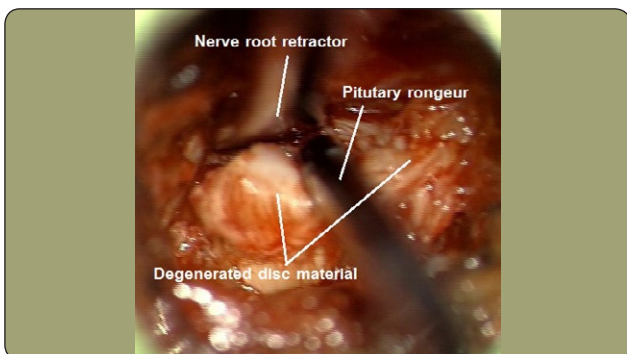


Figure 5. Endoscopic view: using the pituitary rongeur and nerve root retractor during the discectomy step of the decompression procedure.



Figure 6. Surgical wound length after endoscopic fenestration.

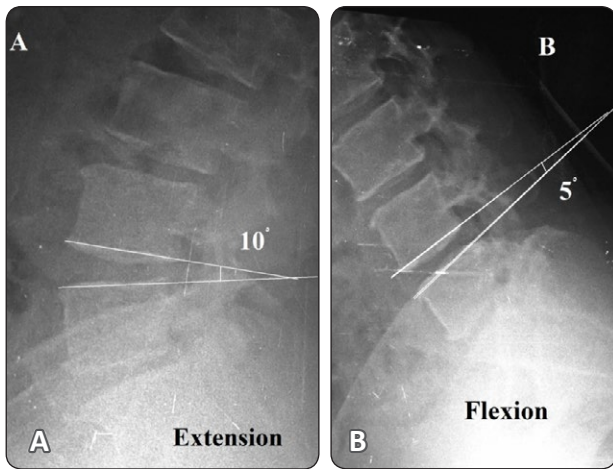


Figure 7. Postoperative dynamic views of one of our patients. (A) The intervertebral angle is 10 degrees in extension and (B) 5 degrees in flexion. There was no anteroposterior translation and the change in angulation angles between the flexion and extension is less than 10 degrees which indicated the preservation of the motion segment stability.

DISCUSSION

The results of standard surgical decompression of lumbar spinal canal stenosis in which wide laminectomy and partial or complete facetectomy were performed without fusion were generally disappointing.^{16,18,19,41} Getty et al.¹⁰ in 1981, introduced conventional open unilateral and bilateral laminotomy for decompression of LCS as a less invasive surgical option with comparable results reported since then and ranging from 59% to 84% improvement rates.^{2,29,30,34,42} Only few series^{35,37,41} have directly compared open laminotomy with open laminectomy. Several studies^{1,2,20,22,31,33,38} have shown benefits of spinal endoscopic fenestration, including decreased blood loss, shorter operative time, shorter hospital duration, decreased postoperative narcotic requirement, decreased rate of infection and CSF leak, and a decrease in time required for returning to work.

In the present study, the overall results were good to excellent in 85.7% of our patients and remained unchanged at 3 years postoperatively. None of

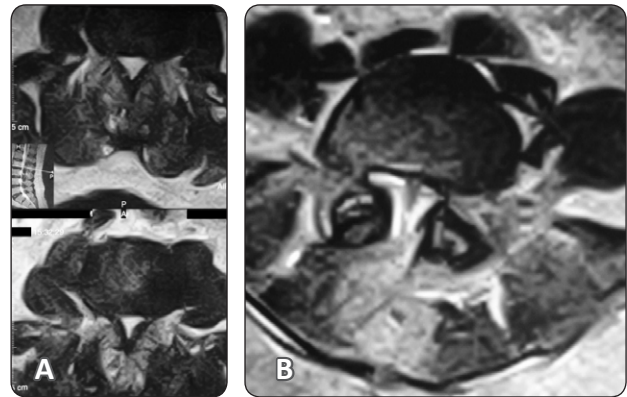


Figure 8. (A) Preoperative MRI T2 axial view showing spinal canal stenosis also with thick ligamentum flavum. (B) MRI T2 axial view (one-year after endoscopic fenestration) showing the amount of decompression bilaterally through a unilateral portal with preserved facet joints with excellent clinical outcome.

our patients had reoperation for instability and there was no reported de novo spinal instability on follow-up postoperative dynamic lumbar radiographs in any of our patients. Our results concurred with Palmer et al.,³³ in prospective clinical series of 8 patients. They utilized the surgical microscope and tubular retractor system in microscopic fenestration for lumbar spinal canal stenosis associated with spondylolisthesis with 88% excellent outcome with no increase in the degree of spinal instability on postoperative dynamic lumbar radiographs in all patients. Their mean operative time was 92 minutes, and the mean estimated blood loss was 33 ml. In our study, the mean operative time was 88.5 ± 15.6 minutes (range, 65–130) (early 20 procedures, 118 ± 12.5 minutes, and the late 15 procedures, 70.6 ± 10.4 minutes). The mean estimated blood loss was 31.6 ± 15.1 ml (range, 20–40). Our results were also comparable to Oertel et al.³² in a retrospective clinical follow-up study analyzing the results of the unilateral microscopic technique for lumbar spinal canal stenosis, and had 94 (92.2%) of the 102 patients available by the end of the 4-year follow-up period improved. In 2014, Henky et

al.¹² in a prospective study of 62 patients, reported a mean operative time of 68.9 min and a mean estimated blood loss of 47.4 ml.

In healthy persons, it is believed that the paraspinal muscles, especially the multifidus muscle, play a key role in stabilization of the spine.²⁸ Stripping, dissection, and excessive cauterization and retraction of the multifidus are quite likely to tether the medial branch of the dorsal ramus, with subsequent risk of muscle denervation.⁴ Elderly patients who have already weak atrophied back muscles are more liable for this problem. We refer the excellent outcome of our patients and their highly satisfactory level to the minimally invasive and the preservative nature of the endoscopic fenestration procedure not only to the paraspinal muscles but also to the posterior osteoligamentous complex. We used a muscle-splitting approach with sequential dilators and a 1.8 cm working channel that preserved the integrity of the paraspinal muscles, especially the lumbar multifidus muscle and the short rotators, whereas in the open procedures a muscle stripping approach was used with a longer skin and fascia incision.

Other studies^{39,40} proved long-term changes in electromyographic studies of the paraspinal muscles for as long as 4 years after surgery. Moreover, the end result of stripping of the paraspinal muscles is the formation of mechanically ineffective dense fibrous tissue. Consequently, the segmental instability increases and causes a postoperative mechanical LBP ranging from 11% to 15%.^{17,23} Postoperative isokinetic strength and endurance tests after open muscle-stripping procedures revealed that there is atrophy associated with decrease in muscle strength of the paraspinal muscles.²⁷ Postoperative radiological evidence (postoperative spinal CT or MRI) of paraspinal muscle atrophy was beyond the scope of our study and the reason why we did not use postoperative spinal CT or MRI scans routinely to assess the amount of decompression is that the amount of radiologically confirmed decompression is poorly correlated to the surgical outcome.^{13,14} In our study, we depended mainly on the clinical outcome of our patients.

Excellent to good outcome was reported in 85.7% of our patients and these results remained stable throughout the follow-up period. Five patients (14.3%) who reported no preoperative mechanical LBP reported no postoperative mechanical LBP, five patients (14.3%) reported improvement in their LBP, twenty-four patients (68.5%) reported no change in their level of mechanical LBP, and only one patient (2.8%) rated the pain as worse and was referred to the pain clinic. The mean back pain insignificantly increased from 3.8 ± 0.75 to 3.9 ± 0.74 postoperatively ($P=0.865$). Our explanation for these results is that after decompression of the neural elements the neurogenic claudication leg pain completely vanished, leaving the preoperative level of the mechanical LBP due to degenerative spondylotic changes plus the procedural pain. Therefore, the less invasive the surgical procedure, the less postoperative the LBP felt by the patients.

The incidence of complications in our study was 14%. Incidental durotomy was the most serious (5.6%) among complications. This event may be due to excessive traction on the dura during decompression of the contralateral side. Overall complications were minor and comparable to or even less frequently encountered than those complications reported by others.^{3,9,11,22,26,30-33,38,42} In our study, the 8.6% incidence of reoperation for residual or restenosis at operated levels and recurrent disc herniation were close to or lower than the average of values reported in the literature.^{9,12,15,30,32,37,42}

Palmer et al.³³ in their prospective clinical series of 8 patients, utilized the surgical microscope and tubular retractor system in microscopic fenestration for lumbar spinal stenosis reported only one durotomy (12.5%) that was covered with Gelfoam. In our study, there were no serious complications such as nerve root injury, cauda equina syndrome, spondylodiscitis, or deep vein thrombosis. Dural tears were encountered in 2 patients (5.6%) and were managed using Surgiseal and tailored patch from dorsolumbar fascia with no postoperative CSF leakage. In 2014, Henky et al.¹² reported the results of 62 patients with canal stenosis treated with unilateral laminotomy for bilateral decompression. They reported

accidental durotomy in 3.2% and wound infection in 2% of their patients. In a retrospective study of 102 patients by Oertel et al.³² the incidence of complications was 9.8% with reoperation reported in 7 patients for restenosis and in 2 patients for spinal instability.

One of the shortcomings of our study is the relative small number of patients in both groups as large number of patients magnifies the outcome parameters. This is maybe due to the strict following of the inclusion criteria for enrollment of patients in this study. Another shortcoming is the absence of a controlled group that would have suboptimal outcomes proven in the literature by several studies.^{16,18,20,41} We did not like to offer our patients a procedure we believe would be suboptimal and not up to date. However, a 36-month follow-up that allowed observation of persistence of the initial good out-come and the prospective nature, the homogeneity of patient population, and the independent observers are strengths points of the current study.

CONCLUSION

Endoscopic fenestration is a safe and effective technique in patients with degenerative lumbar stenosis. It allows adequate decompression of the neural elements and preserves spinal stability.

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العنوان العربي

النوفذة بالتنظير الداخلى كحل جراحي لضيق القناة العصبية الفقارية القطنية التنكسي أحادى المقطع المتحرك.

البيانات الخلفية : تطورت مؤخرًا جراحات التدخل المحدود (النوفذة بالتنظير الداخلى) لتصبح الحل الجراحي المعياري الحديث لضيق القناة العصبية الفقارية القطنية التنكسي.

الغرض: كان الهدف من هذه الدراسة هو التحقيق في سلامة وفعالية النوفذة بالتنظير الداخلى كحل جراحي لضيق القناة العصبية الفقارية القطنية التنكسي.

تصميم الدراسة: تم علاج خمسة وثلاثون مريضًا على التوالي بواسطة النوفذة بالتنظير الداخلى باستخدام نظام تنظير داخلى متعدد الموسعات المتتابعة (METRx) وخضعوا للمتابعة لمدة 3 سنوات. وشملت بيانات النتائج الأولية : مقياس التصنيف العددي (NRS) للآلام الظهر والساق و مؤشر أوزويستري للعجز ODI لتحديد حجم الألم والعجز على التوالي. تضمنت النتائج الثانوية الوقت المستغرق لأتمام الجراحة وكمية الدم المفقود أثناء الجراحة و الأشعة الديناميكية القطنية قبل الجراحة وبعدها بثلاثة اشهر ومعايير ماكناب المعدلة McNab

المرضى و الطرق: تم علاج المرضى بواسطة النوفذة بالتنظير الداخلى باستخدام نظام تنظير داخلى متعدد الموسعات المتتابعة (METRx)، في قسم تقويم العظام التابع لجامعة الزقازيق مصر في الفترة ما بين مايو 2013 و يونيو 2015 ، وتم إجراء آخر زيارة متابعة في يوليو 2018. تم فقط تضمين المرضى الذين أكملوا 36 شهرًا من المتابعة في التحليل النهائي لهذه الدراسة. تم تنفيذ جميع العمليات من قبل الباحثين الذين لديهم خبرة كبيرة في تقنيات التنظير الداخلى للعمود الفقري. تم الحصول على بيانات المتابعة من زيارات متابعة المرضى بالعيادات الخارجية من قبل أطباء مستقلين عن الدراسة.

النتائج: لم تكن هناك مضاعفات خطيرة مثل إصابة جذر العصب ولا متلازمة الضغط على الاعصاب القطنية والعجزية (cauda equina syndrome) ولا الالتهابات التقيحية بالفقرات او الغضروف ولا تخثر الدم بأوردة الساقين. في المتابعة النهائية ، كان التحسن في آلام الساق والإعاقة مهمًا من الناحية الإحصائية ، ولم يؤثر إجراء النوفذة بالتنظير الداخلى على ثبات الفقرات القطنية. بلغ معدل النجاح الإجمالي بأمثياز 85.7% ، و 5.7% عادلة ، و 8.6% ضعيف.

الاستنتاج: فى الايادى ذوات الخبرة العملية تصبح تقنية النوفذة بالتنظير الداخلى آمنة وفعالة لعلاج مرضى ضيق القناة العصبية الفقارية القطنية التنكسي لأنها تسمح بإزالة الضغط الكافي للعناصر العصبية والحفاظ على استقرار العمود الفقري في شريحة الحركة مع نتائج ممتازة.