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RESEARCH ARTICLE

OUTCOME AFTER SURGICAL INTERVENTION FOR LIGAMENTOUS LUMBAR CANAL STENOSIS: NON-RANDOMIZED COMPARISON OF CONVENTIONAL LAMINECTOMY AND BILATERAL FENESTRATION

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Glossary of Abbreviations:

CT: Computerized tomography
LBP: Low back pain
LCS: Lumbar Canal Stenosis
LSS: Lumbar Spinal Stenosis
ODI: Oswestry Disability Index
VAS: Visual Analogue Scale
MRI: Magnetic Resonance Imaging
PVMs: Para Vertebral Muscles
RCT: Randomized Controlled Trail

ABSTRACT

Background: Decompression through different fenestration techniques may effectively reduce unnecessary tissue damage, and therefore, decrease the incidence of the complications. The use of the surgical microscope or magnification loupe helped a lot to improve outcomes with such techniques. **Methods:** This study included 40 Adult patients with ligamentous lumbar canal stenosis in the period from July 2015 to August 2016. Patients had either laminectomy or bilateral fenestration. The main outcome measure was pain intensity (Back pain and Leg pain) over a twelve-month period. Other outcome measures included: Duration of operation and length of hospital stay. **Results:** There was statistically significant difference in the postoperative intensity of leg pain and low back pain between both groups after 12 months, with lower pain intensity in the bilateral fenestration group. Also, there was a statistically significant improvement in *leg pain* and low back pain in favors of the bilateral fenestration group **Conclusion:** Bilateral fenestration would provide relief of symptoms in cases of ligamentous lumbar canal stenosis, with less tissue damage and functional preservation of the spine in comparison to lumbar laminectomy.

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INTRODUCTION

One of the most useful definitions of Lumbar canal stenosis since its description, is "a disproportion in the spinal canal between the size of the neural elements and the space available." Compression of the neural elements cause pain and neurological symptoms (Arbit, 2017; Hoh, 2010; Garfin, 2000). It can be either central or lateral stenosis (Lohman, 1976; Coric, 1997). There are three morphological variations of the spinal canal: a round canal, an ovoid canal, and a trefoil canal (Alvarez *et al*., 2017; Lee, 2014; Botwin, 2003; Cinotti, 2002). Symptoms of lumbar canal stenosis would include: back pain, lower limb pain (neurological claudication pain or sciatic pain), weakness and incontinence, Different theories had been used to describe such pathology (Alvarez, 2017; Patel, 2015; Sasai *et al*., 2008; Sobottke *et al*., 2009). The aim of surgical intervention in such cases is relief of symptoms by adequate decompression of the neural elements while preserving as much of the biomechanical function of the lumbar spine**,** the extent of decompression should be determined per each affected anatomical site (Palmer *et al*., 2002). Decompression through different fenestration techniques may effectively reduce unnecessary tissue damage, and therefore, decrease the incidence of the complications. The use of the surgical microscope or magnification loupe helped a lot to improve outcomes with such techniques (Guiot *et al*., 2017). Microdecompression of nerve roots have been reported in cases of discogenic canalstenosisinstead of laminectomy for the sake of preserving more biomechanical function of the lumbar spine (Colak *et al*., 2008; Young *et al*., 2017; Tai *et al*., 2008).

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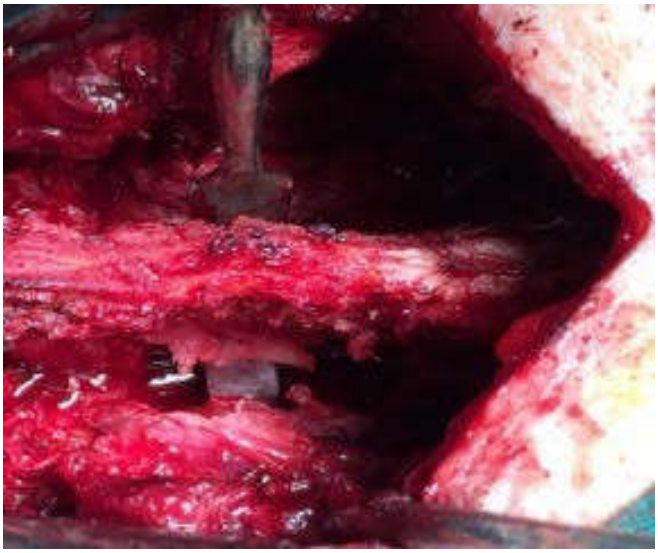

Figure 1. Shows the dissector passing through the bilateral fenestration bony work in one of our cases

In this study, we present our experience with bilateral fenestration for decompression of both nerve roots in cases of ligamentous lumbar canal stenosis in comparison to conventional laminectomy.

Patients and Methods

This study included 40 Adult patients with ligamentous lumbar canal stenosis in the period from July 2015 to August 2016. Patients had either laminectomy or bilateral fenestration. All patients were exposed to thorough preoperative examination and counselling. Data collection started upon approval of our institutional ethical committee for the study. Patients included in the study we also exposed to preoperative radiological examination was done in the form of Plain X-rays Lumbo-sacral spine, A-P and lateral views together with lateral dynamic (flexion and extension) views to discover translator instability in the main segment as well as in adjacent segments. Magnetic Resonance Imaging (MRI) was done for all patients preoperatively to demonstrate any impingement on the spinal canal, lateral recess and/or foramen from ligamentum flavum hypertrophy, facet joints hypertrophy or disc herniation.

For the bilateral fenestration group, bilateralforaminotomies and resection of the ligamentum flavum were done to decompress the canal and the nerve roots with undercutting of the spinous process. Preservation of the spinous process, supraspinous and interspinous ligament was planned, although partial facetectomies or segmental resection of the supraspinous and interspinous ligaments between the two spinous processes were needed in some cases (severe central stenosis), with or without discectomy. Surgical Microscope or loop were used for Magnification Fig 1 For the laminectomy group removal of the lamina, supraspinous and interspinous ligaments was done with bilateral roots decompression via foromonotomy with partial facetectomy if needed.

Post-operative Management included

Clinical evaluation: Postoperative clinical evaluation was done for all patients through the Visual Analog Score (VAS) and Oswestry Disability Index (ODI) at 6 weeks, 6 months and one year (in most cases).

Radiological evaluation: Postoperative Plain X-rays were obtained in the second day postoperative, then after 6 months. Postoperative CT was done in most of cases to assess the extension of bony work. MRI was done only for the patients with residual pain or those showed no improvement.

Statistical Methodology: Chi-square tests and analyses of variance were used to compare the baseline characteristics of the cases between the two treatment groups. Age was analyzed as a discrete variable while sex, was categorized as male/female. The main outcome measure was pain intensity (Back pain and Leg pain) over a twelve-month period. Other outcome measures were: Duration of operation, length of hospital stay, and complications [dichotomized as present/absent)]. The overall effectiveness of the treatment was assessed as using ODI. The mean improvement in pain amongst the treatment groups were first compared with an analysis of variance followed by multiple comparisons tests based on the Bonferroni method. Multiple linear regressions weren't used to analyze the effect of the treatment since there were no statistically significant baseline characteristics. Statistical significance was set at a probability value (p-value) less than 0.05.

RESULTS

Preoperative analysis of pain on the VAS for the back pain and lower limbs pain in both groups showed that the mean VAS for low back pain in Laminectomy group was 5.9±1, and was 6.1±0.9 in bilateral fenestration group. The mean VAS for lower limb pain was 8.4±0.6 in both groups. The P-value was > 0.05 for both, so there weren't any significant differences in the clinical presentation between the laminectomy and the Microdecompression groups making our cohorts comparable. The blood loss in the Laminectomy group ranged from 350 cc to 200 cc with mean 253.5, while in the bilateral fenestration group ranged from 100 cc to 300 cc with mean 210. There was a significant difference in the mean blood loss between the both groups of the study with a P-Value= 0.01 (<0.05). The operative time in the laminectomy group ranged from 98 min to 140 min with mean 121, while in the bilateral fenestration group ranged from 100 min to 185 min with mean 124.9. Statistical analysis showed that there was no significant difference in the operative time between both groups in our study. P-Value = 0.45.

In laminectomy group: the preoperative VAS of *Low back pain* ranged from 4 to 7 with a mean of 5.85, while postoperatively, it ranged from 2 to 6 with a mean of 3.75. The mean change (improvement) on VAS (calculated by the subtraction of the postoperative VAS from the preoperative VAS) in low back pain was 2.1. In bilateral fenestration group: the preoperative (VAS) of *Low back pain* ranged from 4 to 7 with a mean of 6.05.Postoperative VAS ranged from 2 to 4 with a mean of 2.85. The mean improvement on VAS in low back pain was 3.2. There was statistically significant difference in the postoperative VAS of low back pain between the bilateral fenestration and laminectomy groups after 12 months (P-Value =0.0029). Also, there was a statistically highly significant difference in favors of the bilateral fenestration group regarding the improvement of the low back pain on the VAS(P- Value = 0.001)after 12 months follow up. In laminectomy Group: the preoperative VAS of *leg pain* ranged from 7 to 9 with a mean of 8.4, Postoperative VAS ranged from 1 to 6 with a mean of 3.35.

The mean change (improvement) on VAS (calculated by the subtraction of the postoperative VAS from the preoperative VAS) in leg pain was 5.05. In bilateral fenestration group: the preoperative VAS of *leg pain* ranged from 7 to 9 with a mean of 8.35, while postoperatively, it ranged from 1 to 4 with a mean of 2.35. The mean improvement on VAS in leg pain was 6. There was statistically significant difference in the postoperative VAS of leg pain between both groups after 12 months (P- Value =0.0028). Also, there was a statistically significant improvement in *leg pain* in favors of the bilateral fenestration group(P-Value = 0.0033). The Postoperative Hospital Stay in the laminectomy group ranged from 2 to 7 days with mean 3.35, while in the bilateral fenestration group ranged also from 2 to 7 days with a mean of 2.9. There was no significant difference in the postoperative hospital stay between the bilateral fenestration and laminectomy groups in our study. P-Value = 0.3. In laminectomy Group: the preoperative ODI ranged from 45% to 60% with a mean of 54.9%. Postoperative ODI ranged from 18% to 50% with a mean of 29.75%. The mean change of ODI (i.e. Pre ODI – Post ODI) was 25.15%. In bilateral fenestration group: the preoperative ODI ranged from 52% to 65% with a mean of 58.15%. Postoperative ODI ranged from 23% to 35% with a mean of 27.1%. The mean change of ODI (i.e. Pre ODI – Post ODI) was 31.05%. There was no statistically significant difference in the postoperative ODI between the bilateral fenestration and laminectomy groups after 12 months (P-Value =0.2).

DISCUSSION

For years, the surgical treatment of degenerative lumbar canal stenosis has been wide laminectomy, which allows decompression of the neural elements by deroofing the spinal canal. However, the success rate of this procedure is only about 64%, this has been attributed to local tissue trauma, and postoperative spinal instability, which has led to frequent surgical failures and dramatic increase in lumbar fusion surgery (Korovessis *et al*., 2004). Currently, there are several surgical approaches to correct lumbar spinal stenosis (LSS). Although conventional laminectomy for LSS has been routinely performed, this procedure involves the dissection of the bilateral paravertebral muscles (PVMs) that are detached extensively from the spinous process and laminae. In addition, the posterior midline ligaments, such as the supra- and interspinous ligaments, lose their original attachments when the spinous processes are removed.

Surgical damage to these important stabilizing structures may lead to postoperative segmental malalignment, instability, and subsequently failed–back surgery syndrome (Macnab, 1976; Sihvonen *et al*., 1993). To limit such a "not uncommon" postoperative clinic diagnosis, various authors have proposed more tailored and less invasive techniques in the treatment of degenerative lumbar canal stenosis. In particular, bilateral and unilateral laminotomy for bilateral decompression have been described (Tai *et al*., 2008; Thomé *et al*., 2005; Bresnahan *et al*., 2009; Watanabe *et al*., 2005). Our current study is a Non – randomized prospective comparative study. Reviewing the outcome of two comparable groups of patients, in group one, decompressive surgery was carried out in the form of laminectomy. In the second group, bilateral fenestration was done. However, no randomization took place and the decision for the way of decompressive surgery was up to the surgeon preference.

Postoperative pain: Our results showed a significant difference between the two treatment groups as regard postoperative VAS LBP, as the bilateral fenestration group showed a lower mean postoperative VAS compared to the laminectomy group (2.85± 0.6708204 Vs 3.75±1.069924). In addition, a highly significant difference was found regarding change in VAS LBP, with higher mean improvement among the bilateral fenestration group cases compared to the other group cases (3.2±0.60 Vs 2.1±1.3) that could be related in part to the less destruction of the spinous process and minimal bony work done. Back muscles provide most resistance to external load in stabilizing the lumbar spine. Detachment of these muscles from the spinous processes and vertebral arches with subsequent wide retraction has been associated with muscle denervation and atrophy. Additionally, the spinous processes and the interspinous ligaments act as a posterior tension band. Biomechanical studies have demonstrated that spinous processes and interspinous ligaments resist significant force towards the end of the range of flexion and provide a modest contribution to the force of back muscles during extension. Thus, minimizing disruption of back muscles and avoiding removal of spinous processes, vertebral arches and interspinous ligaments can possibly reduce muscle weakness, low-back pain, accelerated spondylosis and surgically induced instability (Bresnahan *et al*., 2009). In comparison to other studies, Gijsbert *et al* in 2015 conducted a Systematic review study comparing the effects of Laminotomy versus traditional decompressive laminectomy surgery for lumbar spinal stenosis. Regarding the postoperative VAS of back pain, based on 2 studies done on 223 patients, Thome *et al* in 2005 reported no statistically significant difference regarding improvement in back pain at rest, but back pain during walking favored participants treated with bilateral laminotomy. Postacchiniin 1999 reported a significant improvement in VAS back pain among participants treated with bilateral laminotomy compared with those who underwent conventional laminectomy (Thomé *et al*., 2005; Overdevest *et al*., 2015; Postacchini *et al*., 1999).

Based on Gijsbert *et al* Systemic review in 2015, regarding VAS of leg pain, theyconcluded that a statistically significant difference favored bilateral laminotomy, while Postacchinifound no statistically significant differences between treatment groups. Celik andFu compared leg pain VAS scores of participants undergoing bilateral laminotomy and conventional laminectomy. Between those who received bilateral laminotomy and laminectomy, very low-quality evidence shows a significant difference regarding VAS leg pain in favor of bilateral laminotomy or fenestration. Our study showed a significant difference between the bilateral fenestration and Laminectomy groups regarding postoperative VAS for leg pain, As the Mean Postoperative VAS Leg pain was lower in the bilateral fenestration group (2.35±0.81 Vs 3.35±1.1). In addition, a significant difference was found regarding change or improvement in VAS for leg pain among the bilateral fenestration cases compared to the other group cases (6±0.7 Vs 5.05±1.1). These results of our study suggest that bilateral fenestration achieved an efficient way for roots decompression that was comparable, or even better in some cases, to the effect of laminectomy (Overdevest *et al*., 2015; Çelik *et al*., 2010; Fu *et al*., 2008; Postacchini, 2017). In our study, there was no significant difference between Microdecompression and Laminectomy groups cases as regard postoperative ODI.

However, a highly significant difference was found regarding change in ODI (calculated as Pre-operative ODI – Postoperative ODI), with a higher mean change in favor ofbilateral fenestration group cases compared to the other group (31.05±2.6 Vs 25.15±7.9). A systemic review, included 3 studies on 139 patients, showed that there was no statistically significant difference regarding postoperative functional disability (Overdevest *et al*., 2015).

Blood loss: There was a statistically significant difference between the 2 study groups regarding intraoperative blood loss. Bilateral fenestration group showed lower mean blood loss than the Laminectomy group (210±60.78435 Vs 253.5±41.58378). One study comparing intraoperative blood loss among patients treated with bilateral laminotomy and those treated with conventional laminectomy did not report a statistically significant difference (Celik *et al*., 2010). However, Thome *et al*.and Yagi *et al*.did find a statistically significant difference in favor of unilateral laminotomy when compared with conventional laminectomy (blood loss 177 mL vs 227 mL and 37 mL vs 71 mL, respectively).[21,26,29]

Operation time: There was no significant difference between the 2 treatment groups in our study regarding operation time. However, the laminectomy group showed decreased duration of surgery in comparison to bilateral fenestration group. (124.9±21.6 Vs 121±11.4). This may be explained by the limited working space for decompression in the bilateral fenestration group which make these techniques technically demanding and depending on the surgeons' experience in this approach and the learning curve. There was no significant difference between both treatment groups regarding postoperative hospital stay in days, however there was a lower Mean Hospital stay in the bilateral fenestration group in comparison to the laminectomy group (2.9±1.3 Vs 3.35±1.4). Celik *et al* reported no significant difference regarding length of hospital stay after bilateral laminotomy (mean 2.2 days) compared with conventional laminectomy (2.3 days). The quality of evidence is low (only one high-quality Randomized Control Trial (RCT) with 71 participants (Çelik *et al*., 2010).

Complications: In our study, the rate of complications in the laminectomy group was higher in comparison to the bilateral fenestration group. It was about 30% in laminecomy, and 20% in Microdecompression. Based on Gijsbert *et al* Systemic review, all studies included in the review reported procedure-related complications. None of the studies reported procedure-related mortality, however, the most commonly reported complication of the surgical procedure was a dural tear. Between those who received bilateral laminotomy and those undergoing conventional laminectomy, low- quality evidence shows no significant differences regarding cumulative incidence of complications (three RCTs, 303 participants) (Overdevest *et al*., 2015).

Postoperative instability: One case developed post-operative instability in the laminectomy group of our study, patient presented after one year with worsened back and leg pain. Plain x-rays showed spondylolisthesis grade 1. Fixation with transpedicular screws was done. However, our follow up end-point was 1 year which would not be enough to answer the possibility of instability. Yang *et al* (2013) reported 9 cases (9, 7%) of spondylolithesis over 2 year follow up after performing laminectomy on 92 cases with degenerative lumbar canal stenosis (Chen *et al*., 2007).

Dural tear: Three cases had intraoperative dural tear that was repaired by stitches. Two cases showed no C.S.F collection or leak, while one case developed C.S.F leak and lumbar drain was inserted.Dural tear occurred in one case of Microdecompression during central decompression. Laminectomy was needed for better visualization and dura was repaired with stitches. It is worth mentioning that this case was included in the laminectomy group during the follow up period. Authors reported (Thomé *et al*., 2005; Çelik *et al*., 2010) in some studies a significantly lower incidence of incidental dural tear in the bilateral fenestration group compared with the laminectomy group (1/37 vs 7/34 and 2/40 vs 8/40, respectively).

Conclusion

Bilateral fenestration would provide relief of symptoms in cases of ligamentous lumbar canal stenosis, with less tissue damage and functional preservation of the spine in comparison to lumbar laminectomy. Patients with bilateral fenestration had less back pain or lower limb pain and hence less sick day leaves in relation to others who received laminectomy.

Conflict of interest statement: We the authors of this article have no conflict of interest related to this submitted article entitled "Outcome after surgical intervention for ligamentous lumbar canal stenosis: Non-Randomized comparison of conventional laminectomy and bilateral fenestration."

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