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Evaluation of wide interlaminar fenestration surgery in degenerative lumbar canal stenosis

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Abstract
Background: With the increasing longevity of population and a continually climbing proportion of middle-aged and elderly persons, the problem of lumbosacral spine is a significant health care issue, causing backache and Neurogenic claudication**.**
Methods: Thirty patients with degenerative lumbar canal stenosis were included in study and wide interlaminar fenestration with or without discectomy was carried out**.** Patients were followed and analysis of the outcome was done for improvement in pain, neurological improvement and improvement in claudication distance**.**
Results: Diagnosis of degenerative lumbar canal stenosis were made by clinical examination and confirmed by measuring neural canal diameter in MRI**.** Patients were selected randomly and total 30 patients included in study with mean age of 45.9 year and with mean duration of symptom was 38**.**67 months**.** Wide interlaminar fenestration was done at two level (L4-5, L5-S1) in 9 patients and at one level in remaining 21 patients (L4-L5 in 12 and L5-S1 in 9). All the patients improved in terms of back pain, sensory and motor symptoms including neurogenic claudication**.**
Conclusion: At the end of our study we find that Wide Interlaminar fenestration done in degenerative lumbar canal stenosis provides not only full resolution of neurological symptom but also maintains spinal stability at the same time**.**

Keywords: Lumbar canal stenosis, Neurogenic claudication, Interlaminar Fenestration

Introduction
Lumbar spinal canal stenosis is defined as an anatomical or functional narrowing of the osteo-ligamentous vertebral canal and/or intervertebral foramina causing direct compromise of the dural sac, the caudal nerve roots and their vasculature enough to cause symptoms or signs [1]. It is a clinical syndrome of backache, buttock or leg pain with characteristic provocative and palliative features [2].
Lumbar spinal stenosis can be classified on the basis of either aetiology or anatomy. The etiological classification distinguishes congenital or developmental stenosis from acquired or degenerative spinal stenosis [3]. Congenital or developmental stenosis is due to either idiopathic narrowing of the spinal canal or developmental narrowing secondary to a bone dysplasia such as chondroplasia. Acquired or degenerative stenosis may occur as a result of an underlying metabolic disorder such as Paget disease, a tumour, an infection, post traumatic osteoarthritic changes, or instability with spondylolisthesis following previous operation, disc prolapse, *Ligamentum flavum* hypertrophy and facetal hypertrophy compromising the dural sac. Degenerative lumbar spinal canal stenosis is prevalent in the age group of 30–70 years and commonly seen in 40-50 years of age group [3]. Out of these types acquired degenerative spinal stenosis is most common. This is further subdivided into central, peripheral and degenerative spondylolisthesis types.
Central spinal stenosis denotes involvement of the area between the facet joints, which is occupied by the dura and its contents. Stenosis in this region usually is caused by protrusion of a disc, bulging annulus, osteophyte formation, or buckled or thickened *Ligamentum flavum.* Symptomatic central spinal stenosis results in neurogenic claudication with generalized leg pain.

Lateral to the dura is the lateral canal, which contains the nerve roots; compression in this region results in radiculopathy [19, 20]. The lateral recess, also known as "Lee's entrance zone," begins at the medial border of the superior articular process and extends to the medial border of the pedicle [4, 18].

Patient usually presents with back pain, claudication and leg pain which may or may not be associated with neurological deficit. Neurogenic claudication also known as pseudo-claudication is diagnostic of spinal canal stenosis. It is a clinical syndrome with symptoms of leg pain, paraesthesia and weakness that are associated with walking or standing. Symptoms relives on sitting or bending forwards.

Therapy for lumbar spinal canal stenosis remains difficult. Conservative treatment is by physiotherapy, anti-inflammatory drugs and the use of a lumbar corset [5, 6, 7, 8]. Conservative management is limited and not satisfactory [5, 14]. Surgical procedures include decompression, decompression and fusion with or without instrumentation. Decompression by total laminectomy is the gold standard treatment for the central canal stenosis in the lumbar region [9, 10, 11, 12]. It is critical that sufficient bone is removed to free the nerve roots, but the extent of decompression should be as small as possible, in order to prevent postoperative instability [16].

However, too limited a decompression can be accompanied by re-growth of bone that affects the long term results. Also total laminectomy at multiple levels may result in instability of the spine [8, 12, 13] and restriction of movement in long term. Verbiest suggested that narrowing is due to encroachment by the articular process on the spinal cord and the laminectomy alone may not suffice without removal of the medial part of the articular facets [9, 15]. To maintain stability of spine and alternatives to total laminectomy, hemi laminectomy, laminoplasty and interlaminar fenestration have been advocated.

In our study, Wide Interlaminar fenestration surgery has been done to decompress the dynamic segment in degenerative lumbar canal stenosis. This is based on the fact that the central canal may be divided into a static and a dynamic segment. The static segment is the area at the level of the pedicles which is narrow only in primary canal stenosis [13]. The dynamic segment at the level of the *Ligamentum flavum* is narrowed in degenerative secondary canal stenosis. The decompression of the dynamic segment by the Wide Interlaminar fenestration technique consists of the removal of the hypertrophied *Ligamentum flavum* by minimal removal of the margins of the lamina, Chevron cut of under surface of spinous process with partial medial facetectomy if facetal hypertrophy was seen, preserving the posterior structures including the spinous process, and interspinous ligaments. Thus there is no instability of the spine and no need for any fusion or instrumentation, even if done at multiple levels.

The purpose of this study was to evaluate the clinical results of Wide Interlaminar fenestration technique in LCS which if favourable would expiate the requirement of laminectomy and its associated instability. Also there is no need of costly specialised instruments and the technique is less invasive than the conventional one *(*Hemi/total laminectomy*).*

Materials & Methods

Between June 2011 to May 2013, thirty patients of acquired degenerative lumbar canal stenosis were randomly selected from the OPD and patients were included in the study after taking consent from the patients and permission from Ethical committee. Study includes 18 males and 12 females with the range in the group was 30 years with the minimum age of 30 years to maximum age of 60 years with mean age group of 45.90 years.

Randomly selected patients have been evaluated in detail by clinical history and examination to confirm the lumbar canal stenosis & underwent a pre-op X-RAY and MRI assessment of cross section area of lumbar spine. The canal cross sectional area of 180 +/- 50 mm^2 is the normal range, while 100-70 mm^2 is considered as moderate stenosis. Canal cross section area less than 70 mm^2 is indicative of severe stenosis. (Fig. 1, 2)

Inclusion criteria*:* Patients of degenerative Lumbar Canal Stenosis*:* -

1. With or without lateral canal Stenosis *(*based on MRI findings*).*
2. With or without spondylolisthesis grade I.
3. Failure of conservative treatment for four weeks.
4. JOA score <15.

Exclusion criteria

1. Pure lateral canal Stenosis.
2. Patients with history of previous spine surgery.
3. Patients unfit for anesthesia.
4. Patients with severe chronic or co-morbid diseases and suspected malignancy.
5. Patients with peripheral neuropathies.
6. Patients with peripheral vascular disease.
7. Patients with spinal cord tumors.
8. History of acute spinal injury.
9. Kyphosis.
10. Scoliosis.
11. Spondylolisthesis grade II and III.
12. Geographic inaccessibility to follow up.
13. Patient who did not came in follow up.
14. The patient who refused to given consent for the study.

In our study, Wide Interlaminar fenestration surgery has been done to decompress the dynamic segment in degenerative lumbar canal stenosis. Multiple level interlaminar fenestrations with discectomy, if required, were carried out in all the patients. (Fig**.** 5, 6, 7 & 8)

All the patients were allowed to sit, stand and walk depending on amount of post-op surgical pain. None of patients have immediate or late onset of backache or restriction of spinal movement that indicates post-op spinal stability.

Thus there is no instability of the spine and no need for any fusion or instrumentation even if there is multiple level stenosis. This technique of spinal canal decompression with minimal surgical intervention is thus useful in the increasing geriatric population, who have associated co-morbidities, and cannot withstand extensive surgery with blood loss. The purpose of this study is to evaluate the clinical results of Wide Interlaminar fenestration technique in LCS which if favourable would expiate the requirement of laminectomy and its associated instability.

Patients were recalled for follow-up after two weeks from the day of surgery, then two months, at 6th month and then at one years for clinical and functional evaluation. Detailed history taking, clinical examination and relevant investigations if required any, has been performed and the results of surgery have been evaluated in the term of improvement of JOA score (Table I).

Joa score

The Japanese Orthopaedic Association score is a clinical symptom score and the same has been used in our study for the assessment of treatment.

Table 1: Pro-forma

Parameter	Finding	Points
Low back pain	none	3
	Occasional mild pain	2
	Frequent mild	1
	Occasional severe	1
	Frequent sever pain	0
	Continuous sever pain	0
Leg pain and/or tingling	none	3
	Occasional slight symptoms	2
	Frequent slight symptoms	1
	Occasional severe symptoms	1
	Frequent severe symptoms	0
	Continuous severe symptoms	0
Gait	Normal	3
	Able to walk > 500 meters although it results in pain, tingling and/or muscle weakness	2
	Unable to walk > 500 meters owing to leg pain, tingling and/or muscle weakness	1
	Unable to walk >100 meters owing to leg pain, tingling and/or muscle weakness	0
Straight leg raising test (includes a tight hamstring)	Normal (> 70^0)	2
	30^0 to 70^0	1
	< 30^0	0
Sensory disturbance	None	2
	Slight disturbance (not subjective)	1
	Marked disturbance	0
Motor disturbance	Normal (grade 5)	2
	Slight weakness (grade 4)	1
	Marked weakness (grade 0 to 3)	0
Turn over while lying	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Standing	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Washing	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Leaning forward	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Lifting or holding a heavy object	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Walking	No restriction	2
	Moderate restriction	1
	Severe restriction	0
Urinary bladder function	Normal	0
	Mild dysuria	-3
	Severe dysuria	-6

Where score ranges from minimum - 6 to maximum up to 29

Results

Male: Female ratio was 3:2

The mean duration of backache in the study group was 38.67 months. Pre-operative symptoms had lasted from 12 to 96 months. Overall, the maximum numbers of patients were presented with the history of backache of 0-24months duration (50%) with earliest of 12 months.

The mean age of the patients in the study group was 45.90 years. The range in-group was 30 years with the minimum age of 30 years to maximum age of 60 years. Overall, the maximum numbers of the cases were between the ages of 40-50 years (40%).

Pain corresponded to L5 nerve root in 12 patients (40%) while to S1 in 9 (30%) and both L5, S1 in nine patients (30%). Stenosis at two levels was seen in 9 patients. Wide Interlaminar fenestration was done at two levels in 9 patients.

The canal diameter was ranging from minimum of 0.79 cm to maximum of 1.01 cm at L4-L5 and 0.79 cm to 1.05 cm at L5-S1. The mean canal diameter at L4-L5 was 0.896 cm and at L5-S1 was 0.897 cm. The mean of canal diameter at all stenotic levels was 0.895 cm. (Fig 1, 2, 3, 4 showing comparison between pre and post-op MRI in sagittal and axial views)

Discectomy was done in 15 (50%) out of 30 patients. All of them had a significant disc prolapsed contributing in spinal canal Stenosis and to neurological weakness, which were

diagnosed on MRI Scan.

Pre-operatively, all 30 patients had low back pain and leg pain, which relieved completely in 29 patients but one patient has mild occasional back pain, while leg pain relieved completely in all patients at 1-year follow-up.

Straight leg raising test was positive in 12 patients within the range of 30 to 70 degrees, which was more than 70^0 in all at one year follow up.

The mean claudication distance in the study was 173.5 meters, with minimum of 50 meters and maximum of 380 meters. 40% of patients had claudication distance less than 100 meters while 30% had claudication distance in between 101-200 meters only 10% have claudication distance between 201-300 meters and only 20% have claudication distance between 301-400 meters. At the end of 1 year all the patients were able to walk >400meters without claudication. **(**Graph 1**)**

Pre operatively out of thirty, 15 patients had sensory disturbances. Three of them had marked sensory disturbance while other 12 had slight disturbances. At the end of one year only one (3.33%) patient had slight sensory deficit. (Graph 2)

Pre operatively 12 patients had slight motor weakness *(*grade 4 MRC*).* All these 12 patients had sensory disturbances also. One year after the surgery, none of the patient was having motor disturbances. (Graph 3)

In our study, subjective evaluation of the surgical outcome of the patients using Japanese Orthopaedic Association *(*JOA*)* score yielded excellent results in all. The mean pre-operative JOA score was 9.17. Post operatively the mean JOA score was 22.47 at 2nd week, 24.50 at 2 months, 26.50 at 6 months and 27.6 at one year follow up (Table II). The difference was significant ($p < 0.05$) using "Paired 't' test" (Table III)

Table 2: Joa score

	JOA pre-op	JOA post-op at 2 weeks	JOA post-op at 2 months	JOA post-op at 6 months	JOA post-op at 1 year
N	30	30	30	30	30
Minimum	7	20	23	25	26
Maximum	13	25	26	29	29
Range	6	5	3	4	3
Mean	9.17	22.47	24.50	26.5	27.6
Std. deviation	1.78	1.50	1.10	1.04	0.96
Median	9	22	24	26.5	27.5
Std. error of Mean	0.325	0.274	0.201	0.190	0.175

Table 3: Test Statistics

	JOA post-op at 2 weeks - JOA pre-op	JOA post-op at 2 months - JOA pre-op	JOA post-op at 6 months - JOA pre-op	JOA post-op at 1 year - JOA pre-op
Calculated t value	65.1	60.1	51.2	54.1
Table Value 't' at df=29 for p 0.05	2.0452	2.0452	2.0452	2.0452

Discussion

In our study the mean age was 45.90 years while the range was from 30-60 years. Lumbar canal stenosis most commonly affects the middle-aged and elderly population [1]. In a study on 90 patients by George *et al* [1], commonest age groups affected were 40-49 years.

In our study male*:* female ratio was 3*:*2. Males are affected with higher frequency than women [15].

In our study duration of symptoms was ranging from 12 months to 96 months with mean duration of 38.67 months. Study by George *et al* [1], the duration of symptoms was ranging from 3 months to 144 months.

In our study L4-L5 level was involved in 40% of cases and L5-S1 in 30% of cases while 30% had both L4-L5 and L5-S1 involved. According to Epstein the most common site is L4-L5 [21].

In our study the mean canal diameter at L4-L5 was 0.89 cm and at L5-S1 was 0.89 cm. the mean of canal diameter at all stenotic level was 0.89 cm. Weiner *et al* in their study suggested that there appears to be a relationship between severity of stenosis and outcomes of Decompressive surgery such that patients with a greater than 50% reduction in cross sectional area are more likely to have a successful outcome [24].

In our study there were 15 patients having a significant disc prolapse correlating neurologically with the associated lumbar canal stenosis. Discectomy was performed at all stenotic level in all of them. Kirkardly-Willis *et al* in a review article had drawn attention to the association of nucleus pulposus with degenerative and developmental stenosis [22].

In our study all the 30 patients had low back pain and leg pain preoperatively. Post operatively, occasional mild back pain in only one patients but no claudication in any patients. In a study the backache was the most important symptom which brought the patient to medical consultation followed by leg pain [1]. In a study by Kida [14], low back ache was present in 3 out of 70 patients treated with fenestration technique after 3 years of follow up while 26 patients out of 57 had low backache who were treated with extensive laminectomy, after 3 years of follow up.

Preoperatively the mean claudication distance in the study was 173.5 meters, with minimum of 50 meters and maximum of 380 meters. Postoperatively at one-year follow-up all the patients showed complete improvement in the claudication distance. In a study by George *et al*, on 90 patients, 44 out of 78 with neurogenic claudication showed improvement in claudication distance during the follow-up [1].

Preoperatively out of thirty, 15 patients were having sensory disturbances. Twelve patients had slight motor weakness (grade 4 MRC) all these 12 patient had sensory disturbance also. In all of these patients only one had persistent sensory involvement and motor weakness improved in all at one year follow up. In a study by George *et al*, study population had improvement in motor weakness. Sensory improvement was seen in the study population [1]. Motor deficit was less common than sensory [1, 3].

In our study, subjective evaluation of the surgical outcome by the patients using Japanese Orthopaedic Association (JOA) score yielded excellent results in all. The mean pre-operative JOA score was 9.17 which improved significantly to 27.6 at one year follow up. The difference was significant ($p < 0.05$)

using "Paired 't' test". In a series of 64 patients of lumbar canal stenosis due to degenerative spondylolisthesis the Japanese Orthopaedic Association (JOA) score increased from 14.9 points before operation to 25.4 points at the time of the study on average [23].

In our study, patients had significant improvement at the end of their one year follow up. However, the follow-up and study size were small. Long term follow-up is required.

Wide Interlaminar fenestration surgery has significant advantages compared to standard laminectomy technique for lumbar canal Stenosis. It was noted that Wide Interlaminar fenestration offered sufficient although minimal decompression, relieved the pain of root origin also (symptoms in the leg). Wide Interlaminar fenestration preserves spinal stability even if done at multiple levels on both sides for bilateral symptoms and signs.

In our study consistently good results are attributed to proper selection of patients by clinical examination, precise and early diagnosis on MRI scan, meticulous surgical protocol consisting of proper surgical position, adequate decompression and negative suction for draining the hematoma.

Surgical procedures include decompression, decompression and fusion with or without instrumentation. Decompression by total laminectomy is the gold standard for the central canal stenosis in the lumbar region [11, 17]. It is critical that sufficient bone is removed to free the nerve roots, but the extent of decompression should be as small as possible, in order to prevent postoperative instability. However, too limited decompression can be accompanied by re-growth of bone that affects the long term results. Also total laminectomy at multiple levels may result in instability of the spine. Preservation of the stable spine is of paramount importance because the relief of symptoms in the leg may not satisfy the patient if back pain develops or is made worse. Aryan and Ducker [16] and Nakai [17] *et al* reported that greatest advantage of multiple wide fenestration is that it preserves stability of spine.

Even after adequate decompression, the degenerative changes are known to continue, giving rise low backache. Therefore, it is important to inform the patients before surgery that they are may have some pains afterwards so that they are prepared psychologically and do have more balanced approach to their situation.

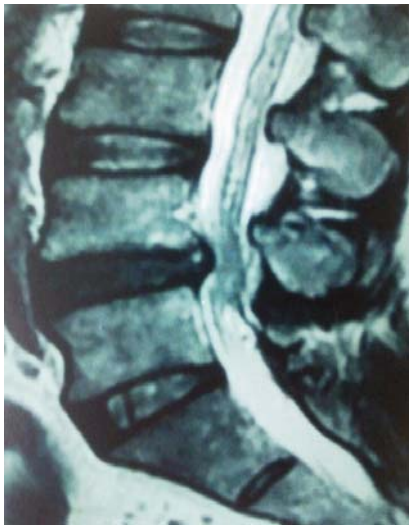


Fig 1: Pre-Op T2 Sagittal View - Showing Disc Prolapse L4-L5 with *Ligamentum flavum* Hypertrophy

Fig 2: Pre-Op T2 Axial View - Showing Disc Prolapse with *Ligamentum flavum* Hypertrophy

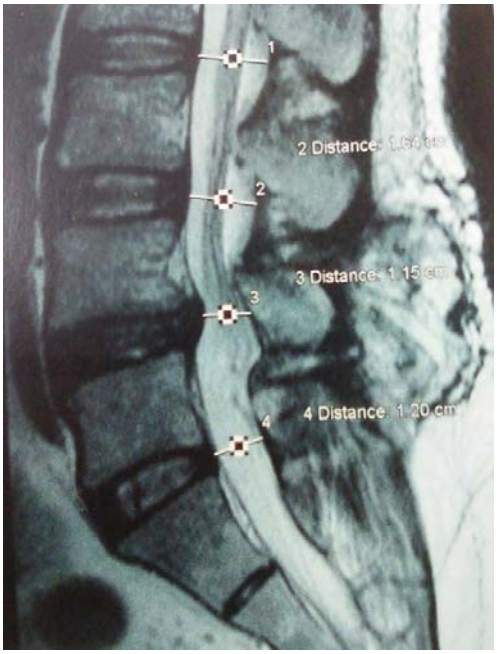


Fig 3: Post-Op T2 Sagittal View - Showing Widened Canal at L4-L5

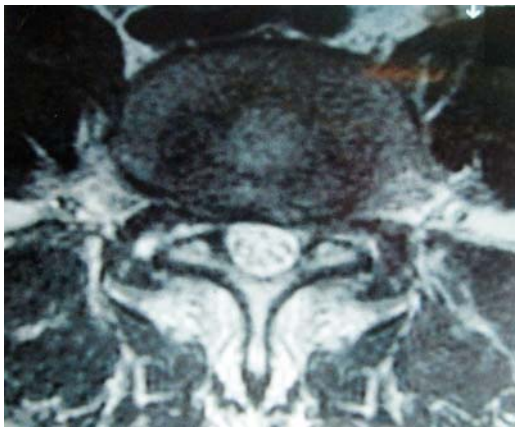


Fig 4: Post-Op T2 Axial View - Showing Widened and decompressed Canal at L4-L5

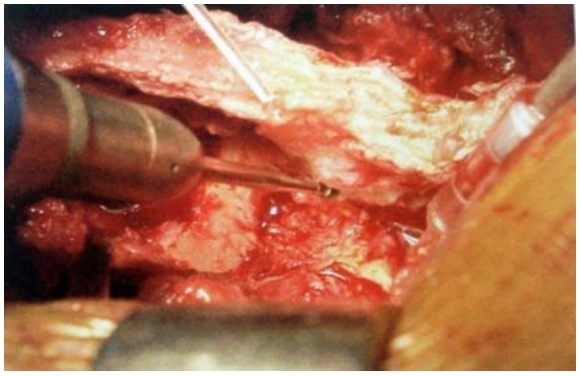


Fig 5: High speed burr being used to thin out the superior margin of the caudal lamina on left side at L4-L5 level of the stenosis to expose the *Ligamentum flavum*

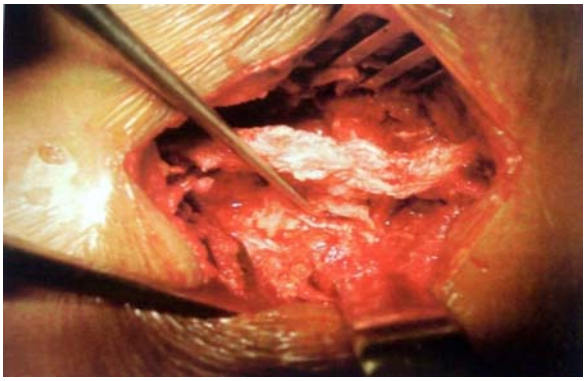


Fig 6: *Ligamentum flavum* being dissected from underlying dura with Watson Cheyen on left side at L4-L5

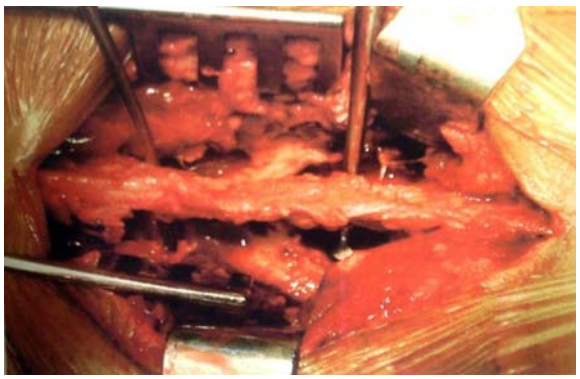


Fig 7: Two level decompression done at L4-L5 and L5-S1 and instruments being passed across the midline below the spinous process

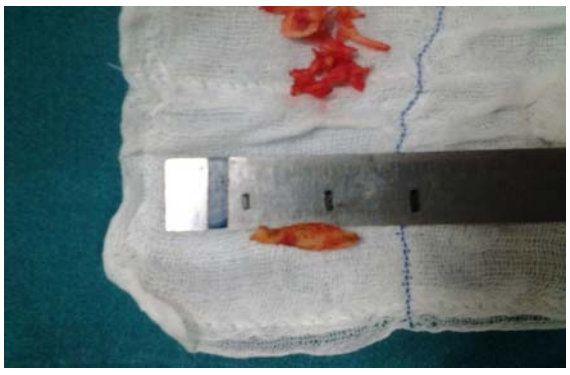
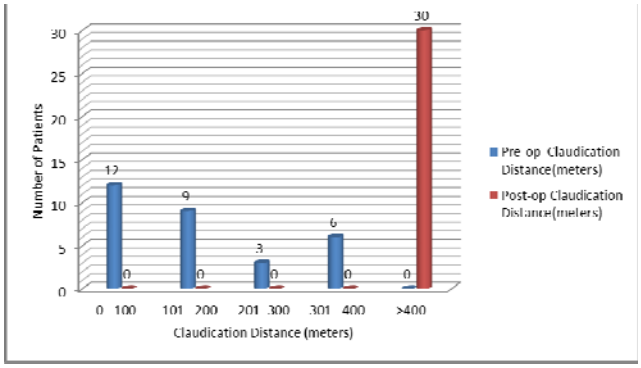
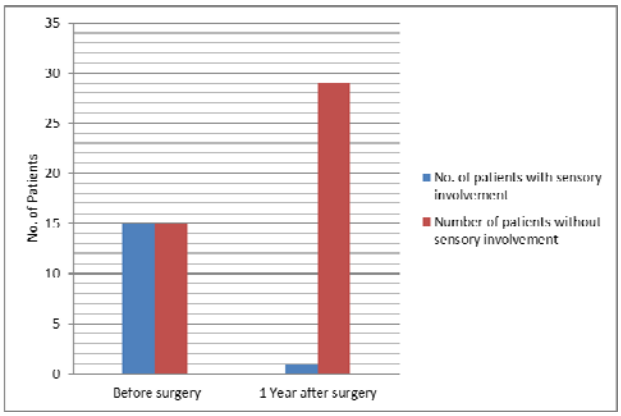


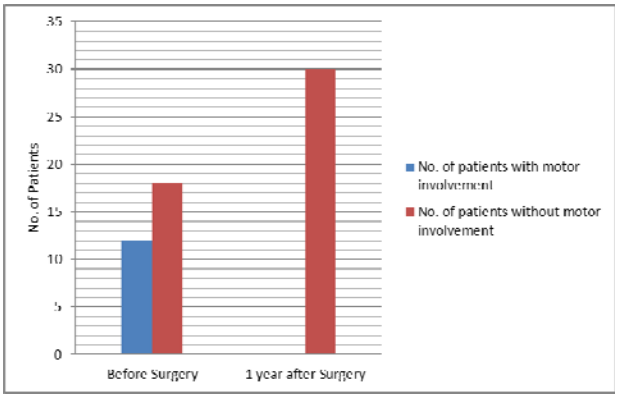
Fig 8: Hypertrophied *Ligamentum flavum* after complete removal from L4-L5 on left side



Graph 1*:* Pre-op & Post-op Claudication Distance at the end of 1 year



Graph 2: Pre-op & Post-op Sensory Involvement



Graph 3: Pre-op & Post-op motor Involvement

Conclusion

The evolution of minimally invasive techniques of Wide Interlaminar Fenestration has led to safe and effective applications for the treatment of lumbar spine stenosis with preservation of posterior spinal structure and thus preserving stability of spine. Literature also suggests that multiple interlaminar fenestrations is now treatment of choice in developmental stenosis and it is a preferred surgical option for degenerating stenosis when narrowing is mild to moderate because it preserves spinal stability [25]. Our study also suggests that multiple wide interlaminar fenestrations done in spinal stenosis provides adequate neurological decompression besides maintaining spinal stability also there are no need of costly specialized instruments and less invasive technique as compared to the conventional one (Hemi or total laminectomy).

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