Lumbar Canal Stenosis - A Study of Spinous Process Osteotomy in Posterior Decompression

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ABSTRACT

Study Design: *Prospective*

Background: *Lumbar canal stenosis (LCS) remains one of the most frequently encountered, clinically important degenerative spinal disorders in the ageing population. Diagnosing it clinicallyis made more difficult due tocoexisting degeneration of the spine, hip or knee joint or diseased vessels and nerves of lower limbs or due to de-conditioning of spinal musculature and ligaments.*

Purpose of the study: *The purpose of our study was to assess the results of spinous process osteotomy & laminotomy in cases of lumbar canal stenosis.*

Material and Methods: *It was prospective study with 25 confirmed cases of lumbar canal stenosis adhering to inclusion criteria and stable spine. Patients were assessed pre-operative and post- operative using LINS Functional Ability Criteria, VAS scale for back pain and leg pain, JOAS score and Satisfactory Recovery Rate- Hirabayashi Method(Based on Pre-op and Post-op JOAS scores) with an average follow-up of 1 year.*

Results: *There were 25 patients, 12 (48%) males and 13 (52%) females. Mean age of group was 44.48 ± 7.52.There were14 (56%) patients with two level involvement followed by 6 (24%) patients with three level involvement and 5 (20%) patients with single level involvement. In single level involvement maximum number was of L4-L5.All 25 (100%) patients presented with Claudication and radiculopathy; 9 (36%) had unilateral radiculopathy while 16 (64%) had bilateral radiculopathy.10(40%) patients had motor weakness and sensory involvement.1(4%) patient presented with cauda equina syndrome with associated sphincter involvement.All patients were treated with Spinous process osteotomy and fenestration and foraminotomy. In addition to that, discectomy was done in 14 (56%) patients while laminotomy was required in 3 (12%) patients Functional assessment as per LINS criteriashowed that satisfactory results (Percentage of patients in Excellent and Good Class) were achieved in 90% of the patients.There were significant improvement in back pain (60%) and excellent improvement in leg pain (76%) in terms of VAS. Improvement in JOAS score was also excellent (72%).according to Hirabayashi method, 12 (48%) patients had 'Excellent' results (JOAS recovery rate >70%); and 10 (40%) patients had 'Good' results (JOAS recovery rate between 45% and 70%).*

Conclusion: *The Spinous Process Osteotomy (SPO) technique is one of the surgeries associated with minimal muscle injury, effective andfaster long lasting decompression, and satisfactory neurological and functional outcomes with acceptable low risk of complication highly safe for all concerned and maintenance of spinal stability by utilizing standard outcome measures with logical expectation to maintain excellent to good results at long term follow up.*

Keywords: *Lumbar Canal Stenosis, Spinous Process Osteotomy, SPO, JAOS score, LINS criteria, Hirabayashi Method*

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INTRODUCTION

Surgery for lumbar spinal stenosis (LSS) is the most common surgical procedure involving the adult lumbar spine.[1] Degenerative spinal stenosis is a progressive disorder that involves the entire spinal motion segment as described by Kirkaldy-Willis.[2,3] Lumbar spinal stenosis is one manifestation of the general process of spinal degeneration that occurs with aging, and often becomes symptomatic in the fifth and sixth decades of life. Unfortunately, lumbar spinal stenosis continues to be misunderstood and under-diagnosed, and many patients are never offered effective treatment for their symptoms.

The symptoms of lumbar stenosis are of two types, one due to central canal narrowing causing Neurogenic Claudication (unilateral/bilateral) and other due to narrowing of the vertebral foramen causing Radicular symptoms. Patient can present with one of them or both of them. Although the diagnosis can be strongly suspected from the history and physical findings alone in many cases, non-contrast stress MRI now provides a confirmation in many cases, and now routine myelography is no longer necessary. For patients who are persistently symptomatic despite adequate conservative care, surgery can offer a highly rewarding and effective for improvement in quality of life.

Lumbar canal stenosis was first described by Sachs and Frankel in 1900. However its first clinical description is attributed to Henk Verbiest – a Dutch neurosurgeon (1954). Sincethen surgeons are searching for accurate method of definite diagnosis and operative treatment for the same. Various methods for operative treatment for lumbar canal stenosis have been developed and described in literature since then with varied results. These includes hemilaminectomy, standard laminectomy, wide laminectomy, laminotomy, split spinous process laminectomy, spinous process osteotomy & laminectomy and their numerous modification. Weiner[4] and other authors[5,6] have described Spinous process osteotomy with good clinical results. It gives the surgeon the possibility to work across the midline, which facilitates the approach to the lateral recesses. In spinous-process osteotomies for spinal stenosis decompression one side of the paraspinal muscle is divided and the spinous processes are cut horizontally at the junction of the lamina and spinous process. They reported its benefit of minimal muscle injury, early recovery, and minimal damage to spinal anatomy.

We conducted this study with the aim to assess the results of spinous process osteotomy & laminotomy in cases of lumbar canal stenosis.

MATERIAL AND METHODS

It was a prospective study with 25 patients with lumbar canal stenosis, who adhered to our inclusion criteria. Evidence of lumbar canal stenosis was obtained from history, clinical examination, Lumbo sacral spine X-rays with dynamic views. It was confirmed with MRI.

Inclusion Criteria: Confirmed cases of Lumbar canal stenosis not responding to conservative treatment and steroid blocks for minimum of at least 12weeks, only exception were patient with non-recovering or deteriorating neurological symptoms. Another important criterion was claudication distance of less than 100 meters.

Exclusion Criteria: Elderly patients above 70 yrs., high anaesthestic risk patients, patients with medical comorbidities like congestive heart failure, livercirrhosis, coagulopathy and diabetesmellitus. Also patients with lumbar spondylolisthesis with instability requiring additional instrumentation. Patient was assessed pre-operatively and post-operatively by using VAS Pain scale for back and leg pain, Disability (quality of life or working capacity) in terms of LINS scale, Japanese Orthopaedic Association Scale (JOAS)[7] and Satisfactory Recovery Rate- Hirabayashi Method (Based on Pre-op and Post-op JOAS scores).[8]

PROCEDURE[2]

Procedure was done under general Anaesthesia. Patient was put in prone position without pressure and localization of spinal levels was done according to IITV guidance. With a suitable length midline incision dorsolumbar fascia was exposed. Unilateral para-median incision in the fascia was made thus preserving the supraspinous and interspinous ligaments with subperiosteal dissection of the paraspinal muscles from the spinous process and laminae on one side only. Stripping of the multifidus muscles beyond the medial aspect of the facet joint was avoided to preserve their innervation. With a curved osteotome, each spinous process was freed from the lamina at its base. Only the levels shown to be affected on preoperative imaging were released.

Freed spinous process was retracted to one side with the paraspinal muscles beneath the retractor and the other blade of the retractor beneath the multifidus muscles to expose the midline. We modified the procedure by not resecting upper and lower half of lamina but doing fenestration, foraminotomy ± laminotomy (unilateral or bilateral) depending on patient's clinical and imaging problem. Complete laminectomy was not done in any case. Intra-operatively when the discectomy was done and nerve root or dorsal root ganglion or significant root manipulation required for proper decompression then Abgel piece soaked in 40mg kanacort was put over and around it to reduce root inflammation and resulting neuritic pain during post-operative period. During closure negative suction drain was kept and spinous process was taken to its original place by suturing paraspinal muscle and fascia with supraspinous and intraspinous ligament with intermittent vicryl OS suture at all level. Water tight closure of lumbar fascia was done.

POST-OPERATIVE PROTOCOL

Physiotherapy in form of active back range of motion exercise, passive and active SLR exercise, back extension exercise and William's abdominal strengthening exercise to gradual gait training started suitably next post-operative day as tolerated by patient. Patients were discharged on 3rd to 5th post-operative days after favourable wound status. Patients did not need to wear a rigid lumbar brace. Patients were called in follow up on 15th day for stitch removal, 6 weeks, 3 month, 6 month and 1 year and then every 6 months.

PATIENT ASSESSMENT AT FOLLOW UP

Patients were evaluated preoperatively and 15th day, 6 weeks, 3 month, 6 month,1 year and then every 6 monthly postoperatively using the LINS Functional Ability Criteria, VAS scale for back pain and leg pain, JOAS score and Satisfactory Recovery

Rate- Hirabayashi Method (Based on Pre-op and Post-op JOAS scores). For the purpose of checking the stability of the spine and to rule out iatrogenic instability post-operatively, we took dynamic lateral view of lumbosacral spine in all patients at least once after 3 months.

RESULTS

Table 1: **Demographics**

	Male	**Female**	**Total**
No. of Patients	12 (48%)	13 (52%)	25 (100%)
Age - Mean±SD	44.08 ± 8.27	44.85 ± 7.07	44.48 ± 7.52

Table 2: **Type and Level of Pathology**

Pathology → / **Level ↓**	**Degenerative LCS**			**Associated Spinal Pathology**		
				Stable Listhesis	**PIVD**	**Stable Degenerative Scoliosis**
Single level	5 (20%)			6 (24%)	13 (52%)	0 (0%)
	L3-L4	L4-L5	L5-S1			
	0 (0%)	4 (16%)	1 (4%)			
Double level	14 (56%)			0 (0%)	1 (4%)	2 (8%)
	L3-L4,L4-L5		L4-L5,L5-S1			
	2 (8%)		12 (48%)			
Triple Level	6 (24%)			0 (0%)	0 (0%)	1 (4%)
	L3-L4,L4-L5,L5-S1					
Total	25 (100%)			5 (20%)	14 (56%)	3 (12%)

Table 3: **Presenting Symptoms**

Symptoms	**No of patients**
Motor weakness +Associated Sensory Hypoaesthesia	10 (40%)
Cauda Equina Syndrome with Sphincter involvement	1 (4%)
Claudication with Unilateral radiculopathy	9 (36%)
Claudication with Bilateral Radiculopathy	16 (64%)

Table 4: **Management**

Procedure			
SPO + Fenestration + Foraminotomy			25(100%)
Additional Procedure		Discectomy	14(56%)
		Laminotomy	3(12%)
SPO Details			
Level of Surgery	Single Level	Right side	4 (16%)
		Left side	8 (32%)
	Double Level	Right side	2 (8%)
		Left Side	9 (36%)
	Triple Level	Right Side	0 (0%)
		Left side	2 (8%)
Side of Decompression	Unilateral	Right	6 (24%)
		Left	8 (32%)
	Bilateral		11 (44%)
Neurological Recovery	Fully Recovered	8 (80%)	Total 1 (10%)
	Partially Recovered	1 (10%)	
	Same	1 (10%)	

Table 5: **Assessment**

A. Functional assessment as per LINS criteria

Post-op → / **Pre-op ↓**	**No. of Patients**	**Poor**	**Fair**	**Good**	**Excellent**
Poor	13 (52%)	1 (4%)	0 (0%)	6 (24%)	6 (24%)
Fair	12 (48%)	0 (0%)	0 (0%)	4 (16%)	8 (32%)
Good	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Excellent	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	25 (100%)	1 (4%)	0 (0%)	10 (40%)	14 (56%)

B. JOAS score and VAS

Criteria	Pre-op Average	Final Follow-up Average	Improvement
Back Pain VAS	6.48	2.56	60%
Leg Pain VAS	8.36	2.00	76%
JOAS	5.12	12.56	72%

C. Satisfactory Recovery Rate- Hirabayashi Method (Based on JOAS Scores)

Result	Recovery Rate	No. of patient
Excellent	>70%	13 (56%)
Good	45-69%	10 (40%)
Fair	25-44%	1 (4%)
Poor	<25%	1 (4%)
Total		25 (100%)

1. **Demographics (Table 1)**: There were 25 patients. Out of them there were 12 (48%) males and 13 (52%) females. Mean age of group was 44.48 ± 7.52 with that of male was 44.08 ± 8.27and of female was44.85 ± 7.07.
2. **LCS type and Level (Table 2)**: There were highest number of patients 14 (56%) with two level involvement followed by 6 (24%) patients with three level involvement and 5 (20%) patients with single level involvement. In single level involvement maximum number was of L4-L5.Along with LCS there were some associated spinal pathology. 6 (24%) patients had stable listhesis and 3 (12%) patients have Stable Degenerative Scoliosis at the time of presentation. There were 14 (56%) patients had associated PID; 13 (52%) of them had PID at single level while 1 (4%) had PID at 2 levels.
3. **Presenting Pathology (Table 3)**: All 25 (100%) patients presented with Claudication and radiculopathy; 9 (36%) had unilateral radiculopathy while 16 (64%) had bilateral radiculopathy. 10(40%) patients had motor weakness and all of them also had sensory involvement also. 1(4%) patient presented with cauda equina syndrome with associated sphincter involvement. Bilateral neurological claudication with radiculopathy was commonest presentation and cauda equina paresis with sphincter involvement was most serious presentation which needs urgent decompression.
4. **Management (Table 4)**: All patients were treated with Spinous process osteotomy and fenestration and foraminotomy. In addition to that, discectomy was done in 14 (56%) patients while laminotomy was required in 3 (12%) patients.

Paraspinal muscles on predominant side of symptoms/ neurological deficit were stripped and spinous process was retracted to opposite side.With bilateral equal symptoms, left sided approach was selected because of convenience of right handed surgeon. So, left sided approach is more common in our study. Decompression was done bilaterally in 11(44%) cases and unilaterally in 14 (56%) cases (Right-6(24%), Left – 8(24%). In our study, out of 25 patients, 10 (40%) patients who initially presented with motor weakness, 8 (32%) patients showed full neurological recovery at final follow-up. 1 (4%) patient with 3 level problem has partial recovery at final follow, while 1 (4%) patient had same motor neurological status at final follow-up but show improvement in sensation with normal sphincter.

1 (4%) patient present with cauda equina paraparesis with bilateral motor weakness, sensory and sphincter involvement of 5 days. He recovered completely after 3 month follow up.

5. **Assessment**

a) **Functional assessment as per LINS criteria**: After treatment at final follow-up; only 1 (4%) patient was in 'POOR' Category as per LINS criteria which is due to intra-op nerve root injury during removal of adherent disc. However that patient was in 'POOR' Category pre-op also. Out of pre-op 'POOR' 13 (56%) patients, 6 (24%) patients become 'EXCELLENT' and 6 (24%) 'GOOD' at final follow up. Out of pre- op 'FAIR' 12 (48%) patients, 8 (32%) patients become 'EXCELLENT' and 4 (16%) patients 'GOOD' at final follow up. Satisfactory results (Percentage of patients in Excellent and Good Class) were achieved in 90% of the patients.

b) **JOAS score and VAS**: The study population showed significant improvement in back pain (60%) and excellent improvement in leg pain (76%) in terms of VAS. Improvement in JOAS score was also excellent (72%).

c) **Satisfactory Recovery Rate:** Hirabayashi Method (Based on JOAS Scores) – In accordance with JOAS, according to Hirabayashi method, 12 (48%) patients had 'Excellent' results (JOAS recovery rate >70%); and 10 (40%) patients had 'Good' results (JOAS recovery rate between 45% and 70%).

COMPLICATIONS

Dural Puncture	Nerve Root Injury	Delayed Infection
4 (16%)	1(4%)	1(4%)

4 (16%) patients had intra-op dural puncture which was sealed with AB gel and Surgical and then checked for integrity by valsalva manoeuvre. Post op these patients were asymptomatic and they were mobilized after 5 days.

Only 1(4%) patient had intra-op nerve root injury due to migrated adherent hard disc which was symptomatic pre op neurological deficit. Post op this patient slowly recovered of deteriorated neurology and sensation returned normal. However paraesthesia and minor motor deficit remain up to last follow up.

1(4%) patient had delayed wound infection which was previously operated for left sided PID L4-5; eight years back by fenestration and discectomy and now developed same level right sided PID with severe radiculopathy. He was operated by L5 spinous process osteotomy with right sided decompression. Excellent symptomatic relief was observed immediate post op and discharged on 4th post op day. After 1 month of follow up there was minor pus discharging sinus on the healed incision, on follow up contrast MRI no discitis found and decompression was satisfactory. Debridement of subcutaneous tissue and muscles done up to lamina and antibiotic given for 4 weeks according to culture sensitivity and patient recovered of problem within 4 weeks with good back range of motion without leg pain.

DISCUSSION

LSS is a narrowing of the spinal canal leading to compression of nervous and vascular structures. The surgical solution is to relieve this compression by performing a decompressive procedure. To achieve this goal of decompression at the disc level where the narrowing primarily takes place, most parts of the ligamentum flava and the lamina (whole or parts of it) are removed. The consequences of bone and ligament removal must be considered when performing decompression for spinal stenosis. Denervation of the paraspinal musculature occurs with wide exposures, which results in altered muscle function.

This was a prospective study of effect of spinous process osteotomy in posterior decompress-sion in patients with lumbar canal stenosis in 25 patients. Our study group was somewhat similar to studies of Weiner et al (46 patients) [4]and Hermansen et al. (55 patients).[9]

In our study averages follow up of 1 year. Hermansen et al. had an average follow up of 21 months.[9] However Weiner et al had follow up of 5years.[4]

Mean age of the study group was below 50 years with 80% of patient belonging to under 50 years age profile. Sex ratio was also almost equal. This shows that prevalence of this problem is high in middle age in our set up.

Because the primary complaint often is back pain and some leg pain, pain relief after surgery may not be complete. Jönsson reported successful results after operative treatment in 62% to 67% of patients, although they noted deterioration at 5 years, with 18% requiring reoperation.[3] Most series report a 64% to 91% rate of improvement, with 42% in patients with diabetes, but most patients still have some minor complaints, usually referable to the pre-existing degenerative arthritis of the spine. Neurological findings, if present, improve inconsistently after surgery.[3]

In our study leg pain VAS was shown to have 70% relief as compared to SPO group of Weiner et al[4] (50%). In our study post-operative back pain VAS was 2.56(60 % relief) whereas post-operative leg pain VAS was 2.00 (76 % relief). It was similar to Hermansen et al[9] who reported post-operative back pain VAS as 3.96 whereas post-operative leg pain VAS was 3.71.

A total JOAS can range from -6 to 15, and is a good indicator of the subjective and objective function. Such assessments cover subjective symptoms (low-back pain, leg pain, and walking capacity) and clinical symptoms (straight leg–raising test, and motor, sensory, and bladder functions).In our study there was 72% improvement in JAOS.

In our study Recovery rate as per Hirabayashi Method was excellent in 56% and good in 36% cases making it more than 90% in terms of Satisfactory Recovery rate. It was similar to SPO group of Weiner et al.[4] (83%).

When we assess our complications we found that there were 6 (24%) cases with surgical complication. It was somewhat higher than the study of Hermansen et al[9] (11%). Out of those 6 cases, 4 (16%) had dural ruptures. Weiner et al[4]. Reported 4 (8%) cases who had dural rupture.Hermansen[9] et al had 1(<1%) case of dural rupture. We had 1 (4%) case of infection where had Hermansen[9] et al had 1 (<1%) case of infection.

When we assess our study we find one limitation in our study. We had not assessed the status of spinous process healing post operatively after osteotomy. Hermansen et al in their study reported the assessment of spinous process healing post operatively.[9] They found a radiologic union for 60 out of 135 (44%) spinous process osteotomies. They reported that "complete-union" group showed better clinical results and scored significantly better in the Oswestry Disability Index and EQ-5D.

However, no statistical difference was found in the pain-scores. There were no differences between the "partial-union" group and the "no-union" group.

Apart from Spinous process osteotomy several surgical techniques have been adopted forpreserving paraspinal muscle function while achieving adequate decompression in lumbar spinal stenosis. Watanabe et al. improvised this technique by splitting the spinous process[10], preserving bilateral paraspinal muscle integrity and performing a complete laminectomy. Lin et al. reported a slight modification wherein they preserved the outer one third thickness of the lamina[11], bent it laterally using an osteotome along with the overlying paraspinal muscles and removed the inner two thirds thickness of the lamina. They minimised paraspinal muscle injury further by preserving their attachment to the laminar surface which was elevated in the original SPSL technique. Cho et al. used the original spinous process splitting technique[12], but restricted laminar resection to bilateral laminotomies, rather than a full laminectomy. Hatta et al. described an interlaminar technique for decompressing single level stenosis by drilling the adjacent portions of the spinous process and splitting the interspinous ligament progressively to expose the interlaminar window.[13] Banczerowski et al. used a modification of the SPSL technique for spinal tumour resection and described an 'archbone' technique for enlarging the spinal canal diameter by placing a complimentary tricortical iliac crest graft in between the distracted ends of the split spinous processes.[14]

Although spinal stability radiological and clinical appears to be unaffected in these initial preliminary results, long-term follow up is needed for confirmation. We believe this minimal muscle injury technique (which also preserves posterior spinal ligaments) can reduce back muscle atrophy and weakness and there by maintain spinal stability on longer follow up also.

CONCLUSION

Commonly used techniques of lumbar decompression results in extensive back musculature injury and vertebral osseous and non-osseous damage leading to significant iatrogenic instability and subsequent problem of exaggerated back pain and restenosis, whereas minimally invasive techniques like endoscopic procedure often provide inadequate visualization and/or decompression and involve costly instrumentation and time consuming. Spinous Process Osteotomy minimizes destruction to tissues not directly involved in the pathologic process, including the paraspinal musculature as well as the interspinous/supraspinous ligament complex and facets and even maintaining their stabilization properties. Thus Spinous Process Osteotomy appears to result in satisfactory spinal decompression with advantages of minimal muscle trauma and post-operative discomfort, satisfactory and fast decompression with conventional instruments, maintenance of spinal stability, earlymobilization, shortening of post op hospital stay, reduction of postoperative back pain. There is no disadvantage of this procedure except perception of new approach and initial careful orientation curve. Surgeon should perceive the method as satisfactory decompression along with combination of fenestration SOS discectomy/ laminotomy and foraminotomy.

AUTHOR'S CONTRIBUTION

The study was designed by VS, AA. Patients screening, procedure, data collection, documentation was done by VS, AA. Literature search, study and review were done by MD. MD, AV and VS wrote the manuscript.

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CONFLICT OF INTEREST: None

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