



MICHAEL J. LEE, M.D.

ASSISTANT PROFESSOR
UNIVERSITY OF WASHINGTON MEDICAL CENTER
SPINE
WWW.ORTHOP.WASHINGTON.EDU/FACULTY/LEE

RANDAL P. CHING, PH.D.

Variations in Surgical Treatment for Lumbar Stenosis and Biomechanical Implications

- Laminectomy is the conventional method for treating lumbar stenosis.
- Instability of the lumbar spine has been reported to occur as frequently 8-31% after laminectomy. Symptomatic instability may require additional surgery, including possibly fusion.
- Less extensive surgeries, like bilateral laminotomy can be done to treat stenosis. These less extensive surgeries may preserve the tissues that provide lumbar stability.
- We have tested motion patterns in human cadaveric lumbar spines after laminotomy and laminectomy.
- Our preliminary data suggest that bilateral laminotomy may lead to less instability.

Spinal stenosis is a common condition in the elderly and can also occur in younger individuals on a congenital basis. In spinal stenosis there is a narrowing of the spinal canal resulting in mechanical compression and irritation of the nerve tissue within the canal. Stenosis can occur from a combination of disc bulging, disc herniation, facet osteophytes, endplate osteophytes, ligamentum flavum hypertrophy, and epidural lipomatosis. The majority of patients with spinal stenosis can be treated without surgery. Patients with substantial and refractory symptoms may require surgical management.

Traditionally, laminectomy has been the most frequently used method for surgical decompression used in the treatment of stenosis. In a laminectomy the surgeon removes the lamina, spinous processes, interspinous ligament, and undercuts of the facet joints. This procedure is effective in treating neurological leg pain, but there are concerns regarding the possibility of instability after this procedure. As a result, less invasive techniques for

decompression have been introduced, such as laminotomy. In a laminotomy the surgeon partially moves the lamina and the facet while maintaining the central structures (spinous process, inter and supraspinous ligaments). The advantage of the laminotomy is that it requires less resection of bone and soft tissue and may result in a more stable spine after the decompression. However, the disadvantage is that laminotomy is technically more difficult and requires more surgical time than the laminectomy. In addition, concerns exist if the decompression achieved by laminotomy is comparable to that achieved by laminectomy.

Numerous biomechanical studies have demonstrated that with sequential resection of posterior spinal column elements, there is sequentially increasing instability. When performing a laminectomy, it has been recommended to retain at least 50% of the facet bilaterally and sufficient pars to prevent instability. Despite these measures, the incidence of post laminectomy instability has been reported to range from 8 to 31%.

To our knowledge, there has been no biomechanical study examining stability of the decompressed spine with the posterior ligamentous complex intact. All previous biomechanical studies examined stability after resection of these structures. We hypothesize that laminotomy, with its retention of these structures will allow for a more stable spine than a laminectomy.

Research

Our research focuses on the biomechanical stability after decompression of the lumbar spine. We used human cadaveric lumbar spines and tested their motion under normal physiologic forces. We record the motion of the entire spine and the motion at each level. Using reflective spheres attached at each level and 4 cameras, we can accurately track the motion of each segment. We then mount the spines into our spine simulator, which mimics forces seen under physiologic human conditions. We evaluate the spine motion in flexion and extension, side to side bending, and rotation. We evaluate the spine's

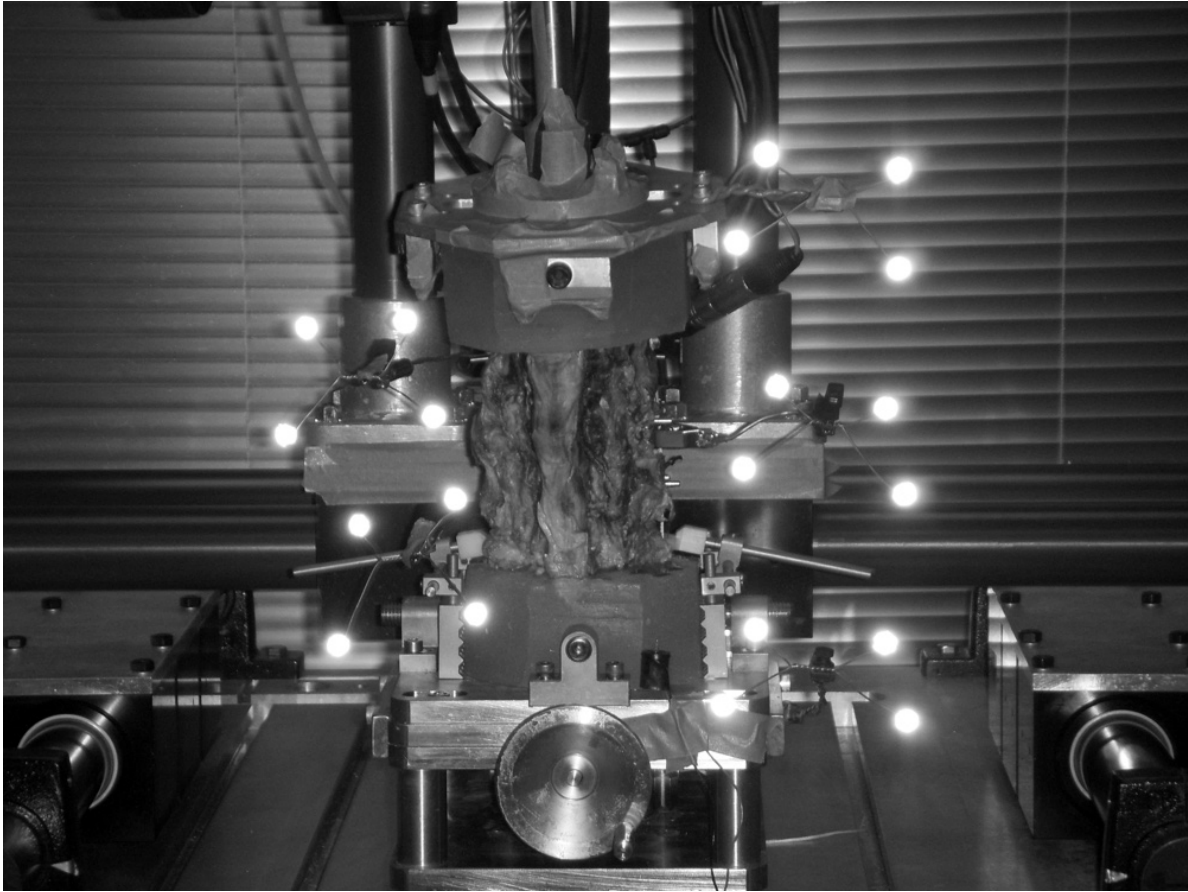


Figure 1: The intact spine loaded in the simulator using reflective spheres to record motion patterns.

motion and stiffness under three conditions for each specimen tested sequentially.

1) Trial 1: Intact lumbar spine – no surgery (Figure 1).

2) Trial 2: Lumbar spine after bilateral lumbar laminotomy at L2-3, L3-4 & L4-5. Laminotomy entails removal of ligamentum flavum, and partial facetectomy to visualize the medial aspect of the pedicle to ensure adequate lateral recess decompression. The spinous process, inter and supraspinatus ligaments were preserved (Figure 2).

3) Trial 3: Lumbar spine after full laminectomies at L2-3, L3-4 & L4-5. This entails full removal of the lamina, supra and inter spinous ligaments, and spinous processes (Figure 3).

Lumbar spine kinematics (full spine and segmental) are measured using a Vicon motion tracking system (Vicon Motion Systems, Lake Forest, CA). The total range of motion (ROM) from L1 to L5 are assessed as well as the segmental range of motion between L1-2, L2-3, L3-4, and L4-5. Additionally, the overall and segmental stiffnesses are computed from the

moment-angle plots.

The paired two-sample t test is used to evaluate differences in stiffness and range of motion after 1) bilateral laminotomy and 2) laminectomy. Statistical significance is defined as $p < 0.05$.

Results

In this study we found that there is a significant difference in the increase of motion and decrease of stiffness of the spine after laminectomy vs. laminotomy (Table 1). The laminectomy procedure resulted in almost twice

	% Change From Intact	
	Increase in Motion	Decrease in Stiffness
Laminotomy	17.49	11.80
Laminectomy	36.76	27.20
Significance	$p < 0.05$	$p < 0.05$

Table 1: Increased Motion and Decreased Stiffness for Laminotomy and Laminectomy.



Figure 2: An oblique view of the laminotomized spine with retention of central structures.

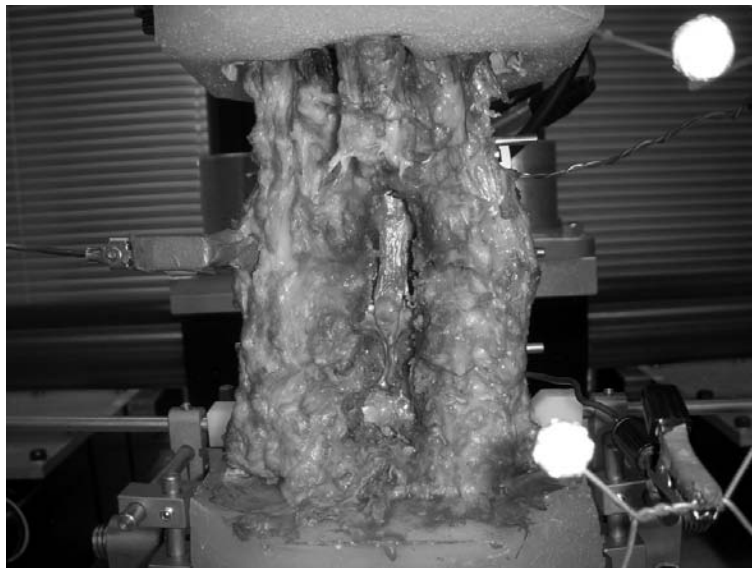


Figure 3: The laminectomized spine.

as much motion increase than the laminotomy procedure.

Discussion

We have learned from previous studies and experiences that the more of the lumbar spine we remove, the more unstable it becomes. Previous studies have suggested that at least 50% of the facets should be maintained and that the pars interarticularis should be preserved as well. Resection beyond these guidelines can result in an unstable spine. Newer studies have suggested that abnormal motion and subtle instability may result even despite following these guidelines. Our preliminary data suggest that laminotomy may result less instability than laminectomy.

In the surgical decision-making, numerous factors have to be taken into consideration. If the patient is elderly with multiple co-morbidities and cannot tolerate extended general anesthesia, the laminectomy procedure may be more appropriate as it is more easily done and with less operative time and less risk to the patient. If a patient's spine is stiff with severe arthritis and does not have much motion to begin with, the benefit of laminotomy may be lost on a spine that is already stiff and quite stable. If there is severe stenosis, a full laminectomy may be required to adequately treat the patient's neuro-compressive symptoms. Occasionally in spine surgery, a rent in the spinal sac may occur and cerebrospinal fluid may leak. To repair such a leak requires the adequate exposure. A full laminectomy may be required to adequately expose and repair such a leak.

Furthermore, it is recognized that spinal stenosis may recur after decompression by laminotomy or laminectomy. It is not clear how often or how soon stenosis recurs with each procedure. Future studies examining symptom relief, extent of decompression, resultant hypermobility and future predisposition to instability will help in determining the optimal procedure for the patient.

Acknowledgements

This study was funded by a Departmental Initiative Grant from the Department of Orthopaedics and Sports Medicine.

Recommended Reading

Fox MW, O.B., Onofrio BM, Hanssen AD., Clinical outcomes and radiological instability following decompressive lumbar laminectomy for degenerative spinal stenosis: a comparison of patients undergoing concomitant arthrodesis versus decompression alone. *J Neurosurg*, 1996. 85(5): p. 793-802.

Detwiler PW, S.C., Taylor SB, Crawford NR, Porter RW, Sonntag VK., Biomechanica; comparison of facet-sparing laminectomy and Christmas tree laminectomy. *J Neurosurg*, 2003. 99(2 (Suppl)): p. 214-220.

Abumi K, P.M., Kramer KM, Duranceau J, Oxland T, Crisco JJ., Biomechanical evaluation of lumbar spinal stability after graded facetectomies. *Spine*, 1990. 15(11): p. 1142-7.

Atlas, S.J., et al., The Maine Lumbar Spine Study, Part III. 1-year outcomes of surgical and nonsurgical management of lumbar spinal stenosis. *Spine*, 1996. 21(15): p. 1787-94; discussion 1794-5.