Indirect Decompression of Lumbar Spinal Stenosis Following Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Introduction: Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is increasingly utilized in the treatment of degenerative conditions of the lumbar spine. The restoration of disc height and lumbar sagittal alignment following MIS-TLIF provides indirect decompression of the neuroforamina, however its effects on central canal stenosis are not well characterized.

Objective: To evaluate clinical outcomes and radiologic variables of sagittal segmental alignment and central canal dimensions in patients with lumbar spinal stenosis undergoing MIS-TLIF.

Methods: We conducted a retrospective review of MIS-TLIFs performed between 2014 and 2018. We identified patients who had both preoperative and postoperative upright lateral radiographs and magnetic resonance imaging (MRI) of the lumbar spine. MRI scans were analyzed for changes in central canal dimensions. Radiographic measurements included disc and neuroforaminal height, segmental lordosis, and spondylolisthesis.

	MIS-TLIF Demographic, Clinical, and Operative Data			
	All Patients (N=18)	**Static Cage (N=9)**	**Expandable Cage (N=9)**	**Mean/Percent Difference (95% CI)**
Number of TLIFs	20	10	10	0%
Age (years)	58.3 ±9.1	56.1 ±10.7	60.4 ±7.0	-4.3 (-13.3; 4.8)
Sex, Female	12 (66.7%)	7 (77.8%)	5 (55.6%)	22.2%
Body mass index (BMI, kg/m^2)	28.6 ±7.3	27.1 ±8.0	30.1 ±6.6	-3.0 (-10.3; 4.4)
Follow-up Duration (months)	26.5 ±11.3 (Range 12 – 50)	30.6 ±12.4 (Range 15 – 50)	22.4 ±9.0 (Range 12 – 37)	8.2 (-2.6; 19.0)
Mean Duration from Surgery to PostOp MRI (months)	15.6 ±14.2 (Range 0.2 – 47)	20.8 ±15.3 (Range 0.6 – 47)	10.5 ±11.8 (Range 0.2 – 37)	10.3 (-3.3; 23.9)
PreOp Radiologic Diagnoses				
Foraminal Disc Herniation	12 (60%)	5 (50%)	7 (70%)	-20%
Disc Bulge/Central Herniation	17 (85%)	9 (90%)	8 (80%)	10%
Spondylolisthesis	13 (65%)	6 (60%)	7 (70%)	-10%
Operative Levels				
L2/L3	2 (10%)	1 (10%)	1 (10%)	0%
L3/L4	3 (15%)	2 (20%)	1 (10%)	10%
L4/L5	13 (65%)	7 (70%)	6 (60%)	10%
L5/S1	2 (10%)	0 (0%)	2 (20%)	-20%
Expandable Cages	10 (50%)	0 (0%)	10 (100%)	-100%
Side of Facetectomy				
Right	5 (25%)	2 (20%)	3 (30%)	-10%
Left	14 (70%)	7 (70%)	7 (70%)	0%
Bilateral	1 (5%)	1 (10%)	0 (0%)	10%
Fusion at Last Follow-up	18 (90%)	8 (80%)	10 (100%)	-20%

Table 1. Demographic and operative characteristics of patients who underwent MIS-TLIF with static or expandable cages and concomitant central canal stenosis. Values are presented as n (%) for categorical or mean ±SD for continuous variables. P-Values calculated using Mann-Whitney test for age, BMI, and follow-up durations, Fisher's Exact test for sex, spondylolisthesis and Chi-Square test for other categorical variables. There were no statistically significant baseline differences among the static and expandable cage cohorts P>0.05.

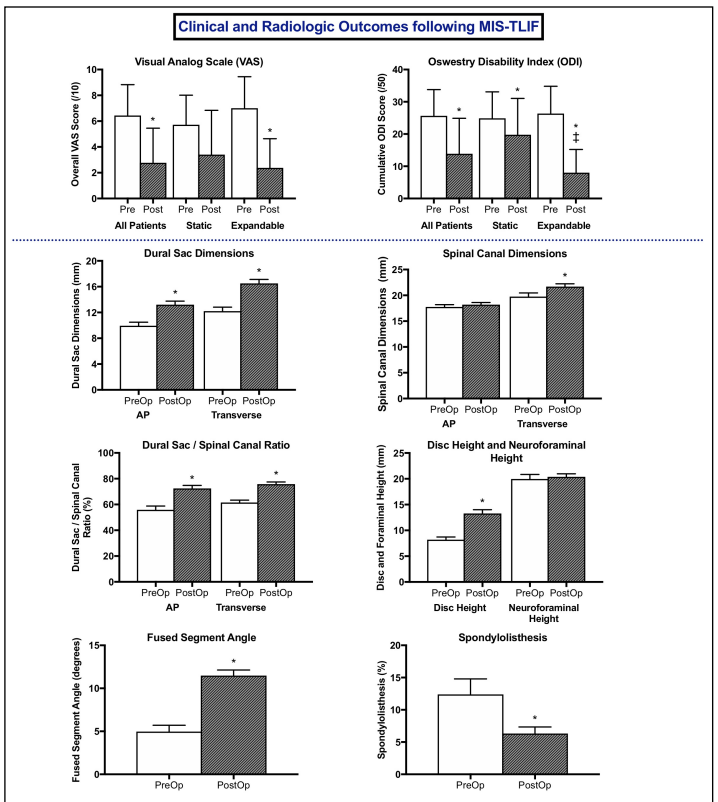
Results: Of the 74 consecutive patients who underwent 81 MIS-TLIFs, we identified 18 patients with 20 levels of intervention (Age 58.3 ±9.1 years, Mean ±SD; 66.7% Female), predominantly L4/5 (65%). Expandable interbody devices were utilized in 50% cases. No additional central canal decompression was performed beyond the limited facetectomy to access the disc space. Follow-up duration after surgery was 26.5 ±11.3 months. Patient-reported clinical outcomes were significantly improved postoperatively.

The anteroposterior dural sac diameter increased from 9.9 ±0.6mm (Mean ±SEM) preoperatively to 13.2 ±0.5mm postoperatively (P <0.001). Transverse dural sac diameter increased from 12.2 ±0.6mm to 16.5±0.6mm (P <0.001). There was a significant reduction in spondylolisthesis. The percentage offset of one vertebra over its adjacent segment decreased from 12.4 ±2.4% to 6.3 ±1% (P <0.01). Patients experienced significant increases in segmental disc height and lordosis, but neuroforaminal height was not significantly increased. Similar changes were observed within and between static and expandable cage subgroups; however, the magnitudes of disc height and segmental lordosis correction were greater with expandable cages.

	MIS-TLIF Clinical and Radiologic Outcomes						
	Pre-Operative			**Post-Operative**			
	All Patients	Static Cage	Expandable Cage	All Patients	Static Cage	Expandable Cage	Mean Change All Pts PostOp -PreOp (95% CI)
Patient-Reported Outcome Measures (Mean ± SD)							
Mean VAS Score /10	6.6 ±2.5	6.0 ±2.4	6.9 ±2.6	**2.5 ±2.6**	2.8 ±3.6	**2.4 ±2.3**	**-4.1 (-6.0; -2.2)**
Mean Cumulative ODI Score /50	25.6 ±8.1	24.9 ±8.2	26.3 ±8.5	**13.1 ±10.7**	**18.8 ±11.6**	**8.0 ±7.2***	**-12.6 (-18.2; -7.0)**
MRI Radiologic Variables (Mean ± SEM)							
AP Dural Sac (mm)	9.9 ±0.6	10.1 ±0.8	9.8 ±0.8	**13.2 ±0.5**	**13.9 ±0.8**	**12.6 ±0.7**	**3.28 (1.8; 4.8)**
AP Spinal Canal (mm)	17.8 ±0.4	18.3 ±0.7	17.2 ±0.5	18.2 ±0.4	18.9 ±0.6	17.5 ±0.5	0.44 (-0.7; 1.6)
AP Dural Sac/Spinal Canal Ratio (%)	55.9 ±2.9	55.5 ±4.8	56.3 ±3.6	**72.5 ±2.3**	**73.3 ±3.5**	**71.6 ±3.2**	**16.6 (10.4; 22.8)**
Transverse Dural Sac (mm)	12.2 ±0.6	13 ±0.8	11.4 ±0.9	**16.5 ±0.6**	**17 ±0.9**	**16 ±0.9**	**4.29 (3; 5.6)**
Transverse Spinal Canal (mm)	19.8 ±0.7	20.1 ±0.5	19.4 ±1.4	**21.7 ±0.6**	**21.8 ±0.7**	**21.6 ±0.9**	**1.93 (0.9; 3)**
Transverse Dural Sac/Spinal Canal Ratio (%)	61.6 ±1.8	64.3 ±2.7	58.8 ±2.1	**75.8 ±1.7**	**77.3 ±2.3**	**74.3 ±2.5**	**14.24 (9; 19.5)**
Fused Segment Angle (°)	5.0 ±0.7	5.4 ±1.1	4.5 ±1	**11.5 ±0.7**	**10.3 ±0.6**	**12.7 ±1.1**	**6.51 (4.7; 8.3)**
Disc Height (mm)	8.2 ±0.5	8.6 ±0.9	7.8 ±0.6	**13.3 ±0.7**	**10.9 ±0.5**	**15.7 ±0.8***	**5.09 (3.4; 6.8)**
Neuroforaminal Height (mm)	20 ±0.9	18.9 ±0.8	21.1 ±1.5	20.4 ±0.6	19.6 ±0.8	21.2 ±0.7	0.42 (-1.5; 2.3)
Percent Spondylolisthesis (%)	12.4 ±2.4	11.1 ±3.3	13.7 ±3.6	**6.3 ±1**	**4.9 ±1.3**	7.8 ±1.5	**-6.08 (-10.2; -2)**

Table 2. Patient-reported clinical outcome measures, Visual Analog Scale (VAS) and Oswestry Disability Index (ODI). ODI N=17 patients; N=8 Static, N=9 Expandable. VAS N=12 patients; N=4 Static, N=8 Expandable. Central canal dimensions and additional radiographic outcomes at the level of MIS-TLIF surgery, reported preoperatively, and at follow-up at the time of MRI acquisition. Bolded values indicate P <0.05, Wilcoxon signed ranks test for postoperative versus baseline; *P <0.05, Mann-Whitney test Static versus Expandable cage.

Conclusions: MIS-TLIF results in successful indirect decompression of the central spinal canal, without additional posterior decompressive procedures.



Top: Patient-Reported Clinical Outcomes after MIS-TLIF. Data presented as Mean±SD.
Bottom: Anteroposterior and transverse dimensions of the dural sac and osseous spinal canal were measured on axial T2-weighted imaging at each operative level on the preoperative and postoperative MRI studies. Additional radiographic outcomes include disc height, neuroforaminal height, fused segment angle, and percent spondylolisthesis. Data presented as Mean±SEM.
*P<0.05, Wilcoxon signed ranks test versus baseline. ‡P <0.05, Mann-Whitney test Static versus Expandable cage.