Multi-Level Tandem Spondylolisthesis Associated with Reduced “Safe Zone” for Lateral Lumbar Interbody Fusion at L4-5

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INTRODUCTION: Lateral lumbar interbody fusion (LLIF) performs well compared to posterolateral fusion for degenerative spondylolisthesis in terms of restoration of disc/foraminal height, and improvement of sagittal alignment.(1) A ventrally positioned psoas major, which is referred to as the “mickey mouse” or “rising psoas” sign has been correlated with increased risk of nerve damage during LLIF(2). The association of this sign with sagittal malalignment has not been studied.

METHODS:

This is a retrospective cohort study. Patients with low back pain and adequate lumbar MRIs and spine radiographs were identified at a single institution from July 2016 to July 2021. Exclusion criteria were patients with spine trauma, infection, transitional anatomy, or metastatic disease, or patients who had prior lumbar or abdominal surgery. Three cohorts were established: 1) single level grade 1 degenerative spondylolisthesis (DS), 2) multi-level, tandem DS (TDS), and 3) controls without DS. Cohorts were propensity matched for age and gender. T2-weighted, axial MRI was used to measure from a tangent line along the L4-L5 intervertebral disc space to the apical (ventral) and central position of the psoas major muscle belly. Spinopelvic parameters, including lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and PI-LL mismatch were recorded for all patients using lateral lumbar spine X-rays. Global sagittal balance was measured via sagittal vertebral axis (SVA) on 36” cassette full-length spine plain films.

The primary outcome of this work was apical and central psoas position at L4-5, which was calculated using a stepwise multivariate linear regression that included patient demographics, spinopelvic parameters, and degree of spondylolisthesis. Secondary outcomes were associations between single and multilevel spondylolisthesis and spinopelvic parameters, which were identified using a one-way analysis of variance with a Bonferroni correction for between-group comparisons.

RESULTS:

A total of 230 patients (92 without DS, 92 with single-level DS, 46 with TDS) were included. Mean cohort age was 68.0 ± 8.8 years, 185 (80.4%) were female and mean BMI was 30.9 ± 7.3. Age, BMI, and sex were similar between groups.

Increased grade of spondylolisthesis (no DS to DS to TDS) was associated with significantly increased PI, PT, and PI-LL mismatch ($p < 0.01$ all relationships). Increased grade of spondylolisthesis was associated with more ventrally positioned center psoas (no DS: 23.6 ± 7.3 mm, DS: 24.1 ± 7.3 mm, TDS: 29.6 ± 8.9 mm, $p < 0.001$ all relationships) and apex psoas positions (no DS: 43.5 ± 8.4 mm, DS: 44.9 ± 7.8 mm, TDS: 50.7 ± 10.5 mm $p < 0.001$ all relationships).

Increased PI-LL mismatch (0.2, 95% CI 0.1 to 0.3) was independently associated with a more anterior position of the center and apex of the psoas muscle. Severity of spondylolisthesis (no DS to DS to TDS) was associated with anterior displacement of the psoas muscle by 2.1 (95% CI 0.8 to 3.4) mm—the center of psoas was on average 2.1 mm more anterior in DS versus NS, and 4.2 mm more anterior in TDS versus NS. The apex of the psoas was influenced by spondylolisthesis severity (2.6, 95% CI 1.2 to 4.0). Female sex was associated with a significantly more posterior psoas apex (-5.4, 95% CI -8.0 to -2.8).

DISCUSSION AND CONCLUSION:

Increased PI-LL mismatch and more severe spondylolisthesis (DS then TDS) were independently associated with a smaller LLIF safe-zone at L4-5, while female sex was associated with a larger safe-zone. TDS patients had a greater degree of sagittal malalignment (PI-LL mismatch) and pelvic compensation (PT) than both no DS and DS patients. Findings suggest that TDS represents a more severe degree of sagittal malalignment and is a risk factor for lumbar plexus injury during LLIF at L4-5.