How Does Spondylolisthesis Influence Expandable Interbody Cage Stiffness, Force Exertion, and Subsidence?

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INTRODUCTION: Expandable lumbar interbody fusion cage has been shown to be efficacious in treating symptomatic degenerative spondylolisthesis. However, no prior study has evaluated how the presence and severity of spondylolisthesis may influence the biomechanical properties of expandable interbody cages. Our aim is to evaluate the impact of spondylolisthesis on expansion stiffness, force exertion, and subsidence associated with expandable interbody cages.

METHODS: The Mojave PL 3D Expandable Interbody System (Stryker, Leesburg, VA, USA) was utilized for this experiment. Based on the assumption of a 40 mm anteroposterior vertebral body length, two bone foams (superior and inferior) were loaded with 0%, 35%, and 50% anteroposterior offsets to simulate various degrees of spondylolisthesis. Increase in spondylolisthesis grade was associated with greater implant contact with the cortical rim. The expansion stiffness, output force-to-input torque ratio, and subsidence depth at a constant input torque (1 Nm) were measured and compared among the varying spondylolisthesis grades. For all measurements, five experimental trials were performed at each spondylolisthesis grade.

RESULTS: The mean expansion stiffness throughout 100-200 N output force range increased linearly with higher grades of spondylolisthesis (103.6±11.8 N/m at 0% offset, 109.4±18.6 N/m at 35% offset, 125.3±22.1 N/m at 50% offset) (Figure 1A). At all three spondylolisthesis grades, the force exerted onto vertebral bodies was significantly correlated to the input torque to expand the implant. The force-to-torque ratio decreased linearly with greater degrees of spondylolisthesis (186.0 N/Nm at 0% offset, 160.6 N/Nm at 35% offset, 136.5 N/Nm at 50% offset) (Figure 1B). At a constant 1 Nm input torque, the depth of subsidence decreased linearly with higher spondylolisthesis grade (2.3±0.5 mm at 0% offset, 1.5±0.3 mm at 35% offset, and 0.7±0.4 mm at 50% offset) (Figure 1C).

DISCUSSION AND CONCLUSION: The current study demonstrates that the presence of spondylolisthesis significantly influences the biomechanics of expandable interbody cages. Higher spondylolisthesis grade is associated with greater expansion stiffness. The force exerted onto vertebral bodies is correlated to the torque applied to expand the implant, and the force-to-torque ratio decreases with higher spondylolisthesis grade. This suggests that in patients with more severe spondylolisthesis, more torque may be required to achieve the equivalent output force. Finally, at a given input torque, the subsidence depth decreases linearly with higher spondylolisthesis grade. This is likely due to the greater implant contact with the cortical rim, equating to the strongest aspect of the vertebral body in vivo. This study allows for a better understanding of how the biomechanics and subsidence risk associated with expandable interbody cages may change based on the presence and severity of spondylolisthesis.

Figure 1. Impact of spondylolisthesis on expansion stiffness, force-to-torque ratio, and subsidence depth