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Dual Pedicle and Cortical Screws Using Robotic Navigation Improves Load to Failure in the Osteopenic Lumbar Spine: An In-Vitro Biomechanical Analysis

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Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the arrangement of the dual screw technique involving both a cortical screw and pedicle screw in the same vertebral level with multi-rod support.

2) Identify potential benefits of improved ultimate load-to-failure and construct stiffness of the dual screw technique over traditional techniques.

3) Discuss, in small groups, the potential applications of the dual screw technique in the stabilization of the lumbar spine.

Introduction

Investigators quantified the ultimate load to failure and construct stiffness of 4-rod constructs of (1) bilateral pedicle screw (PS) and (2) bilateral dual pedicle and cortical screw (PSCS) techniques in an osteopenic model. Robotic navigation technologies have been developed to improve PS accuracy and may allow for the insertion of both PS and cortical screws (CS) within the same pedicle, providing four points of bony fixation per vertebra. Recent studies demonstrated the radiographic feasibility for a dual screw trajectory for posterior lumbar spinal instrumentation; however, the biomechanical characterization of the technique is presently lacking.

Methods

Cadaveric operative constructs (L2) included (1) bilateral PS fixation with four rods using rod-to-rod connectors (PS 4-rod); and (2) bilateral PSCS dual screw fixation with four rods affixed at PS and CS (PSCS 4-rod) (n=7). Static compression testing was performed. The construct was connected to four 5.5 mm diameter titanium rods, and the cranial ends of two rods were secured to pedicle screws placed within the polyblock. The specimen was loaded in the axial direction to failure at a constant displacement rate of 5 mm/min. Ultimate load to failure (N) and mechanical stiffness (N/mm) were determined.

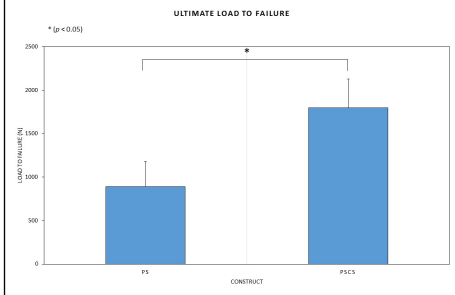
Results

PSCS 4-rod reconstruction significantly improved the ultimate load-to-failure and mechanical stiffness outcomes. The average load to failure between groups was 892.50±288.15N and 1798.04±329.23N for PS 4-rod and PSCS 4-rod, respectively. The average stiffness between groups was 329.67±79.35 and 429.64±84.02 for PS 4-rod and PSCS 4-rod, respectively. A significant difference was noted between groups for both outcome measures ($p<0.05$).

Conclusions

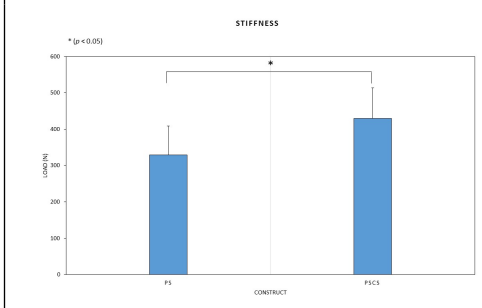
Four-rod reconstruction with dual pedicle and cortical screws significantly improved pedicle fixation and construct stiffness. Increased stiffness and resistance to failure could be an important component, particularly in patients with severe osteopenia, in hardware maintenance in the absence of fusion or until bone fragment healing is finalized following stabilization of comminuted bone.

Ultimate Load-to-Failure



Ultimate load-to-failure analysis. Statistical significance is indicated by one asterisk [(*) $p < 0.05$].

Construct Stiffness



Construct stiffness analysis. Statistical significance is indicated by one asterisk [(*) $p < 0.05$].