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Basic Science

Stability of transforaminal lumbar interbody fusion in the setting of retained facets and posterior fixation using transfacet or standard pedicle screws

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Abstract

BACKGROUND CONTEXT: The transforaminal lumbar interbody fusion (TLIF) technique supplements posterior instrumented lumbar spine fusion and has been tested with different types of screw fixation for stabilization. Transforaminal lumbar interbody fusion is usually placed through a unilateral foraminal approach after unilateral facetectomy, although extraforaminal entry allows the facet to be spared.

PURPOSE: To characterize the biomechanics of L4–L5 lumbar motion segments instrumented with bilateral transfacet pedicle screw (TFPS) fixation versus bilateral pedicle screw-rod (PSR) fixation in the setting of intact facets and native disc or after discectomy and extraforaminal placement of a TLIF technology graft.

STUDY DESIGN: Human cadaveric lumbar spine segments were biomechanically tested in vitro to provide a nonpaired comparison of four configurations of posterior and interbody instrumentation.

METHODS: Fourteen human cadaveric spine specimens (T12–S1) underwent standard pure moment flexibility tests with intact L4–L5 disc and facets. Seven were studied with intact discs, after TFPS fixation, and then with TLIF and TFPS fixation. The others were studied with intact discs, after PSR fixation, and then combined with extraforaminally placed TLIF. Loads were applied about anatomic axes to induce flexion-extension, lateral bending, and axial rotation. Three-dimensional specimen motion in response to applied loads during flexibility tests was determined. A nonpaired comparison of the four configurations of posterior and interbody instrumentation was made.

RESULTS: Transfacet pedicle screw and PSR, with or without TLIF, significantly reduced range of motion during all directions of loading. Transfacet pedicle screw provided greater stability than

FDA device/drug status: Approved (FacetFuse, PedFuse, TLIFT).

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PSR in all directions of motion except lateral bending. In flexion, TFPS was more stable than PSR ($p=.042$). A TLIF device provided less stability than the intact disc in constructs with TFPS and PSR.

CONCLUSIONS: These results suggest that fixation at L4–L5 with TFPS is a promising alternative to PSR, with or without TLIF. A TLIF device was less stable than the native disc with both methods of instrumentation presumably because of a fulcrum effect from a relatively small footplate. Additional interbody support may be considered for improved biomechanics with TLIF.

Keywords: Transforaminal lumbar interbody fusion; Transfacet pedicle screws; LES; Less Exposure Surgery; Facet

Introduction

Instability because of degenerative disc or facet disease and spondylolisthesis is frequently seen at the L4–L5 and L5–S1 levels, which may require fusion to achieve stability and relieve symptoms. Technologies such as facet screws are seeing more popularity because of their ability to aid ''less-exposure'' surgeries, which aim to reduce blood loss, postoperative pain, hospital stays, narcotic usage, and time before recovery and return to activities of daily living [1–5].

Transforaminal lumbar interbody fusion (TLIF) was developed for maintaining intervertebral height and to provide a scaffold for fusion. It is intended to be used with supplemental spinal fixation systems for use in the lumbar spine, such as screw fixation. Transforaminal lumbar interbody fusion is usually placed through a unilateral foraminal approach after unilateral facetectomy, although extraforaminal entry allows the facet to be spared.

Transfacet pedicle screw (TFPS) fixation and pedicle screw-rod (PSR) fixation have been demonstrated to have biomechanically similar stability after repetitive cycling [6] in the presence of an anterior lumbar interbody fusion device, but data are lacking on TFPS compared with PSR fixation with and without a TLIF.

The objective of this study was to determine if TFPS and PSR fixation provide better stability with an intact disc or after removing the disc and placing a TLIF device and to compare the stabilizing potential of TFPS to that of PSR.

Methods

Specimen preparation

Fourteen fresh human cadaveric lumbar spine segments from T12 to S1 were used. The mean age was 53.1 (±11.0) years, and there were 4 men and 10 women. Dual-energy X-ray absorptiometry scans were performed on the L4 vertebra of each specimen to assess bone mineral density and to ensure they were not osteoporotic. Specimens were carefully cleaned of muscular tissue while keeping all the ligaments, the joint capsules, and the discs intact. For testing, the sacrum was reinforced with household wood screws, embedded in a block of polymethylmethacrylate or fast-curing resin (Smooth-Cast 300Q, Smooth-On, Inc., Easton, PA, USA), and attached to the base of the testing apparatus. The T12 vertebra was embedded in a cylindrical metal fixture for the application of loads.

One group of seven specimens was studied in the intact condition, after TFPS fixation (FacetFuse; SpineFrontier, Inc., Beverly, MA, USA) and TLIF (T-LIFT; SpineFrontier, Inc.; TFPS fixation still in place) (Fig. 1, Left). The second group of seven specimens was studied in the intact condition, after PSR fixation (PedFuse; SpineFrontier, Inc.) and TLIF (PSR fixation still in place) (Fig. 1, Right). Figure 2 (Left and Right) demonstrate TFPS in situ as an example of our facet fixation technique. Transfacet pedicle screw diameter was 5.0 mm, and length was 40 mm. Holes were prepared using an awl, and a 3.5-mm cannulated drill bit, followed by tapping before screw insertion. Pedicle screw diameter was 5.0 mm, and length was 40 mm. Holes were prepared using a tapered awl, followed by a pedicle finder/probe, and tapping before screw insertion. Top-locking PSRs were 5.5 mm in diameter and were secured using a locking cap. Transforaminal lumbar interbody fusion graft length was 25 mm, and height was 8 to 12 mm. For TLIF placement, a complete discectomy was performed using rongeurs and curettes from an extraforaminal approach, sparing both facet joints. The TLIF cages were sized to fit snugly within the disc space. The bulleted design allowed the disc space to self-distract as the TLIF cage was inserted. To test the effects of retained facets, we chose an extraforaminal approach; however, the final TLIF placement was identical to a transfacet approach.

Biomechanical testing

The specimens were studied using standard pure moment flexibility tests. For these tests, an apparatus was used in which a system of cables and pulleys imparts nondestructive nonconstraining torques in conjunction with a standard servohydraulic test system (MTS, Minneapolis, MN, USA), as we have described previously [7]. This type of loading is distributed evenly to each motion segment, regardless of the distance from the point of loading [8]. Loads of 7.5 Nm maximum were applied about the appropriate