Biomechanical Comparison of Cervical Fixation via Transarticular Facet Screws without Rods versus Lateral Mass Screws with Rods

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Key words
- Biomechanical stability
- Cadaver
- Cervical spine
- Lateral mass screw
- Material testing machine
- Rod fixation
- Transarticular facet screw

Abbreviations and Acronyms
LMSR: Lateral mass screw-rod
ROM: Range of motion
TFS: Transarticular facet screw

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OBJECTIVE: **Transarticular facet screws restore biomechanical stability to the cervical spine when posterior cervical anatomy has been compromised. This study compares the more recent, less invasive, and briefer transarticular facet screw system without rods with the lateral mass screw system with rods.**

METHODS: **For this study, 6 human cervical spines were obtained from cadavers. Transarticular facet screws without rods were inserted bilaterally into the inferior articular facets at the C5-C6 and C5-C6-C7 levels. Lateral mass screws with rods were inserted bilaterally at the same levels using Magerl's technique. All specimens underwent range of motion (ROM) testing by a material testing machine for flexion, extension, lateral bending, and axial rotation.**

RESULTS: **Both fixation methods, transarticular facet screws without rods and lateral mass screws with rods, reduced all ROM measurements and increased spinal stiffness. No statistically significant differences between the 2 stabilization methods were found in ROM measurements for 1-level insertions. However, in 2-level insertions, ROM for the nonrod transarticular facet screw group was significantly increased for flexion-extension and lateral bending.**

CONCLUSIONS: **Transarticular facet screws without rods and lateral mass screws with rods had similar biomechanical stability in single-level insertions. For 2-level insertions, transarticular facet screws without rods are a valid option in cervical spine repair.**

INTRODUCTION

Posterior cervical spine stabilization and fusion are mandatory when instability results from tumor, trauma, or inflammatory disease as well as from failed lateral mass fixation and revisions. Hadra in 1891 was the first to report successful stabilization by wire of a cervical fracture secondary to Pott disease (9). Since then, many surgical techniques for posterior cervical stabilization and fusion have been developed; at the present time, placement of posterior screw-rod fixation systems is the established technique in cervical spine surgery. These fixation systems include the lateral mass screw-rod (LMSR), transarticular facet screw (TFS) with or without rod, and cervical pedicle screw-rod (1, 2, 7, 8, 10, 11, 18, 21).

LMSR and TFS fixations provide similar biomechanical performances and have similar fixation forces (18). The cervical pedicle screw-rod fixation system has the strongest fixation force among these techniques (12, 14, 15, 20), with the potential for vascular, cord, and nerve root injuries and pedicle perforations as reported for 6.7%–30% of pedicle screw insertions (1-4). Although TFS systems with rods have relatively weaker fixation forces than cervical pedicle screw systems, they can be placed more easily and have a less probable chance of vascular injury (6). In the present study, we tested and compared the biomechanics of a TFS system without rods versus LMSR fixation for 1-level and 2-level insertions.

MATERIALS AND METHODS

Specimen Preparation

We obtained 6 frozen human cadaveric cervical spines (3 female and 3 male; average age, 63 years; age range, 55–78 years) from Science Care (Phoenix, Arizona, USA) that included cervicothoracic junction vertebrae. The specimens were stored in a refrigerator at −20°C and thawed 2 hours to room temperature before use. Fluoroscopy was performed on each specimen to screen for abnormalities. Surrounding soft tissues and muscles were dissected carefully while preserving facet capsules and midline musculoligamentous structures, including the interspinous and supraspinous ligaments. The C3 and T2 vertebrae of each specimen were potted in polymethyl methacrylate resin. The superior and inferior levels were mounted on a custom frame before screw placement and were attached to the upper and lower spine fixtures, respectively, of the loading material testing system (MTS 858 Mini Bionix II; MTS Systems, Eden Prairie, Minnesota, USA).

Facet Screw and Lateral Mass Screw Placements

All screws were placed under fluoroscopic guidance. For nonrod TFS insertion, a drill bit was used to tap a hole, and 3.5-mm cortical screws (NuVasive, Inc.; San Diego, California, USA) with pullout strength–enhancing washers were inserted bilaterally into the facet joint at the C5-C6 level (Figure 1). This screw size was based on previous work by Heller et al. (23), who demonstrated a fixation superior to various other cortical and cancellous screws. The entry point was 1 mm medial and 1 mm inferior to the midpoint of the inferior articular process, and screws were inserted at an angle 25° laterally and 40° caudally (perpendicular to the facet joint). Screws were optimally positioned so that their ends were close to the anterior cortex of the inferior articular facet below. Biomechanical testing was performed at the C5-C6 level; the C6-C7 screws were placed in the same manner (Figure 2). A 4-cortex penetration was confirmed with fluoroscopy at all levels.

After removal of the TFSs, lateral mass screws with rod (DePuy AcroMed, Inc., Raynham, Massachusetts, USA) were inserted first at C5-C6 and then at C5-C7 bilaterally. These insertions followed Margerl's technique (16). The entry points of the lateral mass screws were 1 mm medial and 1 mm superior to the midpoints of the lateral masses, and each screw was placed along a trajectory 45°–50° cephalad and 15°–20° lateral (Figure 3). Biomechanical testing followed.

Biomechanical Testing

Each superior and inferior vertebra of the cervical cadaver specimen being tested was held in a custom frame, which was attached to the fixture of the material testing system machine. Stability of the intact specimen was tested first in 6 modes of motion: flexion and extension, right and left lateral bending, and right and left axial rotation. For each mode of loading, the range of motion (ROM), defined as the angular deformation in all directions at maximum load, was measured. Moments of 2 N-m were applied for each mode of testing with an axial preload of 20 kN.

For comparison of the biomechanical stabilities, 4 different surgical procedures were performed on each specimen, and 6 modes of motion were tested on the C3-T1 spine after each procedure. The following specimens were prepared and tested: the intact spine, nonrod TFS fixations at C5-C6 (1-level) and C5-C7 (2-level), and LMSR fixations at C5-C6 (1-level) and C5-C7 (2-level).

Motion of the C5-C6 and C5-C7 specimens was captured by a video-based motion capture system (Qualisys AB, Gothenburg, Sweden), which used 3 reflective markers at each of the C5, C6, and C7 levels, as required. Axial compression and rotation were provided by the upper spine fixture, whereas flexion-extension and lateral bending were provided by rotation of both spine fixtures in the coronal sagittal plane. The mean value of the ROM for each specimen group was determined, and nonparametric statistical methods were used to ascertain the significant differences among each group because the number of specimens was limited, and data could not be assumed to be normally distributed. Paired comparisons were made between different treatment groups by using the Wilcoxon signed rank test, and significance was assigned at $P < 0.05$.

RESULTS

Flexion-Extension Mode

For flexion-extension, normal ROM values were 11.8 ± 1.4 (mean $\pm$ SE) for the intact C5-C6 levels and 22.7 ± 1.5 for the intact C5-C7 levels (Figure 4). In the 1-level C5-C6 experiment, ROM values were 2.5 ± 0.3 for nonrod TFS fixations and 2.9 ± 0.6 for LMSR fixations. There were no significant differences in ROM between nonrod TFS and LMSR fixation groups in 1-level instrumentation ($P = 0.40$). In the 2-level experiments at C5-C7, ROM values were 6.1 ± 0.5 for nonrod TFS fixations and 3.1 ± 0.4 for LMSR fixations. The C5-C7 2-level instrumentation values represented significant differences in ROM between the 2 groups ($P = 0.018$).

Lateral Bending Mode

The normal ROM values for lateral bending were 4.3 ± 0.7 (mean $\pm$ SE) for the intact C5-C6 levels and 9.7 ± 1.0 for the intact spine at C5-C7. In the 1-level experiments for lateral bending at C5-C6, ROM values were 0.9 ± 0.2 for nonrod TFS fixations and 1.1 ± 0.3 for LMSR fixations. In the 2-level experiments at C5-C7, ROM values were 2.8 ± 0.3 for nonrod TFS fixations and 2.0 ± 0.3 for LMSR fixations. There were

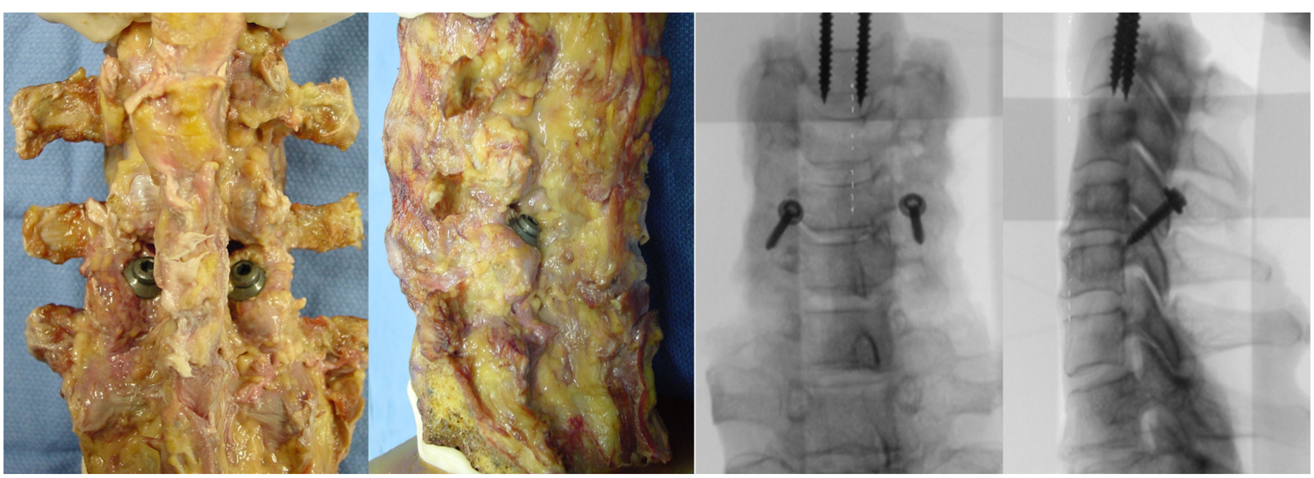

Figure 1. Bilateral placement of transarticular facet screws at C5-C6 and x-ray findings.