# A PEDICLE SCREW BASED DESIGN FOR AN ARTIFICIAL FACET JOINT

[1] Miranda N. Shaw, [1]Vijay K. Goel, [1]Koichi Sairyo, [1]Srilakshmi Vishnubholta, [1]Ashok Biyani
[1]Spine Research Center, University of Toledo and Medical College of Ohio, Toledo, OH; email: vijay.goel@utoledo.edu

## INTRODUCTION

Spinal disorders such as disc degeneration can cause debilitating pain. Currently, several surgical interventions are used to restore spinal stability and normal function in LBP patients. Such surgical techniques include spinal fusion which impairs normal function and the success rate varies. Recently, normal biomechanical motion is restored utilizing artificial discs. Although controversial, if normal function of the spine is to be restored the facet joints may be replaced. Facet replacements may be indicated in cases of facet hypertrophy, spinal stenosis, etc. The following study presents a biomechanical analysis of a pedicle screw based artificial facet design using the finite element technique.

## METHODS

A 3-dimensional, non-linear, ligamentous, experimentally validated, finite element model of the L3-S1 segment was used to determine the effectiveness of an artificial facet. The L4 inferior and L5 superior facets were removed and replaced with artificial L4/5 facets constructed of titanium. The artificial facets were attached to L4/5 titanium pedicle screws (Figure 1A). The capsular ligaments and L4/5 facets were removed for simulation of the surgical technique used to replace the facet joint. For comparison purposes, a rigid pedicle screw and rod system was also simulated with a facetectomy at the L4/5 segment. A 400N compression load and 10.6 Nm extension and rotational moment were applied, being the most relevant loading modes for facet function.

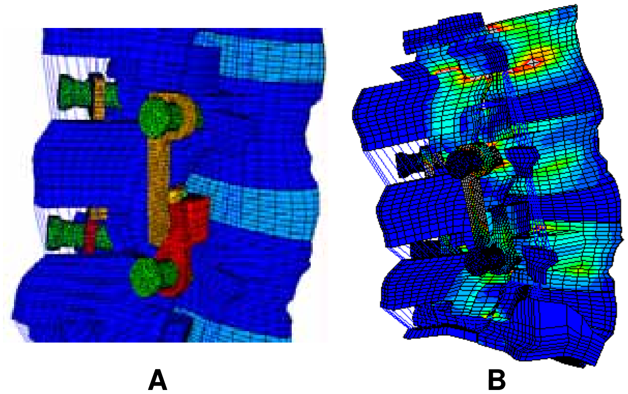


**Figure 1**: L3-S1 Finite element model. **(A)** Model of facet joint replacement across L4/5. **(B)** Stresses acting on the spine and artificial facet joint in extension.

## RESULTS AND DISCUSSION

**Table 1**: Angular motion (deg) across L4/5 for 400N compression and a 10.6Nm bending moment.

| Relative angular motion across L4/5 | Intact Spine | Spine with artificial facet |
|---|---|---|
| Extension | 3.6 | 5.1 |
| Rotation | 2.9 | 4.2 |

**Table 2**: Facet loads (N) transmitted across the L4/5 facet joint at 400N compression and a 10.6Nm bending moment.

| Facet load (N) | Normal facet | Artificial facet |
|---|---|---|
| Extension | 324 | 245 |
| Rotation | 157 | 159 |

The relative angular motion across the L4/5 segment increased as compared to intact, in both extension and rotation. Loads through the artificial joint increased in rotation by 1% but decreased in extension by 25% as compared to the intact case. In extension, a peak von Mises stress of 109MPa was located in the L4 artificial facet pedicle screw while in the rigid screw system the peak stress in the pedicle screw was 122MPa. Stresses on the joint and spine are shown in Figure 1B. For the pedicle screw system, a peak stress in the L4 pedicle screw of 107MPa occurred in rotation as compared to 161MPa for the rigid screw system.

## CONCLUSIONS

The pedicle screw artificial facet design resulted in increased motion at L4/5 due to capsular ligament removal. Loads transferred through the artificial joint also differed from intact loads. The L4 pedicle screw stresses were less with artificial facets than a rigid screw system suggesting that the artificial facet design will perform similarly to the rigid screw system in the pedicles. Additional investigations are needed for other loading modes and designs to understand the complex biomechanical issues involved with the design of artificial facets.