

Basic Science

Influence of an auxiliary facet system on intervertebral discs and adjacent facet joints

Yann Philippe Charles, PhD^{a,b,*}, Lucas Venancio Pires Carvalho Lima, MSc^a,
Sylvain Persohn, MSc^a, Philippe Rouch, PhD^a, Jean-Paul Steib, MD^b, Wafa Skalli, PhD^a

^aLaboratoire de Biomécanique, Arts et Métiers ParisTech, Paris, France

^bService de Chirurgie du Rachis, Hôpitaux Universitaires de Strasbourg, Fédération de Médecine Translationnelle, Université de Strasbourg, 1, Place de l'hôpital, B.P. 426, 67091 Strasbourg Cedex, France

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Abstract

BACKGROUND CONTEXT: Facet supplementation stabilizes after facetectomy and undercutting laminectomy. It is indicated in degenerative spondylolisthesis with moderate disc degeneration and dynamic stenosis.

PURPOSE: To determine the influence of an auxiliary facet system (AFS) on the instrumented disc, adjacent levels' discs, and facet joints and to compare it with fusion.

STUDY DESIGN: Finite element study.

METHODS: L3–L4, L4–L5, and L5–S1 were studied using a validated finite element model with prescribed displacements for an intact spine, lesion by facetectomy and undercutting laminectomy, AFS, and fusion at L4–L5. The distribution of segmental range of motion (ROM) and applied moments, von Mises stress at the annulus, and facet joint contact forces were calculated with rotations in all planes. Institutional support for implant evaluation and modeling was received by Clariance.

RESULTS: In flexion-extension and lateral bending, fusion decreased L4–L5 ROM and increased adjacent levels' ROM. Range of motion was similarly distributed with intact lesion and AFS. In axial rotation, L4–L5 ROM represented 33% with intact, 55% after lesion, 25% with AFS, and 21% with fusion. Fusion increased annulus stress at adjacent levels in flexion-extension and lateral bending, but decreased stress at L4–L5 compared with AFS. In axial rotation, von Mises stress was similar with fusion and AFS. Facet loading increased in extension and lateral bending with fusion. It was comparable for fusion and AFS in axial rotation.

CONCLUSIONS: This study suggests that the AFS stabilizes L4–L5 in axial rotation after facetectomy and undercutting laminectomy as fusion does. This is because of the cross-link that generates an increased annulus stress in axial rotation at adjacent levels. With imposed displacements, without in vivo compensation of the hips, the solicitation at adjacent levels' discs and facet joints is higher with fusion compared with AFS. Fusion decreases intradiscal stress at the instrumented level. © 2013 Elsevier Inc. All rights reserved.

Keywords:

Finite elements; Facet supplementation; Segmental kinematics; Annulus stress; Facet joint contact forces

FDA device/drug status: Investigational (NeoFacet™ facet supplementation system, Clariance).

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The disclosure key can be found on the Table of Contents and at www.TheSpineJournalOnline.com.

* Corresponding author. Laboratoire de Biomécanique, UMR 8005, Arts et Métiers ParisTech, 151, Boulevard de l'Hôpital, 75013 Paris, France. Tel.: +(33) 3-88-11-68-26; fax: +(33) 3-88-11-52-33.

E-mail address: yann.philippe.charles@chru-strasbourg.fr (Y.P. Charles)

Introduction

Lumbar motion preservation systems are aimed to reduce the risk of adjacent segment degeneration (ASD) after spinal fusion [1,2]. Total disc replacement represents an effective treatment for low back pain caused by discopathy [3–5]. Nevertheless, load sharing between the disc and the facet joint complex leads to facet degeneration which may arise as a consequence of discopathy [6]. Facet degeneration may also develop after total disc replacement, resulting in secondary pain [7,8]. This has spawned an interest in the development of posterior nonfusion systems, facet resurfacing, and replacement devices, which address the problem of osteoarthritis and subsequent stenosis [9].

Instrumentation is required after facetectomy or arthrectomy because of segmental destabilization in axial rotation and under shear loading [10,11]. Facet replacement systems were primarily designed for the surgical treatment of lumbar stenosis. In vitro studies and finite element models (FEMs) indicated that these implants could stabilize a lumbar segment and maintain mobility after partial or total facet resection and laminectomy [12–15]. Preliminary results from clinical trials indicate an improvement of the visual analog scale for pain and the Oswestry Disability

Index in degenerative spondylolisthesis [16–18]. Büttner-Janz [9] reported not only on single posterior facet replacement in patients with sufficient disc height but also on additional total disc replacement at the same level to treat disc and facet degeneration. It is not clear to what extent decompression should be performed because shear forces are transmitted through the implant, and two device-related complications with pedicle fixation fractures were reported for one system [19].

The NeoFacet™ (Clariance, Dainville, France) represents an auxiliary facet system (AFS) that was designed for facet supplementation in the following indications: facet osteoarthritis, lateral recess stenosis treated by facetectomy and undercutting laminectomy, and degenerative spondylolisthesis Grade I with a remaining disc height. The AFS uses four pedicle screws with two angulated rods fixed cranially (Fig. 1). The rods are linked to caudal screws by polyaxial connectors, allowing three-dimensional movements. Both rods are cross-linked to restrain axial rotation. Pedicle screws are made of titanium and other components from a cobalt-chromium-molybdenum alloy (CoCrMo).

A previous in vitro study [20] demonstrated that this device could preserve flexibility between lumbar

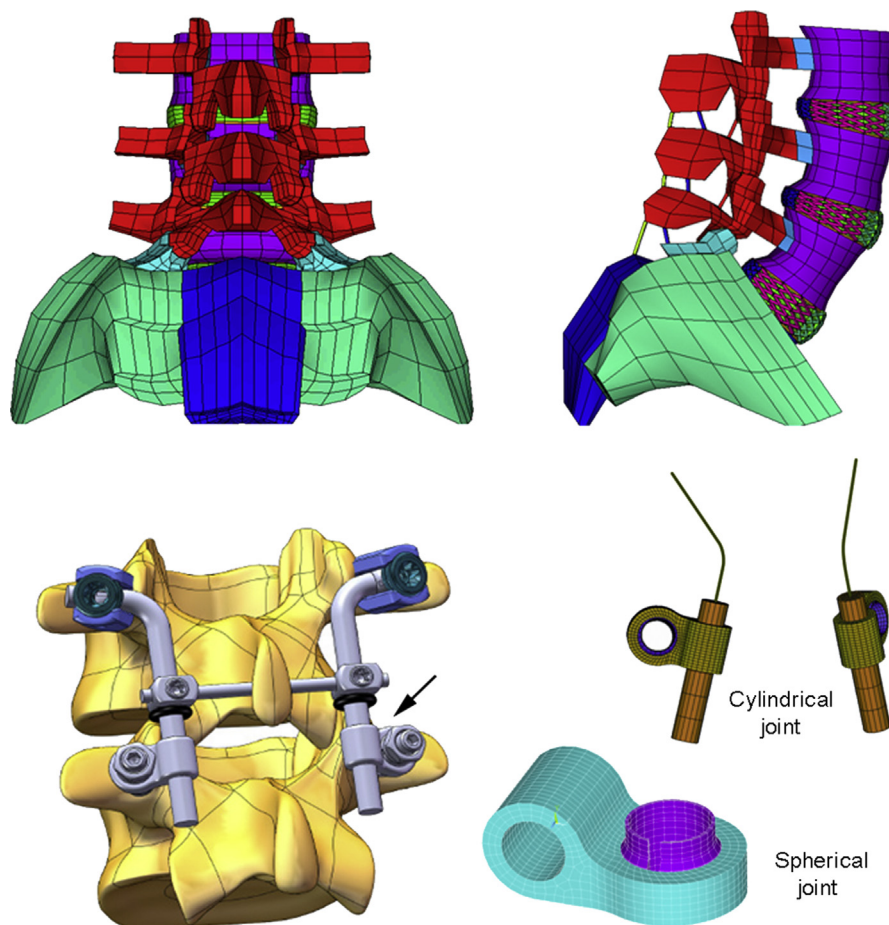


Fig. 1. Finite element model of L3–S1 and auxiliary facet system with detailed view of polyaxial connector (arrow): cylindrical and spherical joints.

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