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# Interbody device endplate engagement effects on motion segment biomechanics

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**Abstract**

**BACKGROUND CONTEXT:** Stand-alone nonbiologic interbody fusion devices for the lumbar spine have been used for interbody fusion since the early 1990s. However, most devices lack the stability found in clinically successful circumferential fusion constructs. Stability results from cage geometry and device/vertebral endplate interface integrity. To date, there has not been a published comparative biomechanical study specifically evaluating the effects of endplate engagement of interbody devices.

**PURPOSE:** Lumbar motion segments implanted with three different interbody devices were tested biomechanically to compare the effects of endplate engagement on motion segment rigidity. The degree of additional effect of supplemental posterior and anterior fixation was also investigated.

**STUDY DESIGN/SETTING:** A cadaveric study of interbody fusion devices with varying degrees of endplate interdigitation.

**OUTCOME MEASURES:** Implanted motion segment range of motion (ROM), neutral zone (NZ), stiffness, and disc height.

**METHODS:** Eighteen human L23 and L45 motion segments were distributed into three interbody groups (n=6 each) receiving a polymeric (polyetheretherketone) interbody spacer with small ridges; a modular interbody device with endplate spikes (InFix, Abbott Spine, Austin, TX, USA); or dual tapered threaded interbody cages (LT [Lordotic tapered] cage; Medtronic, Memphis, TN, USA). Specimens were tested intact using a 7.5-Nm flexion-extension, lateral bending, and axial torsion flexibility protocol. Testing was repeated after implantation of the interbody device, anterior plate fixation, and posterior interpedicular fixation. Radiographic measurements determined changes in disc height and intervertebral lordosis. ROM and NZ were calculated and compared using analysis of variance.

**RESULTS:** The interbody cages with endplate spikes or threads provided a statistically greater increase in disc height versus the polymer spacer ($p=.01$). Relative to intact, all stand-alone devices significantly reduced ROM in lateral bending by a mean 37% to 61% ($p\leq.001$). The cages with endplate spikes or threads reduced ROM by ~50% and NZ by ~60% in flexion-extension ($p\leq.02$). Only the cage with endplate spikes provided a statistically significant reduction in axial torsion ROM compared with the intact state (50% decrease, $p<.001$). Posterior fixation provided a significant reduction in ROM in all directions versus the interbody device alone ($p<.001$). Anterior plating decreased ROM over interbody device alone in flexion-extension and torsion but did not have additional effect on lateral bending ROM.

FDA device/drug status: approved for this indication (Tapered threaded cage; PEEK interbody spacer; Modular spacer).

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**CONCLUSION:** The cages with endplate spikes or threads provide substantial motion segment rigidity compared with intact in bending modes. Only the cages with endplate spikes were more rigid than intact in torsion. All devices experienced increased rigidity with anterior plating and even greater rigidity with posterior fixation. It appears that the endplate engagement with spikes may be beneficial in limiting torsion, which is generally difficult with other ''stand-alone'' devices tested in the current and prior reports. © 2009 Elsevier Inc. All rights reserved.

*Keywords:* Biomechanical; Cadaveric; Endplate; Flexibility; Interbody; Lumbar

## Introduction

Anterior lumbar interbody fusion (ALIF) may be achieved using a variety of techniques. Successful stand-alone ALIF is attractive because it avoids damage to the posterior lumbar musculature [1–4]. ALIF with autologous structural bone graft may result in morbidity to the donor site, whereas allografts, such as femoral cortical ring allografts (femoral ring allograft [FRA]) have limited availability, variable biomechanical properties, and risk disease transmission [5,6]. Alternatives include nonbiologic interbody devices or cages that give structural interbody support and are typically packed with morselized bone graft to obtain fusion.

Despite the appeal of stand-alone ALIF, the clinical success of stand-alone ALIF with structural bone or nonbiologic interbody fusion devices has been variable [7–20]. The clinical variability may be related to the interbody device design's effect on motion segment stability, which may then influence the rate of obtaining a solid arthrodesis. Most cages are available in only limited sizes and lordosis angles, and there may be a lack of congruity of the device to the interbody space. The biomechanical stability of anterior interbody stand-alone devices, of which there are numerous designs, has been studied previously [21–27]. A common finding is the inability to limit torsion [22,25,27,28]. This includes threaded devices, in which the threads are oriented approximately tangent to the applied moment resulting in ''rolling'' of these cylindrical implants [16,22,29]. Tapered cages have been used in place of FRA or polymeric spacers as stand-alone devices or in combination with supplemental fixation [30]. Some devices have design features such as radiolucency that allows assessment of fusion, some have endplate interdigitation with serrations, screw threads, or spikes, and others are modular. Modular devices are able to accommodate a greater variety of disc space sizes and degree of lordosis, and therefore can be customized to a specific patients' desired intervertebral geometry. Interbody spacers that penetrate the endplate with spikes may better resist torsion.

Additional interbody fusion construct stability may be achieved with supplemental fixation, such as anterior plating or posterior interpedicular fixation. It is unknown whether interbody devices combined with this supplemental fixation provides all interbody fusion techniques with variable or the same increase in rigidity, or whether different interbody techniques will approach a common level of rigidity with supplemental fixation. To date, there has not been a published biomechanical study specifically comparing the stability of interbody device designs with different modes of endplate interdigitation (spacer, modular with spikes, and taper/threaded) with or without supplemental fixation.

The purpose of this study was to compare three interbody devices with different endplate engagement and insertion methods. The first device, a polymeric spacer, had minimal 0.5-mm ridges for endplate engagement, the second was a modular spacer with multiple 1.5-mm spikes, and the third was a tapered/threaded cage with 1.0-mm deep threads. They were compared in terms of their ability to decrease interbody motion, increase disc height, and maintain normal lordosis. Furthermore, the effect of supplemental posterior pedicle screw and anterior plate fixation on each device was investigated.

## Materials and methods

Eighteen human L2–3 and L4–5 motion segments were distributed across three interbody device groups—polymeric cage (polyetheretherketone, FRA-type interbody spacer with 0.5-mm serrations in the coronal plane), modular interbody spacer (InFix; Abbott Spine, Austin, TX, USA) with 12 1.5-mm spikes per endplate and holes that allow bone to grow through, and tapered interbody cages (LT [Lordotic tapered] cage; Medtronic, Memphis, TN, USA) with 1.0-mm deep threads for endplate engagement (Fig. 1). Specimens were distributed such that each group contained three L2–3 and three L4–5 motion segments, and no group contained more than one motion segment from the same donor. All specimens were tested intact, after simulated anterior fusion surgery using ''stand-alone'' device (''ALIF''), after ALIF and supplemental posterior interpedicular fixation (Fig. 2, top), and after ALIF and supplemental anterior plate fixation (Fig. 2, bottom).

### *Specimen preparation*

Fresh-frozen human cadaveric lumbar spines were obtained from donors aged 33 to 64 years. Donor tissue was free of bone metastasis, auto-fusion, or advanced spondylosis as evidenced by direct examination, radiographs, and

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