Interbody cage footprint sizes that extend to endplate peripheral region provide better resistance to subsidence

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Introduction:

The goal of the fusion surgery is to fuse the adjoining vertebrae and alleviate pain. An intervertebral cage restores disc height and provides initial stability. However, surgeons may have the option to use implants with various footprints and material properties. The researchers wanted to study the biomechanical effects of increasing footprint sizes through the finite element method.

Methods:

A previously experimentally validated finite element model of an L2-L3 functional spinal unit (FSU) was used [1]. First, a pure moment of ±10 N*m was applied in extension (Ext), flexion (Flex), left bending (LB), right bending (RB), right rotation (RR), and left rotation (LR), Then a 400 N preload was added along with 10 Nm moment only in extension (WP Ext), and flexion (WP Flexion). The TLIF surgical technique was simulated (facetectomy and total discectomy) before cage insertion. Input parameters were different cage footprints (10mm by 26 mm, 14 mm by 30 mm, and 18 mm by 34 mm) and cage material (PEEK or Titanium). The range of motion (ROM) and inferior endplate stresses were computed to assess stability and subsidence as function of footprint and material.

Results:

With the standalone cage, the ROM increased for all loading conditions (shown with an '*', Table 1), compared to the intact data. However, as the footprint increased, the motion was closer to the intact but may not be adequate to stabilize the segment. The location of the highest contact stresses was at the outer edge of the cage footprint in all loading conditions. As the device footprint increased, the location of the highest contact stress changed towards the periphery of the endplate, which is much stronger than the inner endplate region (Table 2).

Discussion:

Data demonstrated increased motion in all loading conditions due to the facetectomy in the TLIF technique since facets resist extension, lateral bending, and axial rotation. As the implant footprint increased, ROM became closer to intact in certain motions. This finding suggests that larger footprint implant will provide better stability when used in conjunction with posterior fixation. The bigger footprint shifted the stress concentration and location to change towards the stronger portion of the endplate (Table 2). Titanium cages followed the same pattern for the contact stress but the magnitude was higher due to the material properties. This suggests that larger footprint cage may have lower tendencies to subside when compared to small footprint cages which have high contact stress in the middle region of the endplate. Standalone cage scenarios were intentionally simulated to understand the contributions of the implant only to stability and subsidence. Studies are in progress to simulate posterior fixation.

Significance:

Increasing implant footprint may reduce the motion as well as the tendency to subside when compared to smaller footprint cages. The use of pedicle screw system in addition will further assist the larger footprint cages. Surgeons should use cages with a footprint that will establish contact in strong peripheral bone endplate region, as far as practical.

References: A. Agarwal, A.K. Agarwal, A. Jayaswal, V.K. Goel; *Effect of distraction force on growth and biomechanics of the spine: a finite element study on normal juvenile spine with dual growth rod instrumentation*. Spine Deformity, 2 (2014), pp. 260–26

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Figures/Tables:

Table 1: ROM for the different footprints and materials of the cage.

	Ext	Flex	LB	RB	RR	LR	WP Ext	WP Flex
TLIF FEA intact	5.10	4.52	3.54	3.53	2.62	2.62	4.93	4.59
PEEK 10 x 26 mm	10.01*	5.54*	5.23*	4.57*	4.01*	7.31*	10.42*	4.71*
Titanium 10 x 26 mm	9.65*	5.50*	3.58*	3.31	4.56*	7.06*	10.51*	4.83*
PEEK 14 x 30 mm	9.50*	5.30*	3.85*	3.45	3.60*	7.50*	9.10*	5.30*
Titanium 14 x 30 mm	8.99*	5.80*	2.80	2.50	3.60*	7.80*	7.90*	5.40*
PEEK 18 x 34 mm	7.60*	5.40*	2.90	2.10	3.42*	7.20*	6.30*	5.30*
Titanium 18 x 34 mm	6.60*	5.40*	2.00	1.60	3.10*	7.60*	5.50*	5.30*

Table 2: Contact stress location for only the PEEK footprints. Dark lines show the location of the cage. The contact location for the PEEK and Titanium were the same, although stresses were higher for the Titanium cages.