INTRODUCTION

Transforaminal Lumbar Interbody fusion (TLIF), using interbody cages is a popular surgical method of treating various spinal disorders. In the past few years, various types of interbody cages have been introduced to spine surgeons. These interbody devices vary in shapes and footprint sizes [1]. The footprint size of the interbody device is an important factor that determines the biomechanical stability afforded by these implants. Moreover, occurrence of subsidence is also believed to be influenced by the footprint size of the device. We hypothesized that a large footprint interbody would help distribute the endplate stresses over a wide surface area, leading to lower peak stresses. Such a device may reduce the occurrence of cage subsidence. For this purpose a Finite Element (FE) analysis was conducted to compare the loading & stress at vertebral endplate following implantation with a AVID TLIF cage with a large footprint compared with regular TLIF cage in different configuration.

METHODS

A 3D, ligamentous, experimentally validated finite element model of L3-S1 lumbar segment [2] was used for this study. The 3D models of the AVID interbody cage as well as a regular TLIF cage were obtained and transferred into the FE model. Four different surgical cases, as shown in figure 1, were simulated which included: A) Double TLIF B) Symmetric TLIF c) Asymmetric TLIF and D)AVID TLIF device. Each cage was placed inside the L4-L5 segment following a simulated surgical procedure which included a unilateral facetectomy plus partial annulectomy and total nucleotomy.

To simulate the surgical procedure for placement of the cage inside the segment, the lower vertebrae (L5) was fixed and the upper one (L4) was distracted until required intervertebral height was achieved for placement of the cage, then a contact was defined between the cage and the vertebral endplate allowing settlement of the vertebral on the cage. A rough friction formulation was then simulated at the interface of cage with endplate and graft with endplate to simulate the rigid fixation at the interface. The cages were assigned material property of PEEK (E=3400 MPa, v=0.3) and were filled with cancelous bone graft (E=100 MPa, v=0.3). A titanium (E=115 GPa, v=0.3) screw-rod fixation construct was added to the cage implanted segment. The rods were fixed to the screw heads and the screws were affixed to the pedicle bone.

Following placement of the cage, first a pre-compressive follower load of 400N was applied to the spine to simulate compression (at standing posture) then a 10Nm bending moment was applied to the segment to simulate physiological Flexion and Extension loadings. The normal load applied to the endplate was computed and the stress distribution at the endplate was plotted for each case.

RESULTS

The normal load applied to the superior endplate is presented in figure 2 for each surgical case. As expected the double TLIF and AVID cases observed slightly higher normal loads at the endplates compared to the other cases in all loadings due to their higher contact area with bone at the interface. The stress distribution at L4 endplate is presented in figure 3. There was smaller stress concentration area, with concentration towards the outer rings of the endplate, for the AVID implanted case.

DISCUSSION

It is evident from the stress contours that the large footprint interbody device (AVID) results in lower stresses in the endplate immediately after surgery. The bigger contact area (Double TLIF & AVID vs. single TLIF case) however leads to an increase in the load applied to the endplate but this in part reduces the load going through the supplementary posterior construct (reducing the failure risk). Moreover, in case of AVID, stresses are distributed in the peripheral region of the endplate (vs. double TLIF and single TLIF case) which is believed to be stronger than central region [3]. Therefore, based on FE data, AVID implant may be able to lower the incidence of subsidence as compared to regular TLIF devices.

SIGNIFICANCE

The FE analysis of the interbody cages provides a good insight regarding the load sharing at the interface of the cage with the bone and subsidence and is helpful to evaluate the critical loadings and cases which may lead to a potential failure and fracture at the endplates.

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REFERENCES