INTRODUCTION

Interbody fusion devices have long been used for treatment of various spinal disorders including deficits of the anterior column of a spinal segment [1,2]. VariLift interbody fixation is novel expandable fusion device which is intended for segmental fixation. Unlike the traditional cage designs, VariLift is able to adjust to the lordotic angle of the motion segment through the expansion mechanism following insertion into the motion segment. In this study, a finite element (FE) analysis was conducted to evaluate the biomechanics of VariLift and comparing its biomechanics with other commercially available cages with similar surgical approach.

METHODS

A 3D, ligamentous, experimentally validated finite element model of L4-L5 lumbar segment [3] was used for this study, Figure 2. The 3D model of the VariLift device as well as a titanium cage (BAK) and a PEEK cage were transferred into the FE model of the segment. The fusion devices were placed into the segment following simulation of PLIF surgical approach. The FE model was modified to simulate a midline laminotomy through bilateral medial facetectomy, partial removal of lamina, incision of ligament flavum and posterior longitudinal ligament plus total nucleotomy and partial removal of annulus. The devices were filled with cancellous bone graft and placed bilaterally on the endplate as shown in Figure 3. A screw-rod fixation construct was added to standalone device implanted models to simulate anterior plus posterior fixation. A rough friction formulation was simulated at the interface of device with endplate and graft with endplate to simulate the rigid fixation at the interface. The rods were fixed to the screw heads and the screws were affixed to the pedicle bone. For the VariLift simulations, a sliding wedge inside each cage was moved along anteriority until the cages were fully expanded with lordotic correction. The expanded device was stabilized within the endplates.

A pre-compressive load of 400N followed by 8Nm moment was applied to each model to simulate physiological loadings of Flexion (Flex), Extension (Ext), Left and Right Bending (LB & RB) and Left and Right Rotation (LR & RR). The segmental motion and normal load and stress applied to the endplates were computed and compared among cases.

RESULTS

The changes in segment kinematics following surgery with respect to intact is shown in Figure 4. For the stand alone device models the VariLift provided more constraint in motion compared to BAK and PEEK cages in Ext, Flex, LR & RR loadings. However in lateral bending the VariLift and BAK cages led to almost similar reduction in motion but still less than the PEEK. Addition of posterior screw system lead to a further decrease in motion. In these cases all device models observed a 90% reduction in intact segment motion in all loadings. The resultant normal load as well as the peak stress applied to the inferior endplate are presented in Figures 5&6. Addition of posterior fixation led to a reduction in normal load applied on the anterior column in extension loading. However in Flexion the effect was vice-a-versa and the endplates observed a higher compressive load when posterior screws were added compared to the stand alone device cases. This effect can be related to the posterior shift in the fulcrum point between the anterior and posterior column which occurs when the posterior construct was added leading to higher distribution of compressive load applied to the endplate compared to the standalone case where part of compressive load balances with the tensile load leading to a smaller resultant load applied to the endplate. In lateral bending and axial rotation loadings all models experienced an almost similar normal load going through the endplate. The peak stress on the endplate was almost similar in standalone VariLift and BAK models and slightly higher than PEEK model in Extension loading. In Flexion model, however VariLift led to a lesser peak normal stress applied to the endplate compared to the other two cages. Addition of posterior screws decreased the maximum normal stress on endplate in all Flex, Ext, LB and RB loadings.

DISCUSSION

The VariLift device showed biomechanical effects on the lumbar segment comparable with those of BAK and a regular PEEK cage. The expansion mechanism leads to a relatively big contact area between the segment comparable with those of BAK and a regular PEEK cage. The expansion mechanism leads to a relatively big contact area between the segment ensuring a better contact between the cage and endplates. In post-surgery. The expansion of the cage has also the advantage of adjusting of the device outer profile to the lordotic angle of the treated segment ensuring a better contact between the cage and endplates. In standalone configuration, VariLift showed significant increase in segment fixation while transmitting a higher normal load compared with other devices in standalone configuration. This showed that standalone VariLift is an effective spinal fixation system that promotes fusion by reduced stress shielding of the graft.

SIGNIFICANCE

Understanding the changes in load sharing at the endplate following inter body cage placement is crucial. It may provide insight about the long term performance of the procedure and predict the risk for adverse effects such as subsidence, failure and fracture of the implant and at bone-implant interface, etc. FE analysis is a helpful tool to evaluate such important biomechanical parameters which are hard or impractical to measure in vitro/in vivo.

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REFERENCES