THE EFFECT OF INTERBODY ARTHRODESIS CAGES ON PEDICLE SCREW AND ROD STRAIN. AN IN-VITRO HUMAN CADAVERIC STUDY.

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Study Purpose: Screw breakage is one of the significant complications when using pedicle screw fixation. In our previous study, we demonstrated that anterior placement of an interbody fusion cage in the sagittal plane produced higher screw hub strain than pedicle screw fixation alone. The purpose of the current study was twofold; 1) Analyze the influence of cage placement in the sagittal plane on the pedicle screw and rod strain using human cadaver spine, and 2) Investigate the effects of interbody fusion cage designs on pedicle screw and rod strain.

Materials and Methods: Six human cadaveric lumbosacral spines (67.5 ± 5.5 yrs.) were utilized in this investigation. 7.0-mm CD transpedicular screws (Sofamor Danek) and 5.5 mm diameter rods were instrumented between the L4 and L5 segment. To measure the strain, modified CD screws instrumented with internal strain gages at screw hub and middle shaft were used in the L4 pedicle, and two strain gages were attached on the anterior and posterior surface of the left spinal rod. Biomechanical testing was performed using a MTS 858 testing device and included axial compression loading modes of 200 Newtons, 500 Newtons, and 1000 Newtons, respectively. After testing of the L4-L5 pedicle screw alone (PS), interbody cages were inserted as follows: [1] anterior placement of titanium mesh cage (Depuy-AcroMed) (AC); [2] middle placement of titanium mesh cage (MC); [3] posterior placement of titanium mesh cage (PC); [4] bilateral carbon PLIF cages (Depuy-AcroMed) (BC); [5] oblique BAK cage (Sulzer-Spinetech) (OB); [6] In-Fix device (Spinal Concepts) (IF). Importantly, the interbody reconstructions were preloaded to -100 Newtons prior to interconnection tightening. The screw and rod strain of all reconstruction techniques were used for the calculation of bending moment and stress, and those were statistically compared using a one-way ANOVA combined with post-hoc Scheffe’s PLSD. Interactions between bending stress and compressive load was analyzed using linear regression analysis.

Results: Mean bending moment of the screw hub for all reconstructions are shown in figure 1. The PS indicated highest values compared to the other reconstructions in all loading modes (p<0.05). Under 1000N compression, all cage reconstructions except AC demonstrated a significantly lower bending moment (p<0.05). No significant differences were detected between PS and AC in all loading modes (p>0.05). The same correlation was observed in bending moment of the screw shaf, while the values were approximately 40% less than those with screw hub. For bending moment of the rod, PS indicated the highest values compared to other reconstructions in all loading modes, though no significant differences were indicated (p>0.05). From the experimental data of bending stress at the screw hub, linear regression analysis was performed. A strong correlation between bending stress and compressive load was observed in all reconstructions (R²=0.96). The calculated value that would exceed the endurance limit of 316L stainless steel (270 MPa) was 2,095 Newtons in PS and 3,214 Newtons in AC reconstruction (Figure 2).

Discussion: The current investigation highlights two important findings regarding the effect of interbody fusion cage placement on screw and rod strain. 1) In the sagittal plane analysis, anterior placement of a cage significantly increased screw strain. From our results, the screw might undergo screw breakage if the physiological compressive force in the lumbar spine exceeds 3,214 Newtons. The interbody fusion cage should be placed as posterior as possible in sagittal plane. 2) Different cage design analysis included three different cages of BC, OB, and IF. All cages lead to significant decreases in screw strain. This may account for the improved lower rate of screw breakage clinically1 when using interbody arthrodesis cages.

Figure 1 Mean bending moment at screw hub for all reconstructions are shown. There are significant differences between PS and symbolized groups in 200N (‡: p<0.05), in 500N (#: p<0.05), and in 1000N (‡: p<0.05).

Figure 2 Linear regression analysis between bending stress and compressive load at screw hub in AC and PS reconstruction are shown. A strong correlation was observed in AC (R² = 0.99) and in PS (R² = 0.985). The dotted line depicted the endurance limit of the screw material (270 MPa).

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