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The Influence of Total Disc Arthroplasty Baseplate Design on Anterior/Posterior Endplate Loading  
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Introduction: Problems with arthrodesis include loss of spinal motion at the index level and increased likelihood for adjacent segment degeneration. Total disc replacement (TDR) is growing in acceptance, however, TDR stability and migration remains concerning. The purpose of this study was to determine initial stability and resistance of TDR baseplate designs in anterior posterior shear.

Materials and methods: Three baseplate designs representative of TDR baseplates under development or market approval were evaluated. The first design encompasses a large central tapered keel (LK). The second design displays a smaller central keel (SK) with a “saw-tooth” profile. The third design possessed a convex domed shaped (DM) base plate with sequentially reduced ellipses comprising the dome. None of the devices possessed a bone ingrowth texture.

Six bovine lumbar vertebrae were contoured for each device. For the LK and SK devices, endplates were milled flat and a keel fabricated. In the case of the DM baseplate, a sanding tool was used to create a concavity within the central region of the endplate.

Vertebrae were secured perpendicular to a load cell and a compressive pressure of 103kPa was applied using a pneumatic air cylinder in order to maintain contact between the TDR baseplate and the vertebral body. A ±100N anterior to posterior load at a frequency of 1Hz for 500 cycles was applied. Continuous load and deflection data was recorded after the first 10 cycles and at 25 cycle intervals thereafter. For each device, the net migration at each cycle interval was averaged and subjected to a non-linear analysis. The fitted parameters were subjected to a 1 way ANOVA with a Tukey post-hoc analysis for comparison between TDR baseplates.

Results: The resulting non-linear exponential fit of the form \((Yo*e^{-K\times cycles} + Plateau)\) was utilized for net deflection versus cycle number for the baseplate geometries. Initial deflection, \(Yo\), for the TRD geometries is statistically different for all designs with the greatest anterior/posterior motion displayed by the DM design (P< 0.05 for all). A similar finding was seen for the asymptotic plateau where the designs were statistically different (P< 0.05 for all). With respect to the K value or settling rate, there was no statistical difference between the DM, LK and SK designs (P>0.05 for all). The span or change from the initial loading cycles did not indicate a difference between designs (P>0.05 for all).

Discussion: The axial stability of a keeled base plate relies on rim contact with cortical bone edges of the vertebral body. In shear, a keeled design would be advantageous as there would likely be bone contact with the posterior edge of the keel. While this may be the case initially, the subsequent settling or migration rate is not significantly different. There is no difference in the amount of shear migration (Span) with respect to the initial position. Interestingly, setting the \(Yo\) value to zero (i.e. normalizing the net deflection) leads to non-significant differences between the DM and the SK groups for all parameters.

Conclusions: Baseplate design affects early implant stability as measured via shear. Although differences in design were statistically significant, clinical outcomes will determined if these micron level differences are clinically meaningful.