Summary

• This study compares the load-displacement response of segments implanted with this prosthesis to that of intact controls.
• The prosthesis restored quantity of motion (ROM) in flexion-extension and axial rotation to previously reported physiologic norms.
• The location of the composite COR calculated in the intact controls agreed well with the in vivo data reported in healthy subjects, validating the in vitro method used for TDR kinematics assessment.
• The pattern of load-displacement curves of implanted segments approximated intact controls.
• Overall, the data suggest that this TDR provides similar kinematics to the lower cervical spine as compared to the in-tact spine.
Purpose

A novel compressible six-degrees-of-freedom cervical disc prosthesis (Spinal Kinetics, Sunnyvale, CA) composed of fiber matrix and polymer core between two metal endplates, is designed to replicate the response of the native annulus and nucleus. We compared the load-displacement response of segments implanted with this prosthesis to that of intact controls.

Methods

Six human cervical spines (C3-C7, 51.5±5.5 years) were tested in flexion-extension, lateral bending and axial rotation (±1.5 Nm). Flexion-extension was tested under 150N follower preload. Disc prostheses were implanted at C5-C6 with the prosthesis midline 0.9±0.6 mm posterior to the segment midline. Range of motion (ROM) was calculated in all tested directions. The quality of motion was assessed in flexion-extension by calculating: (i) stiffness (slope of load-displacement curve) in the high flexibility zone in flexion and extension; and (ii) center of rotation (COR) assessed using digital fluoroscopic images. Data after TDR were compared to (i) intact controls of the specimens, and (ii) "population" intact controls from our database of 36 cervical spines tested using intact controls of the specimens, and (ii) "population" intact controls from our database of 36 cervical spines tested using digital fluoroscopic images. Data after TDR were compared to (i) intact controls of the specimens, and (ii) "population" intact controls agreed well with the in vivo data reported in healthy subjects, validating the in vitro method used for TDR kinematics assessment.

Results

After prothesis implantation, C5-C6 flexion-extension ROM increased from 13.2±3.1 degrees to 15.1±2.2 degrees (p=0.01). Total axial rotation decreased from 9.0±1.6 degrees to 4.4±1.0 degrees (p<0.01). The load-displacement curve pattern in flexion-extension after TDR was sigmoidal, and closely approximated intact controls. The load-displacement curve pattern in flexion-extension after TDR was sigmoidal, and closely approximated intact controls. The prosthesis restored quantity of motion (ROM) in flexion-extension and axial rotation to previously reported physiologic norms. The decrease in lateral bending motion after implantation may be a multi-factorial phenomenon. The anterior-lateral annulus was preserved during implantation to minimize the loss of anterior tension band. Increased pre-tensioning of annulus fibers after prothesis insertion might have increased stiffness in lateral bending and axial rotation. Further, the uncinate processes were untouched. Previous studies suggest that uncinate process resection, apart from allowing neural decompression, may also restore lateral bending to normal values.

Conclusions

The prosthesis restored quantity of motion (ROM) in flexion-extension and axial rotation to previously reported physiologic norms. The decrease in lateral bending motion after implantation may be a multi-factorial phenomenon. The anterior-lateral annulus was preserved during implantation to minimize the loss of anterior tension band. Increased pre-tensioning of annulus fibers after prothesis insertion might have increased stiffness in lateral bending and axial rotation. Further, the uncinate processes were untouched. Previous studies suggest that uncinate process resection, apart from allowing neural decompression, may also restore lateral bending to normal values.

The location of the composite CDR calculated in the intact controls agreed well with the in vivo data reported in healthy subjects, validating the in vitro method used for TDR kinematics assessment. The pattern of load-displacement curves of implanted segments approximated intact controls. CDR for total extension-to-flexion motion of implanted segments was posterior to the midpoint of C5 vertebra, similar to intact controls, but was about 3 mm more cephalad. Further studies are needed to assess the long-term clinical implications of CDR location on the fate of facets joints. Overall, the data suggest that this TDR provides similar kinematics to the lower cervical spine as compared to the intact spine.