Introduction

Recent development of cervical motion prostheses have resulted in a risk of complications associated with endplate fracture and device subsidence. The incidence of these complications may increase with the eminent approval and wider spread usage of these devices. Motion preserving devices function differently than the interbody fusion devices. Unlike interbody bone grafts where a certain amount of settling is tolerable and may potentially increase the fusion rate, a settled total disc replacement will not function properly. Subsidence will result in loss of motion at the implanted disc and potentially increase the stress at the adjacent level due to loss of sagittal balance. There are a number of factors that result in subsidence of the device. One of these factors is the disparity of the endplate which is affected by the intraintral procedures involving bone graft or implants. For each pair of locations with respect to the depth of the body, there was a random assignment for the endplate preparation in order to prevent settling of the device. This study also demonstrated that there was a significant loss of endplate strength with minimal surface burring and the null hypothesis was rejected. There was an average a 47% loss of strength when 1mm of endplate was removed and 54% loss when 2mm of endplate was removed. It is therefore essential that the maximum amount of endplate surface area is preserved during anterior cervical motion preserving procedures. In situations where endplate preparation is necessary, the smallest possible contact surface area should be burred in order to maintain the overall strength of the endplate. This is especially difficult given the concave surface of the superior endplate; it may be advantageous for the next generation of cervical disc devices to fit into this concavity with minimal endplate preparation in order to prevent settling of the device. This study also demonstrated a significant difference in strength between the posterior and the anterior surface of the endplate; the posterior endplate had a significantly greater strength than the anterior aspect of the endplate. Therefore it is advantageous to place the interbody device as posteriorly as possible to take advantage of the increased mechanical strength.

Method

Five fresh human cadaver cervical spines (C2-T1) were harvested en bloc and stored at -20°C until testing. The average age of the specimens were 70±10 years and 2 of the 5 were female and 3 male. The cervical specimens were evaluated by x-ray to rule out bony deformities and severe degenerative conditions. Levels C3-C7 were then dissected and cleaned of soft tissue. Care was taken to preserve the endplates of each vertebra. Each vertebra was partially embedded in a body filler mold to level the superior endplate surface for biomechanical testing of the endplate. The endplate strength was determined using an indentation test method (2mm diameter hemispherical probe) on a MTS Qtest uniaxial testing machine. The location of each indentation test was defined by the dimensions of the individual endplates. A 2x3 matrix pattern was applied to the endplate which resulted in 6 test locations per endplate. There were three equally spaced locations with respect to the width of the body (left, middle, right) and two equally spaced locations with respect to the depth of the body (anterior, posterior). The significance of these locations were representative of the load bearing surfaces following surgical cervical procedures involving bone graft or implants. For each pair of locations with respect to the depth of the body, there was a random assignment for the endplate to be burred to the depth of 0 mm (intact), 1 mm, or 2 mm using a flat (3mm diameter) end mill and a benchtop milling machine. Following the endplate preparation, the indenter probe was pressed into the endplate at each test location to a depth of 3mm at a rate of 12mm/min. Following completion of the testing on the superior surface, each vertebra was removed from the potting material and repotted in order to test the inferior endplate surface. The preparation and testing of the inferior endplate surface was the same as the superior endplate. The endplate strength of each location was determined by the peak failure load from the load-displacement curve. Previous indentation experiments on intact cervical vertebrae had shown no significant differences in endplate strength with respect to superior/inferior surface. As a result of this finding, a 3-way 3x3x2 factorial ANOVA was performed on the endplate strength to examine differences in burring depth (0, 1, and 2mm) and location (left, middle, right and anterior, posterior). Follow-up Scheffe post hoc tests were performed to examine significance. All tests were performed at a 95% level of significance.

Result

The overall ANOVA model was significant (p<0.001). There were significant main effects for burring depth and anterior, posterior location. There was no significant main effect based on left, middle, right location and there were no significant interactions. Significant differences (p<0.001) in endplate strength (figure 1) was noted between the intact endplate (142+/-92N) and burred endplates (1mm depth, 74+/-54N; 2mm depth 65+/-53N). No significant differences in endplate strength existed between the burr depths of 1 and 2 mm. There were also significant differences (p<0.001) in endplate strength between the anterior locations and the posterior locations (anterior, 113+/-82N; posterior, 74+/-65N) with the posterior endplate having more endplate strength than the anterior endplate irrespective of burr depth.

Conclusion

The cervical endplate has been shown to have regional variations, but the thickness of the endplate is approximately 0.85mm. This study demonstrated that there was a significant loss of endplate strength with minimal surface burring and the null hypothesis was rejected. There was an average a 47% loss of strength when 1mm of endplate was removed and 54% loss when 2mm of endplate was removed. It is therefore essential that the maximum amount of endplate surface area is preserved during anterior cervical motion preserving procedures. In situations where endplate preparation is necessary, the smallest possible contact surface area should be burred in order to maintain the overall strength of the endplate. This is especially difficult given the concave surface of the superior endplate; it may be advantageous for the next generation of cervical disc devices to fit into this concavity with minimal endplate preparation in order to prevent settling of the device. This study also demonstrated a significant difference in strength between the posterior and the anterior surface of the endplate; the posterior endplate had a significantly greater strength than the anterior aspect of the endplate. Therefore it is advantageous to place the interbody device as posteriorly as possible to take advantage of the increased mechanical strength.

Although clinical correlation is necessary, the importance of maintaining the integrity of the endplate has been demonstrated.

References
1. Schmitz et al., Acta Radiologica, 2004

Acknowledgement

Synthes Spine

Figure 1: Endplate strength decreases with incremental burring of the surface and increases anteriorly to posteriorly.