Effect of Artificial Disc Position on Spine Biomechanics in the Cervical Spine: A Finite Element Study

1Park, W M; +1Kim, Y H; 2Kim, K; 1Kim, K T; 1Lee, S H
+1Kyung Hee University, Yongin, KOREA; 2Kyonggi University, Suwon, KOREA
yoonhkim@khu.ac.kr

INTRODUCTION
Total disc replacement (TDR) has been suggested for surgical method to treat degenerative disc disease of the cervical spine because it decompresses nerves and preserves motion segments. The short-term outcomes of the TDR of cervical spine has been well reported to treat degenerative disc diseases as a motion preservation technique in spite of some clinical controversies such as implant wear, excessive motion and facet arthrosis at the surgical level [1, 2]. Rohlmann et al. reported that the position of the prosthesis the position and height of the artificial discs strongly affect on intersegmental rotation and selection of optimal position of implants is very important to achieve successful results in TDR surgery [3]. However, little papers have discussed influence of TDR position on spine biomechanics in the cervical spine. In this study, we compared the biomechanical characteristics of fixed- and mobile-core artificial discs by finite element analysis to understand how different implant design concepts affect the biomechanics of the spinal segment after TDR. We also investigated how the position of two types of artificial discs affects on the intersegmental motion of the cervical spine using finite element analysis.

METHODS
A three-dimensional finite element model of five spinal motion segments, from C2 to C7, in intact cervical spine was reconstructed from 1 mm thick computed tomography (CT) images. The CT images were taken from a healthy human body whose height and age were 175 cm and 21 years. The finite element model which consisted of six vertebrae, five intervertebral discs, and six kinds of ligaments was developed to be symmetric across the mid-sagittal plane. Clinical data and results of previous studies were taken for material properties of the model and attachment points of ligaments. Three-dimensional finite element models of two TDR implants, fixed- and mobile core artificial discs, were developed. Each artificial disc was inserted at C5-C6 motion segment of each implanted model, respectively. Anterior longitudinal ligaments and anterior part of intervertebral disc in C5-C6 motion segment were removed to insert the artificial discs. Nonlinear three-dimensional contact conditions were applied on facet joints in cervical spine model and artificial discs. The original position of prosthesis was decided by spinal surgeons. The position of prosthesis varied 1 mm and 2 mm anteriorly or posteriorly. The inferior plane of C7 vertebra was rigidly fixed and 1.5 Nm of follower load for standing, flexion and extension motions were applied respectively.

RESULTS
Intersegmental rotations of C5-C6 motion segment of the intact cervical spine model were 0.2°, -2.8°, and 3.1° for standing, flexion and extension motion, respectively. Those of the fixed-core artificial disc implanted model were 0.0°, -3.7°, and 4.8°, and those of the mobile-core artificial disc implanted model were 0.1°, -3.3°, and 4.6°, respectively. In flexion, posterior position change of 1 mm and 2 mm decreased the intersegmental motion by 1.4° and 3.2° in the fixed-core artificial disc implanted model, and by 1.0° and 2.3° in the mobile-core artificial disc respectively. However, anterior position change showed little effect on the intersegmental motion change in extension (Fig. 2).

The facet contact forces at the surgical level for the fixed- and mobile-core artificial disc implanted models showed 34N and 36 N in extension, respectively, whereas the facet joint contact force in the intact model was 17 N. Similar with intersegmental rotation, there was little change of facet joint force in extension.

DISCUSSION
The results of this study indicated that both fixed- and mobile core artificial discs implanted models showed the motion preservations at the surgical level. The mobile-core artificial disc generated higher intersegmental rotations than the fixed-core artificial disc, but there was no significant difference between two implants. And position of artificial discs in TDR for the cervical spine significantly affects on intersegmental motion in flexion. Although change of artificial discs did not affect on facet joint force, both fixed- and mobile core artificial disc made higher facet joint contact force which would be related to the facet pain and arthrosis. The results of this study suggested that more careful care must be taken to choose options of TDR surgery for achieving the long-term clinical outcomes. The present results could be useful for pre-operative planning of TDR surgery.

REFERENCES

ACKNOWLEDGEMENT
This work was supported by National Agenda Project (NAP) funded by Korea Research Council of Fundamental Science & Technology (2009)