INTRODUCTION

Spinal decompression surgery with spinal fusion is a widely used surgical procedure for the treatment of degenerative spine in the lumbar spine. However, it has been known that spinal decompression surgery causes the spinal instability. Some cadaveric and finite element (FE) studies have reported that adjacent segment degeneration may reduce adverse effects on the adjacent levels resulting from fusion by maintaining physiologic ROM as well as pressure. Therefore the interspinous implants have been recently used due to its advantages such as motion preserving and less subsidence of the implant to the osteoporotic bone.

Some of biomechanical studies have been performed to analyze biomechanical behaviors of the lumbar spine with interspinous implants [1-3]. Those studies have reported that interspinous implants affect increase of spinal stabilization and decrease of intradiscal pressure in extension [1]. However, the various influences by different types of interspinous implants on the lumbar spine are still unknown. In this study, the biomechanical effects of interspinous process implants was investigated for various implants under extension loading condition based on finite element analysis.

METHODS

A three dimensional FE model of a lumbar spinal motion segment from L3 to L4 was reconstructed from 1-mm thickness of computed tomography (CT) images. The CT images were taken from a healthy male volunteer whose height and age were 175 cm and 21 years old.

The FE model consists of two vertebrae, one intervertebral disc, and seven major ligaments (anterior longitude ligament (ALL), posterior longitude ligament (PLL), flaval ligament (FL), inter transverse ligament (ITL), inter spinal ligament (ISL), supra spinal ligament (SSL), and capsular ligament (CL)). The information of material properties and the attachment points of ligaments were taken from literatures [4,5].

In this study, biomechanical characteristics of Coflex (Paradigm Spine, Wurmlingen, Germany), Wallis (Abbott Laboratories, Bordeaux, France), Viking (Sintea Plustek, Assago, Italy) and Interspinous Spacer (Seohancare, Gyeonggi, Korea) were investigated.

Each three dimensional CAD model of the implants was made based on respective designs. Material properties of titanium (E=113GPa, v=0.3) was adapted for the FE model of Coflex, and polyetheretherketone (PEEK; E=4GPa, v=0.25) for the models of Wallis, Viking and Interspinous Spacer (Fig. 1a). The individual FE model of the lumbar spine, in which each interspinous implant was inserted by its surgical protocol, was generated (Coflex, Wallis, Viking and Interspinous Spacer) (Fig. 1b). Nonlinear surface to surface contact conditions with a frictional coefficient of 0.2 were assumed between the implant and the bone in all models.

Inferior plane of L4 vertebra was fixed in all directions and pure extension moment of 7.5 Nm was applied on the superior plane of L3 vertebra in each model. The intersegmental rotation angle of the motion segment and von-Mises stress on the interspinous process were analyzed using ABAQUS Standard™ (SIMULIA, Providence, RI, USA).
RESULTS AND DISCUSSION

The intersegmental rotation angles were decreased by 88%, 89%, 70% and 90% compared with the intact motion segment with Wallis, Viking and Interspinous Spacer, respectively (Fig. 2). Thus, all implanted model showed higher stability than the intact lumbar spine in extension.

The maximum von-Mises stresses in the interspinous process were 173 MPa, 33.8 MPa, 43.8 MPa and 18.8 MPa for the Coflex, Wallis, Viking and Interspinous Spacer, respectively (Fig. 3). The Coflex showed higher maximum von-Mises stresses than any other implants.

Titanium was used for the Coflex interspinous implant. High young’s modulus of titanium may cause subsidence of the implant to the osteoporotic bone. The results of this study showed similar trends with the results from previous studies [1,2].

CONCLUSIONS

We analyzed biomechanical characteristics of different types of interspinous implants. While all kinds of interspinous implants studied in this study increased stability of motions segment in extension, tremendously different values of maximum von-Mises stress was shown in each implant. Therefore, the influence of interspinous implants on subsidence of interspinous process should be considered in the interspinous implant surgery, as well as the increase of stability of motion segment. The results of this study could be useful for evaluating and selecting surgical options and implants in spinal surgeries.

REFERENCES


ACKNOWLEDGEMENTS

This research was supported by 2009 National Agenda Project (NAP) funded by Korea Research Council of Fundamental Science & Technology (P-09-JC-LU63-C01).