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An optimal design of artificial disc FE model for human Lumbar spine discs restoration

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Lately, the incidence of the back pain is one of the disease that is difficult to treat and most highly occurred. It takes to greater economic burden directly or indirectly for treatment. Previous study reported that age-related disc changes could be affected by change in vertebral body shape because of the decreasing bone mineral density(BMD) by aging. [1] Likewise, discogenic back pain is occasioned by the disc degeneration or injury such as abnormal change by aging or accident. There are treatments which are for the spinal surgery such as spinal fusion, artificial disc implantation, discectomy, nucleotomy etc. The most of treatments, however, lead to side effects.[2-3] One of the treatment that minimally invasive procedure takes advantage of reduction of unnecessary exposure and tissue trauma. This procedure has advantage but no absolute standard of treatment for spine disorder because of technical limitation and other factors like fiberized nucleus pulposus. The aim of this study is to provide a methodology of artificial disc implantation by minimally invasive surgery using fluid type artificial nucleus pulposus. The parameter of artificial disc was figured out when 2 types of artificial intervertebral discs were replaced by minimally invasive surgery using FEM. The Balloon Typed Fluidic Artificial Nucleus System is designed to replace the nucleus pulposus for low back pain caused by degenerative intervertebral disc disease through comparing 2 difference type model.

The three-dimensional finite element model (FEM) of the Lumbar spine were reconstructed based on computed tomography (CT) images. Two types of FE lumbar spine model were acquired from reference model, compared with each model through finite element analysis was performed. The reference model is produced intact L4-L5 lumbar model to represent the actual behavior of the lumbar spine. This is to determine the effect of a single disc, the L1-L3 was removed from the entire L1-L5 lumbar spine model to L4-L5 lumbar spine model based on partial model was designated. [Fig. 1] Other models are produced fluid cavity model and fluid cavity contact model. Fluid cavity model is replaced nucleus pulposus as a fluid cavity, fluid cavity contact model is that the balloon part is replaced fluid cavity then, nucleus pulposus is removed. Part of the fluid entering nucleus pulposus is construct that fluid flux is possible through reference node of center of fluid cavity. This is possible to measure fluid pressure by fluid flux that the model is produced for setting up the required pressure after making artificial disc for the surgery. [Fig. 2, Fig. 3]

The design variables of fluid cavity and fluid cavity contact model were single variable which is pressure by fluid flux so that the relationship of fluid flux-displacement was acquired from 2 types results of fluid flux because optimal design was not necessary. The design variables of fluid cavity and fluid cavity contact model were single variable so that fluid pressure results were deducted which was similar to reference model behavior. From fluid cavity model, relation between displacement and fluid pressure was obtained that deduced intradiscal pressure from relation of fluid flux-deflection. Using this result, proper fluid pressure was obtained 0.30536MPa. Under axial compression of 400N, deflection of reference model is -1.125mm, fluid cavity contact model is -1.129mm. Under axial compression of 400N and pure moment of 6Nm, deflection of reference model is -1.812mm, fluid cavity contact model is -1.872mm. Under same condition, rotation angle was that reference model is 1.348^{o}, fluid cavity contact model is 1.519^{o} (400N). Reference model is 5.305^{o}, fluid cavity contact model is 5.844^{o} (400N and 6Nm).

This study started to minimize disadvantage and acquired a good result even some deficiency like clinical study and reduction of repetition on experiment. In this study two kinds of model were compared, and find optimum design to figure out which one the better effect for artificial disc.

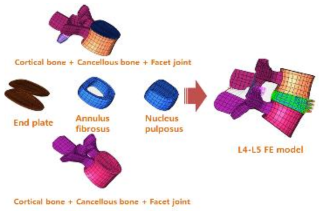

Fig.1 Reference model

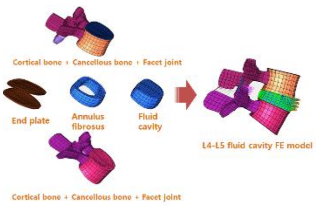

Fig.2 Fluid cavity model. Nucleus pulposus was replaced by fluid cavity that could be measured nucleus inner pressure.

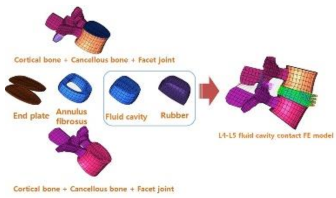

Fig.3 Fluid cavity contact model. Balloon was replaced by fluid cavity that could be measured nucleus inner pressure.

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