INTRODUCTION

In recent year, the design concepts of spinal implants alternation from traditional stable fusion to restore normal spinal range of motion (ROM). Therefore, the method of the spinal implants in vitro test was advanced from traditional load control method (LCM) to displacement control method (DCM) [1-3]. In real life, it is still not clear whether to use LCM or the DCM to evaluate the spinal implants. In this research, finite element analysis was used to see how motions difference at implanted level and both adjacent levels in fusion and non-fusion implants between LCM and DCM.

METHODS

To create a 3-D finite element model (FEM), computed tomography scans of the lumbar spine from L1-L5 of a middle age male was obtained. The commercially available medical image software Amira 3.1.1 and finite element software ANSYS 9.0 was then used to reconstruct the intact lumbar spine (INT). After validating the INT model with previous literatures [4], the L3-L4 of the INT model was modified to insert ProDisc II artificial disc (ADR) or posterior lumbar interbody fusion combined bilateral cages with pedicle screws (PLIF) as shown in Figure 1. These models were constrained at the bottom of the fifth vertebra. All four physiological motions were imposed 10 N-m moments and a preload 150 N on the top of the first level (LCM). The DCM applied pure moments incrementally so that the resultant ROMs under flexion, extension, torsion and lateral bending will match 20, 15, 8 and 20 degrees respectively.

RESULTS AND DISCUSSION

Under LCM, the motion of the PLIF model decreased 86.3%, 86.6%, 53.2% and 78.2% at implanted level in flexion, extension, torsion and lateral bending respectively as compared with INT. The adjacent level motions changed by 23%, 18.6%, -0.7%, 5.7% at L2/L3, and 6%, 12.1%, -2.9%, 8% at L4/L5 in flexion, extension, torsion and lateral bending respectively. For ADR model, motion at implanted level increased 6.8%, 80.9%, 63.2% and 44% at four physiological motions. The ROMs at both adjacent levels of ADR changed no more than 6 % in all motions. The results indicate that PLIF model had higher ROMs at both adjacent levels under flexion and extension. These two motions might induce adjacent disc accelerative degenerations. Otherwise, both ADR adjacent levels had almost the same ROMs in all motions compared with INT. It might indicate no adjacent level disc degeneration will occur under LCM. Contrary to adjacent level, unstable motion at implanted level were observed in ADR model, which indicates that possible accelerative degeneration could occur at preserved annulus.

For the DCM, the motion of the PLIF model decreased 83.5%, 84.7%, 46.4% and 73% at implanted level under four motions. The adjacent level motion changed by 38.5%, 31.9%, 17% and 23% at L2/L3 under four motions. The difference of the motion at L4/L5 were similar to L2/L3 motion. For ADR model, the implanted level motion increased 3.8%, 42.3%, 36.4% and 30.8% under four motions. The adjacent level motion changed by -3.8%, -15%, -12%, -11.6% at L2/L3, and 0.6%, -18.2%, -12.8%, -9.2% at L4/L5 under four motions. The results indicate that PLIF model had higher ROMs at both adjacent levels under all motions, which indicates that possible accelerative degeneration could occur because of all motions under DCM.

For ADR model with DCM, the ROM in the implanted level increased but was still significantly lower than that of LCM. Thus higher risk for patients with ADR implant might be indicated by analysis with LCM. The ROMs at both adjacent levels of ADR showed more than 10 % decrease in extension, torsion and lateral bending. The influence of these abnormal motions will need more evidences through clinical research.

CONCLUSIONS

In this research, differences between LCM and DCM FE analyses for evaluation fusion and non-fusion implants were obtained. These two types of analysis method could be used to predict special conditions in patient’s daily life. The DCM is suitable for after surgery evaluation of patient’s daily life motion restoration. The LCM is suitable for after surgery evaluation of patient’s normal life work loading condition.

REFERENCES
1. Panjabi MM. IV World Congress of Biomechanics, Calgary, Canada, 2002.