FINITE ELEMENT COMPARATIVE ANALYSIS OF THE OUTCOME OF VERTEBROPLASTY AND KYPHOPLASTY INTERVENTIONS FOR THE TREATMENT OF THORACIC FRACTURES IN OSTEOPOROTIC SUBJECTS

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Introduction

Vertebral compression fractures (VCF) are frequent in osteoporosis at the thoraco-lumbar junction, causing the collapse of the vertebral body [Lee et al 2007]. For their treatment two mini-invasive surgical procedures, vertebroplasty (VP) and balloon kyphoplasty (BKP), are often used. It is still under debate which technique is the best in terms of efficacy, costs and safety, mainly about the risk of a new fracture adjacent to the treated vertebra. The aim of this work is to evaluate the biomechanical outcome of vertebroplasty and kyphoplasty by a computational comparative analysis with Finite Element Models.

Methods

A Finite Element Model of intact T9-T11 spinal segment has been constructed starting from CT scans of a healthy patient and then modified in order to simulate a wedge shaped VCF with a reduction of 25% (F25) and 50% (F50) of the original anterior height of T10 vertebral body (Figure 1). The intact segment is representative of a clinical condition in which the F25 or F50 fractures have been totally restored by kyphoplasty on T10 while F25 is representative of a partially recovered situation from a F50 fracture.

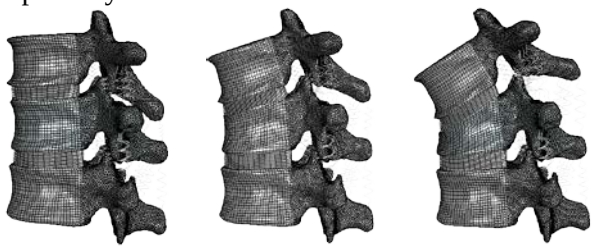

Figure 1: computational models with intact and fractured geometry

The vertebrae were modeled simulating both the trabecular and cortical osteoporotic bone, a distinction has been made between cartilaginous endplates (EPs), nucleus pulposus and annulus fibrosus for intervertebral discs while the ligaments have been modeled as linear springs. The condition of standing has been simulated evaluating the forces acting on the section T9-T11 of the vertebral column [Rohlmann et al 2006] but lever arms and loads were readjusted as to consider the different anatomy of the thoracic segment. For each model the effects of both vertebroplasty and kyphoplasty procedures have been evaluated in terms of stresses in the adjacent structures to the treated vertebral body, (von Mises stresses on EPs and intradiscal pressure, IDP).

Results

Results of computational simulations are reported in Table 1:

		50 VP	25 KP	INT KP
σ_{VM} (%)	EP T9_i	-1.6	-15.7	-67.7
	EP T10_s	-1.7	-27.7	-54.0
	EP T10_i	-1.7	-11.7	-62.8
	EP T11_s	0.8	-3.5	-35.6
IDP (%)	T9/T10	2.5	-3.3	-7.2
	T10/T11	1.4	-4.4	-14.6

Table1: IDP and σ_{VM} percent variations compared to the F50 case (i=inferior, s= superior)

Discussion

The effect of cement injection in the fractured vertebra causes slight variations in stress distribution, as already found in previous studies. The effect of the geometry of the fractured vertebral body on stress distribution on the EPs is significant. From a clinical point of view, kyphoplasty is to be preferred with respect to vertebroplasty in reducing the stress distribution, in particular on the EPs.

References

Lee et al, J Korean Neurosurg Soc, 42:371-376, 2007
Rohlmann et al, Eur Spine J, 15:1255-1264, 2006