2013-09-01

Making an Impact on Vertebral Compression Fractures

Philip Purcell
Institute of Technology, Tallaght, philip.purcell@ittd.ie

Stephen Tiernan
Institute of Technology , Tallaght, stephen.tiernan@tudublin.ie

Fiona McEvoy
Technological University Dublin, fiona.mcevoy@tudublin.ie

See next page for additional authors

Funder: Irish Research Council

MAKING AN IMPACT ON THE TREATMENT OF SPINAL INJURIES

Philip Purcell[1], Fiona McEvoy[1], Stephen Tiernan[1], Seamus Morris[2], Magdalena Tyndyk[3]
1. Bioengineering Technology Centre, ITT Dublin, Tallaght, Dublin 24
2. National Spinal Injuries Unit, Mater Misericordiae University Hospital, Dublin 7
3. Medical Engineering Design & Innovation Centre, Cork Institute of Technology, Bishopstown, Cork

Clinical background

Spinal fractures account for approximately **1.4 million fractures per annum** worldwide [1]. Treatments for these injuries have evolved from simple bed rest through to the intricacy of modern **minimally invasive** surgery. **Balloon kyphoplasty** is one such treatment that uses a balloon to decompress collapsed vertebra, followed by injection of bone cement to stabilise the fracture (Figure 1). Recent research has correlated a **'halo'** feature on kyphoplasty patient x-rays with a **78% re-collapse rate** [2]. The present work documents a new method of mechanical analysis to investigate this issue and **explores alterations to current clinical practices to improve patient outcomes**.

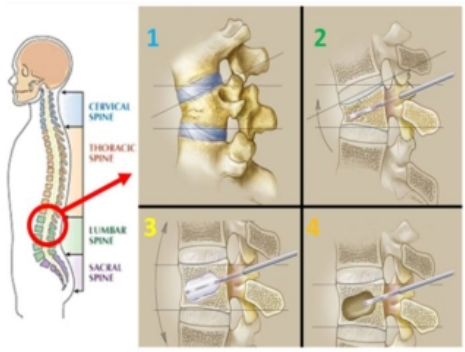


Figure 1, Balloon kyphoplasty treatment [3]

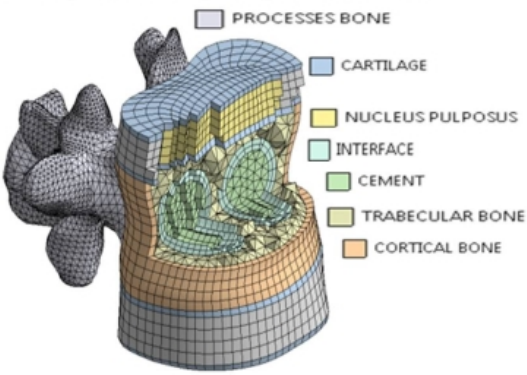


Figure 2, Model of kyphoplasty treatment

Results

Figure 3 depicts the stress change for each of the components in the vertebra model **due to the altered loading** experienced during recovery from kyphoplasty. Results from the model indicate **increases in stress of 11% in the cement, up to 39% in the trabecular bone**. Detailed analysis also found that **altered loading of the interface region** was a contributory factor in causing height subsidence. This supports the clinical indications that the 'halo' effect during kyphoplasty recovery can **substantially increase the risk of re-collapse at the treated level**.

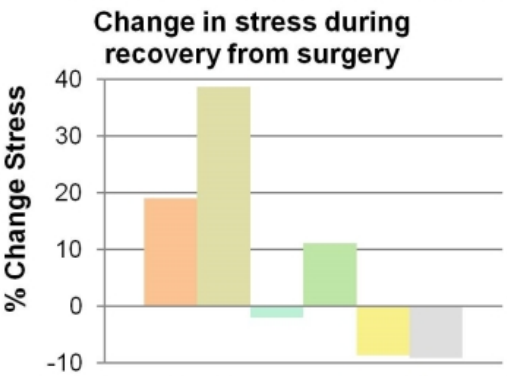


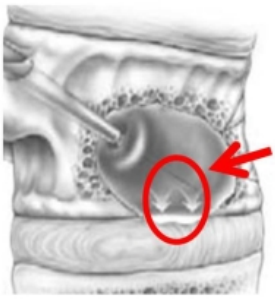
Figure 3, Change in stress of model components due to altered loading (colouring as per Fig. 2)

Modelling

A validated computer model of a human spine was modified to replicate balloon kyphoplasty (Figure 2) in the first lumbar vertebra. The **first lumbar vertebra** was selected since it is the **most common site for spinal fractures**. A **mechanical model** of the kyphoplasty 'halo' was developed by modelling an **interface region** between the bone and injected cement regions. The **thickness** of this region was **derived from a mathematical model** based on the patient's bone properties and the level of bone compaction caused by the kyphoplasty balloon [4].

Clinical Relevance

Results from the mechanical model indicate the incidence of vertebral **re-collapse could be reduced by improving the properties of the interface** between the bone and injected cement. Work is ongoing to achieve this improvement using an alternative surgical technique known as **'egg-shell' kyphoplasty** (Figure 4), which is hypothesised to enhance the long-term integrity of the treatment [5]. This alternative treatment offers surgeons **a new opportunity to improve patient outcomes with no additional equipment expense** and may even yield **savings** with lower incidence of hospital re-admissions.



Hypothesised that egg-shell technique improves structural interlock by forcing cement into bone using balloon

Figure 4, Egg-shell surgical technique [5]

References

1. Johnell *et al*, Osteoporos Int,17:1726-33, 2006
2. Kim *et al*, Osteoporos Int,23:2559-65,2012
3. Kyphon Inc., http://www.kyphon.com, 2013
4.Purcell *et al*, IEEE Comp Soc,41:65-6, 2013
5.Greene *et al*, J Spine Disord Tech,20(3):229-32, 2007

Acknowledgements

Funded by the Irish Research Council EMBARK postgraduate scholarship RS/2011/399