

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*

Follow this and additional works at: <https://arrow.tudublin.ie/ittengoth>



Part of the [Engineering Commons](#)

---

### Recommended Citation

Purcell, P., Tiernan, S., McEvoy, F., Tyndyk, M., Morris, S.,: Making an impact on vertebral compression fractures, Irish Research Council Symposium 2013

This Other is brought to you for free and open access by the School of Engineering (Former ITT) at ARROW@TU Dublin. It has been accepted for inclusion in Other Resources by an authorized administrator of ARROW@TU Dublin. For more information, please contact [arrow.admin@tudublin.ie](mailto:arrow.admin@tudublin.ie), [aisling.coyne@tudublin.ie](mailto:aisling.coyne@tudublin.ie), [vera.kilshaw@tudublin.ie](mailto:vera.kilshaw@tudublin.ie).

Funder: Irish Research Council

---

**Authors**

Philip Purcell, Stephen Tiernan, Fiona McEvoy, Magdalena Tyndyk, and Seamus Morris

Philip Purcell<sup>1</sup>, Fiona McEvoy<sup>1</sup>, Stephen Tiernan<sup>1</sup>, Seamus Morris<sup>2</sup>, Magdalena Tyndyk<sup>3</sup>  
 1. Biengineering 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**.

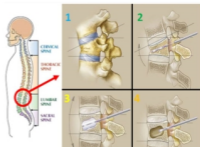


Figure 1, Balloon kyphoplasty treatment [3]

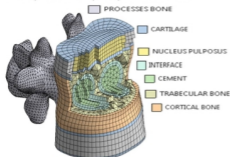


Figure 2, Model of kyphoplasty treatment

## 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**.

### Change in stress during recovery from surgery

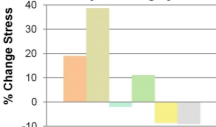


Figure 3, Change in stress of model components due to altered loading (colouring as per Fig. 2)

## 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