Introduction
Total knee arthroplasty (TKA) is the most successful treatment option for end-stage degenerative knee joint disease. Despite this, aseptic loosening remains the most common cause of long-term failure\(^1\) and the number of patients requiring revision surgery is increasing\(^2\). Surface cementation (SC) and full cementation (FC) techniques are commonly employed to achieve tibial component fixation, however, the optimum technique remains unclear.

The objectives of this study are:
- To experimentally and computationally evaluate the magnitude and distribution of proximal tibial cortical bone strains in the intact and post implanted knee.
- To computationally determine the effect of SC and FC techniques on trabecular bone stresses.

Materials and methods

Computational
CT scans were converted into numerical models using the commercially available software Simpleware (v3.2 Simpleware LTD). 3D multi-component finite element models (Abaqus v6.8 Dassault Systemes Inc) of intact, SC and FC methods were developed to investigate the effect of implant fixation method on the resultant proximal tibial strain distribution.

Each model was physiologically loaded to 2060N (3BW) at a ratio of 60:40 to the medial and lateral sides at 0° adduction. Maximum and minimum principal strains were measured on the outer tibial cortex at 5mm, 30mm and 50mm from the tibial cut surface on the antero-medial (AM), lateral (L) and posterior (P) sides.

Experimental
The intact, SC and FC knee was investigated through an experimental strain gauge study. Large left composite sawbone tibiae (#3402, Pacific Research Labs, Inc., Vashon, WA) were implanted with the Genesis® II Total Knee System (Smith and Nephew) using PMMA (Simplex® P Stryker) bone cement by an experienced surgeon.

Results and discussion

A reasonable correlation is evident between the computational and experimental values of cortical surface strain with correlation coefficients of over 0.7. Computed stress distributions in the cortical bone are very similar for FC and SC simulations, with neither technique yielding a similar distribution to an intact tibia (Fig 2(a-c)). However, examination of computed stress distributions in the trabecular bone surrounding the implant reveals that significant differences exist between the two cementation techniques. Significant stresses are computed in the region of the lower stem for the FC model (Fig 3c) in contrast to computed results for the SC model (Fig3b).

Conclusion
- Experimental measurements of surface cortical bone strains do not highlight the differences in SC and FC techniques.
- Computed trabecular bone stresses demonstrate significant differences between FC and SC TKA techniques.
- The SC model demonstrated a more favourable trabecular bone stress distribution than the FC model when compared to the intact tibia.

Acknowledgements
Irish Centre for High End Computing (ICHEC)

References