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# VARIATIONS IN CORTICAL THICKNESS OF COMPOSITE FEMUR TEST SPECIMENS

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## Introduction

The majority of experimental biomechanical studies relating to the proximal femur use synthetic composite test specimens because of the advantages in terms of cost, availability and preservation. Studies report significantly ($p < 0.02$) lower variability than cadaveric bone [1] with standard deviations of up to 16.3% for flexural rigidity, torsional rigidity and axial stiffness measurements [1–3]. In comparison, the variability is between 20 and 200 times greater for cadaveric bone [4]. These studies have considered variability in terms of global measures, however, to the authors' knowledge, no data exists quantifying the variability in local properties. Variability in cortical thickness, for example, would influence strain predictions which are key to thorough validation of a model. The aim of the study was to quantify the variability in cortical thickness for commonly used composite femurs. The study also investigated the influence that these variations have in experimental testing and for validation purposes.

## Methods

Fourth generation Sawbones® composite femurs (n=4) instrumented with tri-axial strain gauges at four locations and CT-scanned (Siemens S5VB40B). The loading applied at the hip used the averaged peak joint reaction vector during walking [5] up to a maximum load of 500N. Variations in cortical thickness were evaluated for the four specimens around the neck region at eight locations using the CT-scanned geometry (Figure 1). A generic and four specimen specific finite element models were created using manufacturers data and validated using experimentally measured strains.

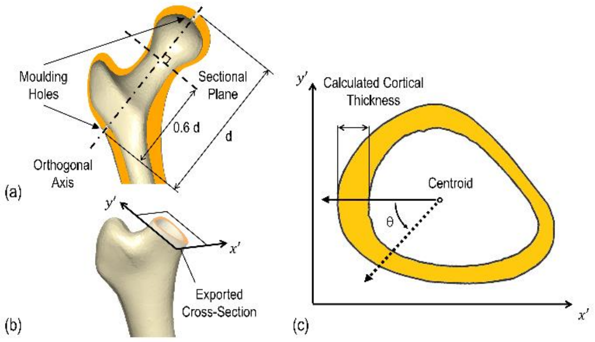


*Figure 1: (a) Definition of the cross-section evaluated for each of the specimens; (b) exported cross-section; and (c) calculation of the cortical thickness.*

## Results

We found that there was considerable variability in the cortical thickness of the composite specimens (up to 48% difference or 16.1% standard deviation of the mean) (Figure 2). The study found that there was significantly ($p < 0.018$) greater variability in experimentally measured strain around the femoral neck than around the shaft. We found that the generic model was not able to satisfactorily match the experimentally measured strains (average error of 135%), however, the predictions of the four specimen specific models were within an average of 13.8% (range: 5.9% to 18.3%). A sensitivity study on alignment indicated that the variability in the predictions at the proximal strain gauges were most likely due to geometric variations between the specimens.

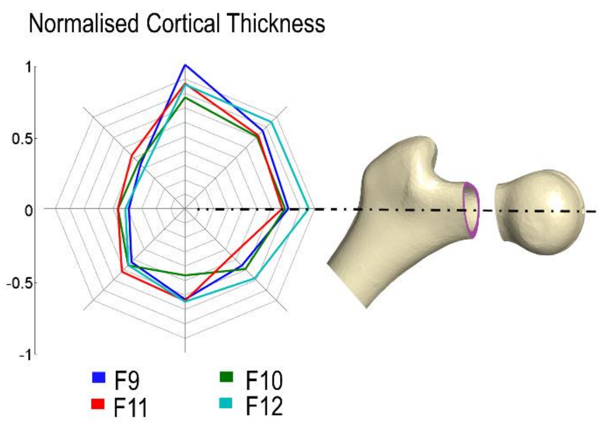


*Figure 2: Normalised cross-sectional thickness at eight locations around the femoral neck for four specimens using the plane referenced in Figure 1.*

## Conclusions

We want to highlight the fact that considerable variations in cortical thickness between fourth generation sawbones models exist. Future studies relying on such measurements need to account for this variability when using composite test specimens, particularly if validation relies upon strain gauge readings made in the femoral neck region.

## References

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