XIAOLONG FAN

PHD STUDENT | PROGRAM 1
ARC TRAINING CENTRE FOR JOINT BIOMECHANICS

PhD duration: January 2020 - October 2023

My interests: finite element modelling, 3D modelling, 3D printing, computational biomechanics, Arduino. I am interested in projects involving bone and implants. My knowledge can be applied to analysing CT/micro-CT images, estimating bone density, and predicting implant performance. My modelling is a useful resource for surgeons.

MMEng (UNSW) **BMME** (UTS) **MPhil** (QUT)

Supervisors:
A/Prof. Saulo Martelli, Prof Peter Pivonka & Prof Yuantong Gu

PROJECT OVERVIEW

Project Title: Modelling stability of humeral component of reverse shoulder implant

THE PROBLEM

Why is it important to validate stability models of the humeral component of a reverse shoulder implant?

The proportion of reverse shoulder replacements continues to increase in recent years, however, potential complications exist which can influence implant performance after surgery. Finite Element Analysis (FEA), as a numerical tool, has the potential to investigate the risk of implant failure during the pre-operative phase and can help to reach an optimal surgical plan. However, it is hard to provide an accurate prediction of an implant's response to different loads and boundary conditions without appropriate model validation.

Why does this need more research?

- Current models of humeral bone derived from clinical CT lack evaluation of the accuracy.
- There is limited research concerning the influence of variables and errors during the segmentation and material assignment procedures that affect FE models for shoulder arthroplasty.
- There is a lack of a concise understanding and validation regarding how trabecular bone responds to the psychological load and how the interface of trabecular bone and implant surface impact the stability of a reverse shoulder replacement implant.
- Better surgery outcomes may be achieved as a result of expanding research in this area, by improving implant selection for each specific patient. Moreover, the implant design could also be improved for each specific patient by taking their bone density into consideration. This study also produces a validation procedure for humeral implant mechanics.

HYPOTHESIS

- FE simulation based on clinical CT images is able to accurately predicate the stability of reverse implant in humeral bone.
  - some parameters, e.g. image filtering and threshold value, have significant effect on the humeral bone model simulation.
  - the numerical model created from clinical CT images can predict the humeral bone mechanical behaviours.
  - the numerical model created from clinical CT images can investigate the interface between the bone and implant.

PROJECT AIMS

The aim of my study is to experimentally validate a finite element modelling procedure based on clinical CT images for the simulation of the primary stability of a Reverse Shoulder Arthroplasty (RSA) implant in the humerus.

OUR SOLUTION & EXPECTED OUTCOMES:

Solutions:

- Compare the accuracy of humeral bone geometry models from different imaging sources (i.e. clinical CT and micro-CT) to validate the parametric effects during the segmentation process on clinical CT images.
- Analyse uncertainties in modelling the geometry and how the material properties of humeral bone affect the predictions of a FE model derived from CT
- Simulate the humeral bone biomechanical behaviours based on differential shoulder physiological loading conditions and validate the model with time-elapsed micro-computed-tomography (μCT) imaging results.

Expected outcomes:

- Support realistic simulations of physiological load configurations and the effects of variations in prosthesis design and implantation technique. Ultimately to provide validated, clinically applicable technology for patient-specific prediction and planning of RSA Stability.

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