QUB - Mechanical and Aerospace Engineering
PhD Project Description

Title: 3D-printed bioresorbable scaffolds for the regeneration of articular cartilage

Theme: Biomaterials & Biomechanics

Project description:

Articular cartilage is a thin (2-3mm) load-bearing connective soft tissue that protects the joints by providing low friction articulating surfaces on the ends of long bones. The cartilage is a highly complex inhomogeneous material whose composition and consequently mechanical properties vary from site to site. Due to its extremely demanding mechanical environment, cartilage is prone to injury or damage. Once damaged/injured, cartilage does not have the ability to heal itself due to the lack of blood supply and may lead to full-thickness defects which ultimately lead to degenerative arthritis (Osteoarthritis, OA). The reduced mobility of the joint due to the degradation of cartilage or OA is a major problem that affects millions of people every year.

The current gold standard treatment for these cartilage defects or OA is total joint replacement, but not without limitations and failures. Alternatively, cartilage tissue engineering (CTE), where the tissue is grown in the lab on biomaterial scaffolds, emerged as a treatment method for cartilage defects. In spite of considerable ongoing and past research, the CTE unable to produce a tissue with required mechanical properties that of native cartilage. These CTE approaches often employ homogeneous scaffold geometries. It is hypothesised that a scaffold with a structural gradient that mimics the native tissue provides a template for superior regeneration of articular cartilage. Additive manufacturing (3D printing) has a significant potential to develop scaffolds with zonally organised micro-architectures and consequently with site-dependent mechanical properties that are similar to native tissue.

Therefore the aim of the current project is to develop zonally stratified cartilage construct similar to that of native tissue by exploiting the tissue engineering capabilities combined with advanced additive manufacturing techniques, novel bioresorbable materials and inhomogeneous cell distributions in biomaterial matrix. When implanted the developed construct into cartilage defects, functional cartilage will be regenerated in vivo and thereby it is possible to restore the healthy state of the joint.

Aims and Objectives:

The current project aims to develop a functional cartilage substitute that recapitulates the zonal architecture, biochemical and mechanical properties of native tissue using a combination of bioresorbable materials and 3d printing as well as external mechanical stimulation in a bioreactor system.

- To design and develop structurally graded biomaterial scaffolds using 3D printing technologies
- To investigate the effects of mechanical stimulation on the tissue formation in cartilage scaffolds in a bioreactor environment
- To develop a mechanobiological model to predict the tissue formation in scaffolds due to applied mechanical stimulation

Key skills required for the post:

The student should demonstrate enthusiasm for research in the field of bioengineering and be willing to develop the following skills to carry out this project:

- Additive manufacturing, 3D printing
- Cell and tissue engineering skills
- Physical testing of biological materials
- Develop finite element models

Key transferable skills that will be developed during the PhD:

- Training will be targeted towards securing employment in academia or medical/pharmaceutical industries.
- Problem-solving and analysis skills will be developed while defining research questions, designing new experiments, processing data and drawing independent conclusions.
- Effective project management, impact and disseminating research findings skills
- The key skills acquired during the course of PhD will also be highly transferrable to careers in R&D in medical device industries and within academia.

Lead supervisor:	Dr Krishna Manda, Email: k.manda@qub.ac.uk
Other supervisor(s):	Prof. Fraser Buchanan and Dr Alex Lennon
Funding mechanism:	Yet to be secured
Application closing date:	Until suitable candidate appointed.
Guaranteed stipend:	This can include a basic stipend and any guaranteed top-up (if available). N.B. Stipend for 20-21 is not yet confirmed. Base stipend for 19/20 is £15,009.
Conditional top-up available:	Amount and condition

PhD students in the School may have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.