June 24, 2023

The Japan Society of Mechanical Engineers
Hokkaido Branch
"Biomechanics Research Meeting"
41st Seminar

(Cosponsored by Hokkaido branch, The Japan Society of Mechanical Engineers and The 176th "Biomechanics" technical sessions, Japanese Society for Medical and Biological Engineering)

Chairman: Toshiro Ohashi

The Biomechanics Research Meeting will sponsor a presentation by distinguished scientists, Prof. Ashvin Thambyah from University of Auckland, New Zealand and Prof. Peter Lee, University of Melbourne, Australia. Faculty members, graduate students, and undergraduates are encouraged to participate in the seminar.

Date&Time: Thursday, July 6, 2023, 10:30-12:00

Place: Room L252, Faculty of Engineering, Hokkaido University

【10:30 - 11:15】

Speaker: Prof. Ashvin Thambyah, Department of Chemical and Materials Engineering, University of Auckland, New Zealand

Title: Mechanical Factors for Pre-Osteoarthritis

Abstract:
The aim of our research has been to understand, from mechanical and structural viewpoints, the initial degenerative processes in the joint tissues, related to the initiation and progression of osteoarthritis (OA). To this end we have established an animal model to study early or pre-OA joint tissue degeneration. Our work is framed around addressing three research questions. Does the initiation of OA begin with changes in (1) cartilage or bone, (2) proteoglycans or collagen, (3) cells or tissue? Our studies have shown that in the early degenerative state of the joint tissues, where macro-scale mechanical properties are yet to be affected, micro-to-nano scale *destructuring* of the collagen network had already taken place. These collagen network changes were found to be strongly associated with bone cement-line microstructural changes. The changes in the bone-cement line were indicated by the presence of 'bone spicules', which were remarkably similar to 'cutting cones' seen in primary bone formation during fracture healing. This similarity provided a mechanical rationale for the bone changes in the joint system in early tissue degeneration. The collagen network and bone structural changes were also associated with significant changes in an *ensemble* of proteins. These included certain SLRPs, angiogenic proteins and TGF-β. High resolution imaging of the chondrons, in tissues exhibiting early cartilage degeneration, further revealed fibrillar-structure changes in the territorial matrix and pericellular capsule, showing a morphology likened to

thickened baskets of fibrillar encapsulation of the chondrocytes. The significance of the above descriptions, of the multi-length scale tissue and cell mechanics in the joint, are discussed with a view on how OA is initiated by mechanical factors.

【11:15 - 12:00】

Speaker: Prof. Peter Vee Sin Lee, Department of Biomedical Engineering, University of Melbourne, Australia

Title: Safer Personalised Medical Implants

Abstract:

Advances in computer-aided engineering, patient-specific computer models, and additive manufacturing transform patients' treatment through personalised solutions. Manufacturers and hospitals are now trialling 'bespoking' as the new standard of care in orthopaedics and maxillofacial surgery. However, there are significant challenges to facilitating personalised medical implant commercialisation and widespread use. Regulatory frameworks for personalised implants are in their early stages. Current standards for testing off-the-shelf devices are not directly transferrable to devices designed for individual patients. Instead, future test standards could be based on information from the patient's anatomy and even lifestyle. There is no well-defined framework or methodology to support the use and increase personalised implants' success rate. The fabrication of the implant is only the first step. Successful treatment requires a comprehensive approach to optimise the use of the personalised medical device. This presentation will focus on the development of a seamless framework based on the Measure-Model-Manufacture-Manage (4M) for point-of-care manufacturing. Comprehensive biomechanical measurements will be used to build patient-specific biomechanical models to represent the underlying physiology of the human body. The models will be used to analyse scenarios that are too expensive or infeasible to perform on patients directly (e.g. loading an implant to failure in the human body). The aim in the measure-model stage is to optimise implant/device design that considers all the biomechanical information before manufacturing using 3D printing. Finally, the measure-model-manufacture becomes a reinforcing loop that improves patient management and outcome. The presentation will also discuss our experience and benefits, from a researcher's perspective, working closely with physicians, industry, and government leaders in pushing the frontiers of personalised medical implants.

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