Characterization of Articular Cartilage Based on the Response of Cartilage Surface to Loading/Unloading

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Abstract : Articular cartilage is a fluid-swollen tissue of synovial joints that functions by providing a lubricated surface for articulation and to facilitate the load transmission. The biomechanical function of this tissue is highly dependent on the integrity of its ultrastructural matrix. Any alteration of articular cartilage matrix, either by injury or degenerative conditions such as osteoarthritis (OA), compromises its functional behaviour. Therefore, the assessment of articular cartilage is important in early stages of degenerative process to prevent or reduce further joint damage with associated socio-economic impact. Therefore, there has been increasing research interest into the functional assessment of articular cartilage. This study developed a characterization parameter for articular cartilage assessment based on the response of cartilage surface to loading/unloading. This is because the response of articular cartilage to compressive loading is significantly depth-dependent, where the superficial zone and underlying matrix respond differently to deformation. In addition, the alteration of cartilage matrix in the early stages of degeneration is often characterized by PG loss in the superficial layer. In this study, it is hypothesized that the response of superficial layer is different in normal and proteoglycan depleted tissue. To establish the viability of this hypothesis, samples of visually intact and artificially proteoglycan-depleted bovine cartilage were subjected to compression at a constant rate to 30 percent strain using a ring-shaped indenter with an integrated ultrasound probe and then unloaded. The response of articular surface which was indirectly loaded was monitored using ultrasound during the time of loading/unloading (deformation/recovery). It was observed that the rate of cartilage surface response to loading/unloading was different for normal and PG-depleted cartilage samples. Principal Component Analysis was performed to identify the capability of the cartilage surface response to loading/unloading, to distinguish between normal and artificially degenerated cartilage samples. The classification analysis of this parameter showed an overlap between normal and degenerated samples during loading. While there was a clear distinction between normal and degenerated samples during unloading. This study showed that the cartilage surface response to loading/unloading has the potential to be used as a parameter for cartilage assessment.

Keywords : cartilage integrity parameter, cartilage deformation/recovery, cartilage functional assessment, ultrasound
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