Correlation of Non-destructive Electromechanical Probe (Arthro-BST) Assessment with Histological Scores and Mechanical Properties in Human Tibial Plateau

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Introduction: Electromechanical properties of articular cartilage obtained with the hand-held electromechanical device (Arthro-BST) correlate strongly with histological scores and with biomechanical properties in human distal femurs [1]. The purpose of the current study was to investigate whether similar correlations are observed in human tibial plateau.

Methods: Pairs of tibial plateau from 6 human donors (5 males and 1 female, average age 48 years) were provided by RTI Surgical (Alachua, FL, USA). Electromechanical properties of the entire articular surfaces were first mapped ex vivo using the Arthro-BST [2]. The device calculates a quantitative parameter (QP) of cartilage electromechanical activity corresponding to the number of microelectrodes in contact with the cartilage when the sum of their streaming potential reaches 100 mV. A high QP indicates weak electromechanical properties and vice-versa. Osteochondral cores were then harvested from normal and visually abnormal regions on the tibial plateau. A total of 56 cores were tested in unconfined compression to obtain the fibril modulus (Ef), equilibrium modulus (Em), and permeability (k) [3] prior to histoprocessing. Safranin O-Fast Green-stained paraffin sections were scored with the Mankin histological-histochemical grading system [4]. The electromechanical QP corresponding to the cored site was calculated as the average of all QPs measured within 6 mm from the core center location.

Results: Safranin O/Fast Green stained sections showed that GAG staining in the cartilage matrix and structural integrity decreased as the electromechanical QP increased (Fig. 1). A strong correlation was found between electromechanical QP and Mankin score ($r = 0.50$, $p = 0.0004$). A strong correlation was also found between QP and Ef ($r = -0.73$, $p < 0.0001$; Fig. 2A) and QP and permeability log (k) ($r = 0.64$, $p < 0.0001$; Fig. 2B). Weak correlations were found between QP and Em ($r = -0.30$, $p = 0.0186$; Fig. 2C) and between QP and thickness of the articular cartilage ($r = 0.42$, $p = 0.0006$; Fig. 2D). As expected, the electromechanical QP decreases with increasing Ef and Em whereas the electromechanical QP increases with Mankin Score, permeability and thickness.
Discussion: The electromechanical QP measured in human tibial plateau correlated significantly with the histological Mankin score and with unconfined compression mechanical parameters, similar to what was previously seen in human distal femurs. In addition, a weak correlation was found between the thickness of the cartilage on the tibial plateau and the electromechanical QP. This is in contrast to what was previously observed in the distal femurs but could be related to topographical variations present on the tibial plateau surface, where cartilage is very thin and rigid in regions covered by the meniscus but thicker and softer in regions not covered by meniscus. In the future, we plan to also map...
electromechanical QP of human patella. Considering these results, we believe that the Arthro-BST can provide a rapid and reliable tool for articular cartilage assessment.

**Significance:** The electromechanical properties of articular cartilage are representative of its structure and stiffness. Since obtaining histological and biomechanical properties requires destructive processing of the samples and is time-consuming, non-destructive and rapid mapping of the electromechanical properties of articular surfaces would be advantageous for the diagnosis of joint disease and for the evaluation of treatments of articular cartilage degeneration.

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