Correlation of Electromechanical Properties with Histological Scores and Mechanical Properties in Human Tibial Plateau

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Purpose: The purpose of the study was to investigate if electromechanical properties of human tibial plateau correlate strongly with histological scores and with biomechanical properties as in human distal femurs (Sim et al., 2014).

Materials & Methods: Six pairs of tibial plateau from human donors (5 males and 1 female, average age 48 years) were provided by RTI Surgical (FL, USA). *Ex vivo* electromechanical properties were mapped across entire articular surfaces using the Arthro-BST. The device calculates a quantitative parameter (QP) which corresponds to the number of microelectrodes in contact with the cartilage when the sum of their streaming potential reaches 100 mV (inversely proportional to electromechanical activity). A total of 56 osteochondral cores were then harvested to be tested in unconfined compression to obtain the fibril modulus (E_f), equilibrium modulus (E_m), and permeability (k) prior to histoprocessing. Safranin O-Fast Green-stained paraffin sections were assessed with the Mankin score. The QP corresponding to the cored site was calculated as the average of all QPs measured within 6 mm from the core center.

Results: Safranin O-Fast Green-stained sections showed a decrease in matrix GAG staining and worse structural integrity as the QP increased as expected (Fig.1). The QP decreased with increasing E_f ($r = -0.73$, $p<0.0001$; Fig.2A) and E_m ($r=-0.30$, $p=0.0186$; Fig.2C) whereas the QP increased with Mankin Score ($r=0.50$, $p=0.0004$), permeability ($r=0.64$, $p<0.0001$; Fig.2B) and thickness ($r=0.42$, $p=0.0006$; Fig.2D).

Conclusion: Similar correlations of the QP with histological score and mechanical parameters were observed in human tibial plateau as in distal femurs, thus reinforcing the interpretation of QP as an accurate assessment of cartilage quality. In addition, there was a positive correlation between QP and cartilage thickness, which could be related to topographical variations present on the tibial plateau surface. Considering these results, we believe that the Arthro-BST can provide a reliable tool for articular cartilage assessment.

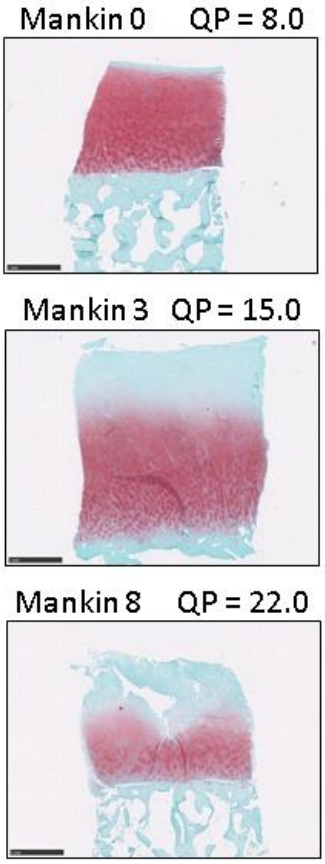

Figure 1. Representative Safranin O/Fast Green stained sections for 3 Mankin scores and their corresponding electromechanical QP; Bars = 1 mm.

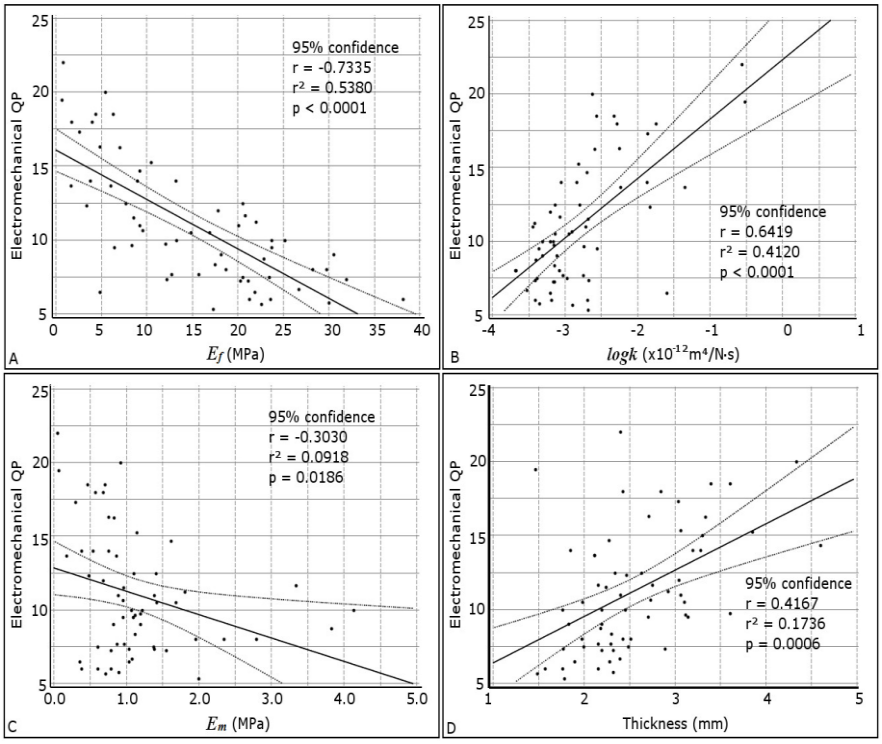

Figure 2. (A) Correlation between the electromechanical QP and fibril modulus E_f; (B) Correlation between the electromechanical QP and permeability *logk*; (C) Correlation between the electromechanical QP and matrix modulus E_m; (D) Correlation between the electromechanical QP and cartilage thickness.