Evaluation of Entire Ovine Cartilage Repair Articular Surfaces: Mechanical and Electromechanical Assessment

S. Sim[1,2], I. Hadjab[1,2], M. Garon[2], E. Quenneville[2], M. Hurtig[3] and C.D. Hoemann[1]

1. Biomedical & Chemical Engineering, Ecole Polytechnique de Montreal, Montreal, QC, Canada 2. Biomomentum Inc., Laval, Qc, Canada 3. Comparative Orthopaedic Research Laboratory, Department of Clinical Studies, University of Guelph, Guelph, Ontario, Canada

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Purpose: To demonstrate the ability of non-destructive automated indentation technique and electromechanical device in assessing the quality of cartilage in a sheep model.

Material & Methods: Electromechanical *ex vivo* mappings of articular surfaces were obtained in distal condyles from 5 sheep (8 – 9 y-o, 9 months post-surgery, bone marrow stimulation model) and 2 control sheep (8 years old) with the Arthro-BST (Biomomentum, Laval) which has a hemispherical indenter (r=3.175mm) to measure electromechanical properties by the quantitative parameter (QP), followed by automated indentation mappings to 50 µm with the Mach-1 (Biomomentum, Laval) with a spherical indenter (r=0.5mm) at the same positions to measure structural stiffness (load/indentation depth). Selected test sites were analyzed histologically and by unconfined compression.

Results: GAG-rich repair tissues showed poroelastic mechanical behavior. According to electromechanical and mechanical properties mappings on control and treated articular surfaces (Fig.1), para-defect articular surfaces showed depressed average structural stiffness and weaker electromechanical properties (high QP) *vs* matching control regions. The QP was lower and structural stiffness higher in the repair site. Repair site tissue thickness varied from 0 to 720 µm compared to ~1100 µm in flanking area. GAG depletion was observed in para-defect tissues in half of the test medial condyles (Fig.2).

Conclusion: Mechanical measures demonstrated poroelastic cartilage behavior in repair tissues elicited in aged sheep. Measures outside the repair sites are suggestive of cartilage degradation and consistent with previous data (Hoemann et al., 2005; Custers et al., 2009). As for the repair site, the increase in the structural stiffness and decrease in the QP could be partly explained by the lower cartilage thickness. This study indicates the utility of functional mechanical measures in large animal cartilage repair studies.

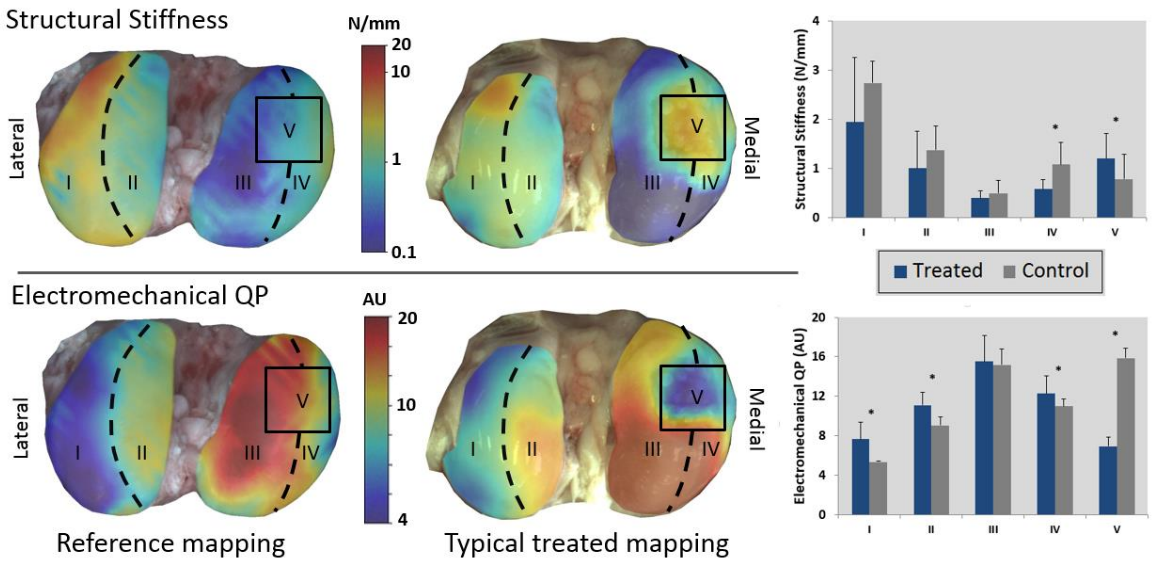

Figure 1. Mapping of control (reference) and treated condyles of the structural stiffness and the electromechanical QP of a representative knee (shown in a standardized right-hand format for the left medial condyle). Structural stiffness and electromechanical QP bar graph for each regions. N=10 treated vs N=4 control, *p<0.05

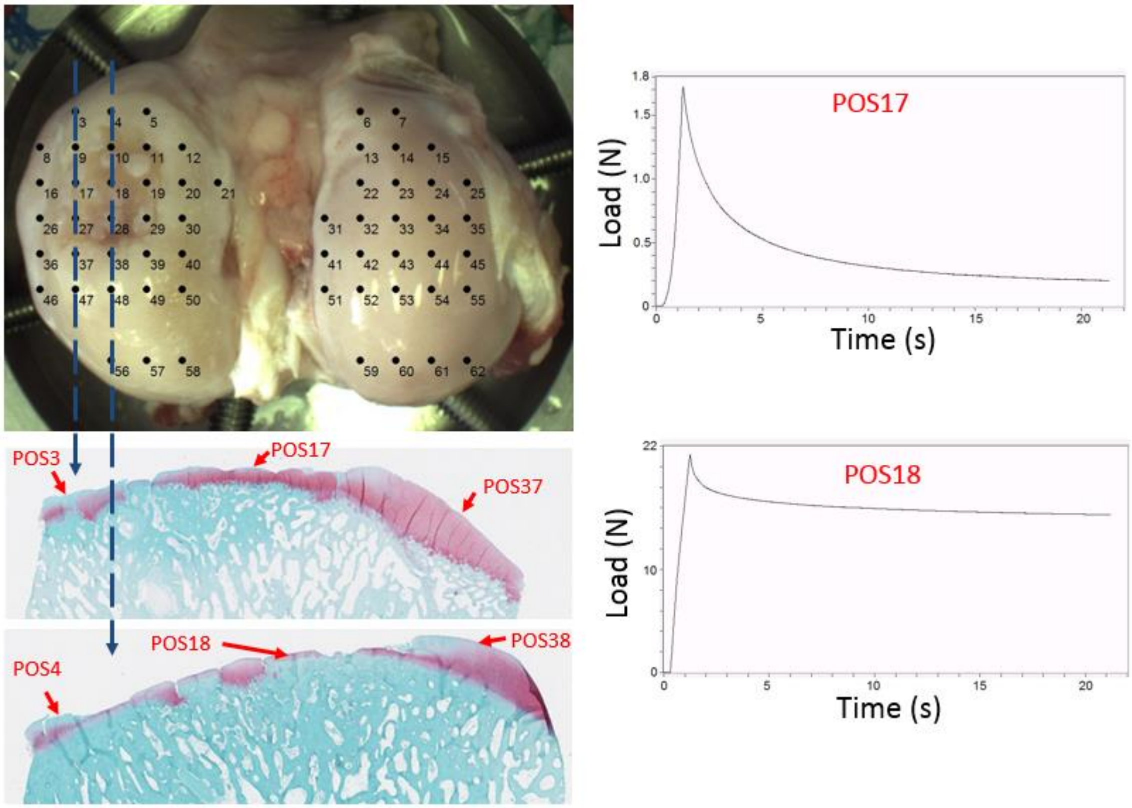

Figure 2. Position grid used for electromechanical and mechanical assessment of the condyle analyzed in Fig. 1, and representative histological slide of test articular surfaces. Position 17 showed poroelastic mechanical behavior, while position 18 is calcified cartilage (not included in averaged data). GAG depletion is observed in regions adjacent to the repair site.