Relevance of the Spatial Distribution Pattern of Mechanical Properties of Articular Cartilage in Animal Studies

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Purpose: The purpose of this study was to assess the importance of taking into account the spatial distribution of the mechanical properties of normal articular cartilage in animal models of cartilage repair, specifically the distributions of thickness and instantaneous modulus.

Material & Methods: Mechanical properties were mapped *ex vivo*, using a novel technique allowing for automated indentation mapping (Mach-1 v500css, Biomomentum Inc.) of visually normal tibial plateau and femoral condyles (right and left joints) from three rats, three rabbits and one sheep. The multiaxial mechanical tester performed perpendicular indentations on the articular surface with a spherical indenter (radius=0.5 mm) at each position (at least 50 positions per articular surface) by simultaneously moving its three stages. Subsequently, the thickness was measured with an adapted version of the needle technique. The instantaneous modulus at each position was obtained by fitting the load-displacement curve (with corresponding thickness) to an elastic model of indentation.

Results: High-resolution maps of the thickness and the instantaneous modulus for the tibial plateau and femoral condyles of the three species were generated (Fig. 1&2). The spatial distribution of thickness and instantaneous modulus reveals a thinner and stiffer cartilage in regions in contact with the meniscus compared to a thicker and softer cartilage on the rest of the surface. This topographic pattern is more striking in tibial plateau than femoral condyles.

Conclusion: Cartilage thickness and instantaneous modulus can vary by a factor up to 10 over a distance of only 5% of the total articular surface width (Fig. 1&2) in those three species. These thickness and modulus maps clearly show that any difference between treated and normal cartilage could be due to a natural topographic variability rather than the treatment itself. In conclusion, this study shows the relevance of mechanical characterization of the entire surface in animal studies of cartilage regeneration or repair.

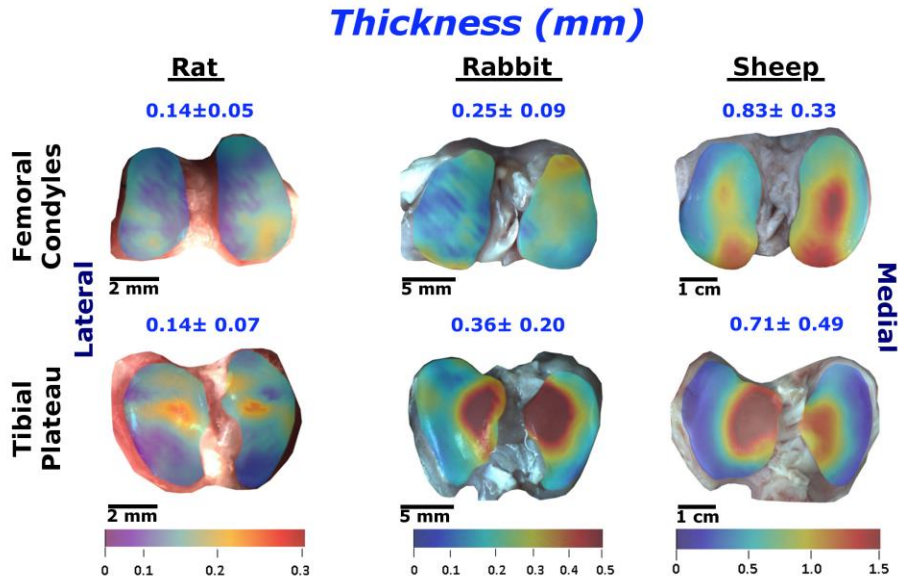

Figure 1. High-resolution mapping of the thickness obtained on rat, rabbit and sheep articular surfaces.

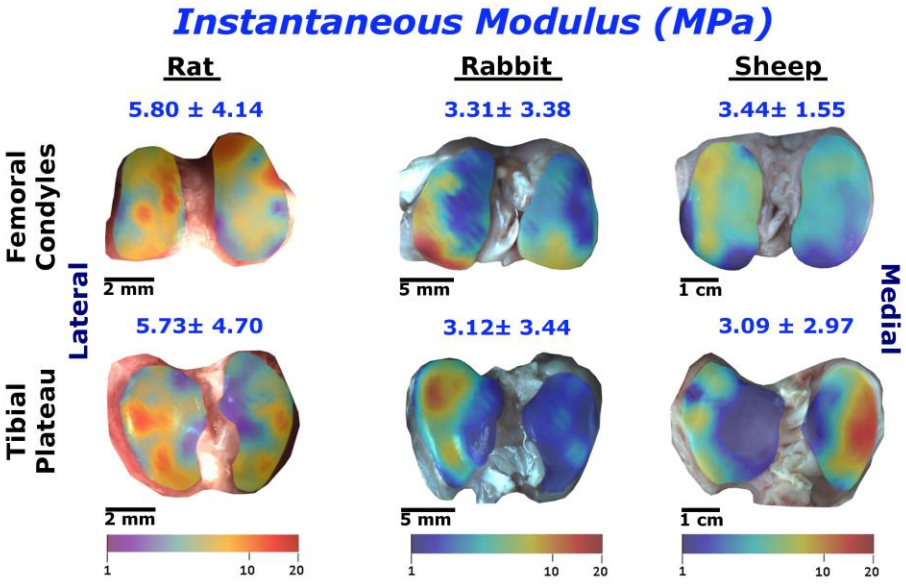

Figure 2. High-resolution mapping of the instantaneous modulus obtained on rat, rabbit and sheep articular surfaces.