

FRICITIONAL PROPERTIES OF ENGINEERED CARTILAGINOUS TISSUES IN BOUNDARY LUBRICATION

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INTRODUCTION: Frictional properties of cartilaginous engineered tissues have not been thoroughly investigated despite being a major function of cartilage. Lubricin is a component of synovial fluid shown to lubricate cartilage in boundary lubrication in a dose dependant manner similar to that of synovial fluid (SF)^{1,2}. Removal of lubricin from cartilage with salt increases the equilibrium friction coefficient (μ_{eq})³. The objectives of this study were to determine 1) the inherent friction coefficient of engineered tissues in boundary lubrication 2) the ability of these tissues to be lubricated by SF and 3) the reversibility of SF lubrication by removal of lubricin with a high salt solution.

METHODS: Equine sternal mesenchymal stem cells (MSC), primary bovine chondrocytes (CON) and meniscal fibrochondrocytes (MEN) were encapsulated in alginate disks (25×10^6 cells/ml) utilizing standard protocols⁴. The constructs were placed in culture with standard culture media supplemented with 10% FBS, 100 U/ml penicillin, and 100 μ g/ml streptomycin. MSC media was supplemented with 5 ng/ml TGF- β 1 to enhance chondrogenic differentiation. Engineered constructs were cultured for 0, 2, 4, 6 weeks and frozen for later friction testing. *Friction testing:* Engineered tissue constructs were tested in a custom friction apparatus utilizing PBS as a lubricant in boundary lubrication. The instrument linearly oscillated the sample at 0.32 mm/sec against glass with an imposed 20% normal strain and μ_{eq} was calculated¹. Samples were thawed in PBS and friction coefficients were measured (PBS). Each sample was then incubated in equine synovial fluid for 1 hour and rinsed with PBS followed with friction testing in PBS (ESF Soak). Following the 2nd friction testing, the samples were then incubated in 1.5M NaCl in PBS for 5 min and then equilibrated in standard PBS for 1 hour. Exposure to 1.5M NaCl has been shown to extract lubricin from the surface of cartilage³. Friction coefficients were then measured for a third time (ESF + 1.5M Extract).

RESULTS: The equilibrium friction coefficient was the same for all engineered constructs from all cell types over 6 weeks in culture. Incubating of the engineered tissues in ESF (testing in PBS) decreased friction coefficient over culture time by approximately 20% in MSC generated cartilage and 50% in both CON and MEN generated tissue. The friction coefficient increased and returned to values similar to unincubated tissue following the extraction protocol with 1.5M PBS.

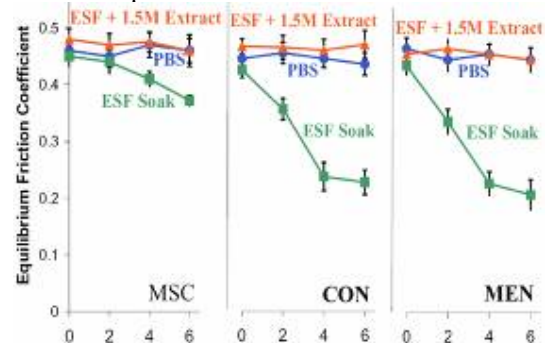


Fig. 1: Friction Coefficients of MSC, CON, and MEN generated cartilage.

DISCUSSION & CONCLUSIONS: Changes in μ_{eq} are minimal with time in culture, suggesting insufficient production and localization of lubricin by three cell types. Constructs from all cell types are lubricated by equine synovial fluid at later culture times and lubrication is reversed with 1.5M NaCl, suggesting production of ECM components that can localize lubricin. The ability to localize lubricin seen by a decrease in μ_{eq} is cell type dependant with CON and MEN similar but greater than MSC generated tissues.

REFERENCES: ¹ J.P. Gleghorn, et al (2005) *Trans Orthop Res Soc*, 1502. ² T.A. Schmidt, et al (2005) *Trans Orthop Res Soc*, 84. ³ J.P. Gleghorn, et al (2005) *Trans Intl Cart Rep Soc*, 7c-6. ⁴ J.P. Gleghorn, et al (2005) *Trans Orthop Res Soc*, 804.

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