Rheometer Enabled Study of Tissue/biomaterial Frequency-Dependent Properties

Authors : Polina Prokopovich

Abstract : Despite the well-established dependence of cartilage mechanical properties on the frequency of the applied load, most research in the field is carried out in either load-free or constant load conditions because of the complexity of the equipment required for the determination of time-dependent properties. These simpler analyses provide a limited representation of cartilage properties thus greatly reducing the impact of the information gathered hindering the understanding of the mechanisms involved in this tissue replacement, development and pathology. More complex techniques could represent better investigative methods, but their uptake in cartilage research is limited by the highly specialised training required and cost of the equipment. There is, therefore, a clear need for alternative experimental approaches to cartilage testing to be deployed in research and clinical settings using more user-friendly and financial accessible devices. Frequency dependent material properties can be determined through rheometry that is an easy to use requiring a relatively inexpensive device; we present how a commercial rheometer can be adapted to determine the viscoelastic properties of articular cartilage. Frequency-sweep tests were run at various applied normal loads on immature, mature and trypsinased (as model of osteoarthritis) cartilage samples to determine the dynamic shear moduli (G*, G′ G″) of the tissues. Moduli increased with increasing frequency and applied load; mature cartilage had generally the highest moduli and GAG depleted samples the lowest. Hydraulic permeability (KH) was estimated from the rheological data and decreased with applied load; GAG depleted cartilage exhibited higher hydraulic permeability than either immature or mature tissues. The rheometer-based methodology developed was validated by the close comparison of the rheometer-obtained cartilage characteristics (G*, G′, G″, KH) with results obtained with more complex testing techniques available in literature. Rheometry is relatively simpler and does not require highly capital intensive machinery and staff training is more accessible; thus the use of a rheometer would represent a cost-effective approach for the determination of frequency-dependent properties of cartilage for more comprehensive and impactful results for both healthcare professional and R&D.

Keywords : tissue, rheometer, biomaterial, cartilage
Conference Title : ICBE 2024 : International Conference on Biomaterials Engineering
Conference Location : Tel Aviv, Israel
Conference Dates : June 27-28, 2024

Open Science Index, Bioengineering and Life Sciences Vol:18, No:06, 2024 publications.waset.org/abstracts/168024.pdf