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A Device for High-Throughput Monitoring of Degradation in Soft Tissue Samples

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Abstract

This work describes the design and validation of a novel device, the High-Throughput Degradation Monitoring Device (HDD), for monitoring the degradation of 24 soft tissue samples over incubation periods of several days inside a cell culture incubator. The device quantifies sample degradation by monitoring its deformation induced by a static gravity load. Initial instrument design and experimental protocol development focused on quantifying cartilage degeneration. Characterization of measurement errors, caused mainly by thermal transients and by translating the instrument sensor, demonstrated that HDD can quantify sample degradation with <6 μm precision and <10 μm temperature-induced errors. HDD capabilities were evaluated in a pilot study that monitored the degradation of fresh *ex vivo* human cartilage samples by collagenase solutions over three days. HDD could robustly resolve the effects of collagenase concentration as small as 0.5 mg/ml. Careful sample preparation resulted in measurements that did not suffer from donor-to-donor variation (coefficient of variance <70%). Due to its unique combination of sample throughput, measurement precision, temporal sampling and experimental versality, HDD provides a novel biomechanics-based experimental platform for quantifying the effects of proteins (cytokines, growth factors, enzymes, antibodies) or small molecules on the degradation of soft tissues or tissue engineering constructs. Thereby, HDD can complement established tools and *in vitro* models in important applications including drug screening and biomaterial development.

1. Introduction

Homeostasis of tissue extracellular matrix (ECM) is regulated by cellular anabolic (synthesis) and catabolic (degradation) processes, both orchestrated by a plethora of cytokines and growth factors (Melas et al., 2014). Imbalance of catabolic and anabolic process is involved in the pathophysiology of many diseases and conditions (including osteoarthritis, scar synthesis, fibrosis) resulting in the formation of abnormal ECM. The development of tools that can quantify ECM remodeling is therefore a major endeavor in many fields of biology and