COMMERCIAL ECMs FOR ROTATOR CUFF TENDON REPAIR OR REINFORCEMENT

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INTRODUCTION

Several natural extracellular matrices (ECMs) have been marketed as patches to reinforce soft tissue repair during rotator cuff surgery. These products include collagen-rich ECMs such as dermis (GraftJacket®, TissueMend™) and small intestine submucosa (SIS - Restore®, CuffPatch™). To our knowledge there is no comparative study that describes the biomechanical and biochemical properties of these materials, specifically as they compare to tendon. Therefore, the aims of this study are to characterize the biomechanical and biochemical properties of four commercial ECMs that are available for rotator cuff tendon repair. Our ongoing work is represented here.

METHODS

Mechanical Testing: One 4 x 45 mm test strip was cut from separate lots of each material: GraftJacket® (Wright Medical Technology, n = 10), TissueMend™ (Stryker Orthopaedics, n = 6), Restore® (DePuy Orthopaedics, n = 10), and CuffPatch™ (Arthrotek, n = 6). Samples were hydrated in physiologic saline (PBS) at 4°C overnight prior to testing. Samples were clamped in custom grips with a nominal gage length of 30 mm. Thickness was determined using a constant pressure LVDT probe. Cross-sectional area was estimated as the nominal sample width times average tissue thickness. Uniaxial tension tests were performed in PBS at 37°C. Samples were preconditioned 5X to loads representing ~10% grip-to-grip strain, then pulled immediately to failure at 10 mm/min. Modulus was determined using grip-to-grip strains from the slope of the stress-strain curve in two regions: (1) ~5% strain, which might be considered physiologic for tendon and (2) the linear region.

Collagen Determination: A 5-8 mg (dry wt) piece from each ECM sample was analyzed for hydroxyproline using a standard spectrophotometric technique [1]. Collagen content was calculated representing 13% of this protein by weight [2].

Data Analysis and Statistics: Analysis of variance was used to compare properties among ECMs. A p-value <0.05 was considered significant.

RESULTS

Representative stress vs. grip-to-grip strain curves for 4 mm wide ECM strips are shown in Figure 1. For comparison, tendon data is reported from a previous study [1]. Failure properties are under-represented in all curves because of grip failures. All four ECMs required 10-30% stretch before they begin to carry significant load (Fig. 1). However, if stretched enough, each material demonstrated a stiff, linear region, and an appreciable breaking strength. In the strain range of ~5%, these materials had a very low modulus relative to tendon (610-840 MPa) (Figs. 1, 2). Maximum properties of ECMs were realized at 30-80% strain but remained one order of magnitude less than tendon, especially at physiologic levels of strain for tendon (~5%).

DISCUSSION

The material properties of all commercial ECMs were orders less than tendon, especially at physiologic levels of strain for tendon (~5%). SIS ECMs were stiffer than dermis ECMs and reached their maximum properties at lower levels of stretch (~20% vs. ~60%). GraftJacket® had less collagen than the other materials, as would be expected for mature dermis ECM, which contains appreciable amounts of elastin.

As a load-sharing augmentation device for tendon repair, commercial ECMs would likely carry only small loads (though a tendon repair would not be as stiff as tendon proper, which was the comparative standard in this study). If used as a primary graft to connect tendon to bone, these ECMs would stretch appreciably under the associated muscle and joint loads. While pre-stretching at implantation may improve their functional contribution, for tendon repair these ECMs may offer more of a biologic advantage than a functional one. ECMs provide a bioactive scaffold for host cell infiltration and constructive tissue remodeling, and the influence of their material properties on these events is unknown. Ongoing studies in our laboratory are investigating other biochemical and cellular properties of these commercial ECMs.


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