A Braided Polylactic Acid Scaffold for Rotator Cuff Tissue Engineering

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Statement of Purpose: Rotator cuff tendon tears are one of the most common musculoskeletal disorders, affecting 40% of people over 60 years old, resulting in over 250,000 repairs every year in the United States with an estimated healthcare cost of $474 million.[1,2,3] Polylactic acid (PLA) as a synthetic polymer has been approved by the US Food and Drug Administration (FDA) for this type of tendon repair because it has a suitable rate of degradation. It takes about 6 months for PLA to break down in the body by a hydrolytic mechanism which generates a non-toxic byproduct, lactic acid, that is readily metabolized and excreted. However, due to the hydrophobic surface of the PLA, limited cell adhesion and proliferation have been observed. Braiding is a conventional textile technology that has been used for scaffold design and fabrication for several decades with the advantage of a unique non-linear elastic behavior in the toe region of the tensile stress-strain curve which is consistent with that of native tendons. In addition, the braiding parameters can be adjusted during the production process which provides the possibility to mimic the heterogeneous structure and properties of the enthesis.[4] Therefore, this study was designed to optimize the braiding parameters, and evaluated the biological performance of the scaffold after being coated with collagen solution.

Methods: Multifilament PLA yarns (Xinxiang Sunshine Textile Company Ltd., Henan, China) were first plied into 2-ply and 3-ply yarns, and then braided into scaffolds at 15, 22.5 and 30 picks per inch (PPI) on a Steeger flat braiding machine.

The tensile properties of the scaffolds were measured on a MTS Criterion 43 tensile tester. The ultimate load was recorded and the Young's modulus was calculated. The suture retention strength was measured by inserting a size 2 suture through the scaffold 5 mm from the cut edge, and measuring the ultimate force needed to cause the failure of the scaffold structure.

For biocompatibility evaluation, the PLA scaffolds were then first immersed into 0.2 wt% sodium hydroxide (NaOH) 10 minutes to activate the surface, and then coated with 500 μg/ml collagen solution (MP Biomedicals) at room temperature for 24 hours. Rat tenocytes were seeded on the scaffolds, alamarBlue™ assay was used to monitor the metabolic activity level of the tenocytes, and a Live/Dead™ assay was used to observe the proliferation and migration of the tenocytes on the scaffolds.

Results: The results showed that with a higher PPI setting, the braiding angle increased, but the number of yarn plies did not affect the braiding angle. From the tensile tests, higher PPI caused a lower ultimate load (Fig 1) and Young's modulus, but the suture retention strength increased (Fig 2).

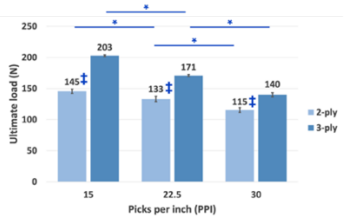

Fig 1. The effect of the number of yarn plies and PPI on the scaffold's ultimate load.

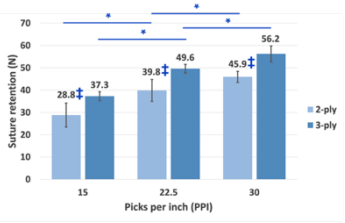

Fig 2. The effect of the number of yarn plies and PPI on the scaffold's suture retention strength

The images of the Live/Dead assay showed improved tenocytes adhesion and proliferation on the scaffolds after being activated with sodium hydroxide and coated with collagen (Fig 3).

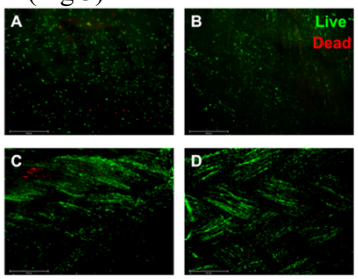

Fig 3. Live/Dead images of scaffolds seeded with tenocytes after NaOH activation and collagen coating after A) 1 day; B) 3 days; C) 5 days; and D) 7 days (Magnification 4x)

Conclusion: Braided scaffolds can provide initial sufficient mechanical support for rotator cuff tendon repair. NaOH pre-treatment can improve the collagen coating efficiency and thus further promote cell adhesion and proliferation.

References:

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