Tendon/Ligament Repair
Team Collagen Constructs

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Technical Advisors: Dr. Tristan Maerz, Meagan Salisbury
Problem Identification

- Meetings with Dr. Bou-Akl & Beaumont to determine clinically relevant needs
- Researched literature for needs and refinement
- Observed needs:
  - Orthopedic need for tendon/ligament injury repair

Market Analysis

● Market Analysis:
  ○ Orthopaedic soft tissue market size - $5B
  ○ Growth: $9.39B by 2024

● Stakeholder Analysis:
  ○ Influential stakeholders: Patients, athletes, orthopaedic surgeons, insurance providers
  ○ Decision makers: Surgeons and insurance providers
Current Solutions

- **Non-surgical**
  - Icing
  - Pharmaceuticals
  - Physical therapy

- **Surgical**
  - Sutures
  - Grafts

- **Limitations**
  - Non-surgical: Temporary, cannot repair complex tendon injuries
  - Surgical: Does not distribute tensile load evenly, risk for immune rejection, and harvest site morbidity
Tissue Engineering

- Current studies use cells (usually stem cells) seeded on scaffold with or without mechanical stimulation
- Few stem cell-based tendon/ligament tissue engineering strategies translated to clinical trials
  - Primarily due to:
    - Significant cost
    - Technical challenges
    - Regulatory hurdles
    - Time-intensive nature of autologous and allogeneic stem cell harvest
Need Statement

There is a need for a similar biomechanical property, anatomically correct solution in tendon/ligament injury repair.

http://m2.wyanokecdn.com/56ff05590efd71e74f0a523c4a4632f0.jpg
Design Concept

- Absence of cells in design
Design Novelty / Design Parameters

● Novelty:
  ○ Biomimetic bioactive scaffold
  ○ Incorporation of alginate containing SDF-1 into scaffold to recruit MSCs

● Design Parameters:
  ○ Biocompatibility of materials
  ○ Biomechanical Properties
  ○ Chemokine release
  ○ Degradation rates
Hypothesis

The created biocompatible collagen scaffold will have similar biomechanical properties as native tendons/ligaments. Also, the scaffold will recruit stem cells and promote growth with the incorporation of SDF-1.
Estimated Deliverables

- Scaffold that has similar biomechanical properties to that of anatomical tendons
- Scaffold recruits MSCs in vitro
- Scaffold promotes cell growth
- Can be implanted in lieu of grafting
Methods

- **Test and Experiments to be done:**
  - Collagen fiber spinning and scaffold assembly
  - Scaffold characterization
  - Biocompatibility testing
  - Mechanical testing
  - Degradation study
  - Release study

- **Equipment to be used:**
  - MTS machine
  - Cell culture equipment
  - Laboratory equipment
    - Pipettes, hoods, centrifuge, vortexer
  - Confocal Microscope
  - Micro CT/ESEM
Design Validation

- Scaffold characterization:
  - Use ESEM and uCT to characterize scaffold microstructure

- Biocompatibility testing:
  - Evaluate cell attachment and proliferation using alamar blue assay and confocal fluorescence microscopy

- Mechanical testing:
  - Compare biomechanical properties with those reported in literature

<table>
<thead>
<tr>
<th></th>
<th>No. of Specimens</th>
<th>Elastic Modulus (MPa)</th>
<th>Linear Stress (MPa)</th>
<th>Maximum Stress (MPa)</th>
<th>Strain Energy to Failure (N·m/ml)</th>
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</thead>
<tbody>
<tr>
<td>Older human (48-86 yrs.)</td>
<td>20</td>
<td>65.3 ± 24.0*</td>
<td>11.3 ± 5.1</td>
<td>13.3 ± 5.0†</td>
<td>3.1 ± 1.5†</td>
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<tr>
<td>Younger human (16-26 yrs.)</td>
<td>6</td>
<td>111 ± 26‡</td>
<td>25.5 ± 14.0†</td>
<td>37.8 ± 9.3‡</td>
<td>10.3 ± 3.1‡</td>
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<td>Rhesus monkey</td>
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<td>186 ± 26</td>
<td>56.2 ± 7.6</td>
<td>66.1 ± 8.4</td>
<td>19.4 ± 3.8</td>
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Design Validation

- Release study:
  - Determine SDF-1 release profile, burst release desired
- Degradation study:
  - Determine the rate at which the collagen structure breaks down
- MSC migration study:
  - Use boyden chamber assay to assess the MSC migration in close proximity to the collagen scaffold containing SDF-1
Budget

- Leftover LESA funding from previous years work
- Beaumont and Providence providing free access to equipment

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<th>Material</th>
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<td>Collagen</td>
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<td>SDF-1</td>
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<td>ELISA kit</td>
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<td>Lab supplies</td>
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<td><strong>Total Cost</strong></td>
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# Timeline

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<td>Background Research</td>
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<td>Alginate Incorporation</td>
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Validation Testing:

- Electropinning Collagen and Assembly
- Alginate Incorporation
- Biocompatibility Testing
- Scaffold Characterization
- Release Study of SDF-1
- Degradation Study of Collagen
- Migration Testing
- Mechanical Testing
- Data Processing/Analysis
- Final Testing & Data Collection
- Final Presentation
Team Structure
References


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Questions?