Characterization of Plantaris Tendon Constructs for Ankle Ligament Reconstruction

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Disclosures can be found in the AOFAS Mobile App.

No authors on the present study have any conflicts of interest pertinent to the work presented herein.
Clinical Questions

- What is the biomechanical strength of the plantaris tendon?
- Does it have enough tensile strength to be considered for ligament reconstruction in the foot and ankle?
Specific Aims

- Evaluate the ability to harvest the plantaris tendon through minimally invasive techniques
- Evaluate the biomechanical properties of the plantaris tendon
Methodology

- 35 plantaris tendons harvested from fresh-frozen cadaver specimens
  - 5 pairs, 25 individual
  - Avg. age 66 years [range, 43-89 years]
  - 17 female, 13 male
- Tendons harvested using tendon stripper
Methodology

- Single, Double and Quadruple constructs
- 20 mm functional length
- Ends sutured in running locking technique
- Tendon woven on template board
- Suture passed transversely to secure construct bundle
Collagen fibers aligned along test axis
- 300 μm fiducial markers used with video to monitor applied strain
- Instron used for cyclic and failure uniaxial tensile testing with 1 kN load cell
- 0.05 MPa preload stress applied to construct for 5 minutes.
- 10 cycles of 8% clamp-to-clamp strain
- Test to failure at 1mm/s clamp displacement
Results

- Minimally-invasive technique
  - Able to harvest 7 of 9 with tendon stripper
  - Average length incision was 2.9 cm (range 2.5-3.5 cm)
  - 2 tendons found with extension of incision
# Results

## Plantaris Tendon Material Properties.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ultimate Stress, MPa</th>
<th>Ultimate Strain, %</th>
<th>Modulus of Elasticity, MPa</th>
<th>Hysteresis, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>19.2 ± 7.0</td>
<td>3.7 ± 1.9</td>
<td>1271.8 ± 622.2</td>
<td>19.9 ± 4.5</td>
</tr>
<tr>
<td>Bohnsack et al⁶ (single)</td>
<td>—</td>
<td>11.0 ± 2.8³</td>
<td>377.6 ± 144.4³</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>28.0 ± 6.8</td>
<td>442.5 ± 102.7</td>
<td>—</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD. —, no data available.
³Present study as measured based on Bohnsack et al.⁶

## Plantaris Construct Structural Properties.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Cross-Sectional Area, mm²</th>
<th>Peak Load at 8% Clamp Strain, N</th>
<th>Stiffness, N/mm</th>
<th>Tensile Strength, N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadruple</td>
<td>10.9 ± 4.1⁵,⁶</td>
<td>94.6 ± 32.2⁵,⁶</td>
<td>133.1 ± 46.3⁵,⁶</td>
<td>205.8 ± 68.2⁵,⁶</td>
</tr>
<tr>
<td>Double</td>
<td>3.8 ± 2.5</td>
<td>47.8 ± 22.6</td>
<td>53.2 ± 28.4</td>
<td>78.4 ± 50.1</td>
</tr>
<tr>
<td>Single</td>
<td>3.9 ± 1.8</td>
<td>39.9 ± 12.1</td>
<td>43.8 ± 14.7</td>
<td>66.9 ± 26.3</td>
</tr>
<tr>
<td>Bohnsack et al⁶ (single)</td>
<td>2.1 ± 0.8</td>
<td>—</td>
<td>42.6 ± 12.9</td>
<td>93.8 ± 14.9</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD. —, no data available.
⁵Significantly greater than a single strand of the same tendon (P ≤ .001).
⁶Significantly greater than for an independent double construct (P ≤ .005).
Results

Tensile Strength

Newtons

0 50 100 150 200 250 300 350 400 450

Single  Double  Intact ATFL Attarian\(^1\)  Intact ATFL Waldrop\(^2\)  Quadruple  Intact CFL Attarian\(^1\)
Conclusions

- Plantaris has tensile strength greater than that of ATFL when quadrupled
- Accessible through minimally invasive approach with limited morbidity
- High tensile strength to size ratio


