THE MECHANICAL PROPERTIES OF BRAIDED TENDON GRAFTS FOR USE IN ACL RECONSTRUCTION

*Nicklin, S; *Waller, C; *Walker, P; *Chung, K; +*Walsh, W R
+*Orthopaedic Research Lab, Prince of Wales Hospital, Sydney, Australia. Orthopaedic Research Lab/Prince of Wales Hospital/Randwick/NSW 2031/Australia, 612 9382 2657, Fax: 612 9382 2660, W.Walsh@unsw.edu.au

Introduction

Controversy surrounds reconstruction of the anterior cruciate ligament (ACL) with regards to graft choice and fixation. Most surgeons performing ACL reconstruction use an intra-articular autogenous graft from either the patellar tendon or hamstrings. It has been suggested that hamstring tendon grafts are weaker than patellar tendon grafts, although there is conflicting data where multiple strands of the hamstrings are used.

In an effort to increase strength, it has been suggested that braiding or weaving of tendons may improve their strength. This was presented at the American Academy of Orthopaedic Surgeons in 1998 and has since been incorporated in an educational video(1). To our knowledge there are no biomechanical studies to support this technique.

This study examined the biomechanical properties of 2 braiding techniques compared to a 4-stranded tendon graft using an in-vitro sheep tendon model.

Methods

Digital extensor tendons from 5 adult sheep (18 months old) were harvested in matched pairs and randomly allocated to 2 braiding techniques: French Plait or a 4-strand weave. The contralateral matched tendons were used as controls. The tendons were frozen on the day of harvest and defrosted overnight prior to preparation. The 2 tendons were doubled over to make a 4 strand construct for both braids and matched controls. The tendons were braided to a length 7 cm with both techniques. All tendons were kept moist with phosphate buffered saline during preparation and stored frozen prior to testing. The tendons were thawed overnight at room temperature before testing.

Tendons were tested using an MTS 858 Bionix Testing Machine (MTS Systems Corporation, Eden Prairie, MN, USA). The tendons were secured in brass grips and frozen with liquid CO2. Care was taken not to freeze the gauge heads. Systems Corporation, Eden Prairie, MN, USA). The tendons were thawed overnight at room temperature before testing.

The tendons were secured in brass grips and frozen with liquid CO2. Care was taken not to freeze the gauge heads. Systems Corporation, Eden Prairie, MN, USA). The tendons were thawed overnight at room temperature before testing.

The precondition stiffness for the braided tendons were significantly lower compared to controls (p< 0.001). The mechanical data to failure (Table 1) revealed a significant reduction in strength and stiffness of the braided samples compared to controls (p< 0.001).

<table>
<thead>
<tr>
<th></th>
<th>Stiffness N/mm</th>
<th>SD</th>
<th>Load N</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plait</td>
<td>120.56</td>
<td>65.04</td>
<td>778.56</td>
<td>134.32</td>
</tr>
<tr>
<td>Control</td>
<td>656.56</td>
<td>169.78</td>
<td>1792.49</td>
<td>503.66</td>
</tr>
<tr>
<td>Weave</td>
<td>92.36</td>
<td>20.87</td>
<td>969.03</td>
<td>224.04</td>
</tr>
<tr>
<td>Control</td>
<td>613.86</td>
<td>97.23</td>
<td>1843.76</td>
<td>456.13</td>
</tr>
</tbody>
</table>

Table 1: Stiffness and load of all samples

The load – displacement curves reflected the different patterns of failure. The braided samples failed in a step-wise manner of multiple peaks with no well-defined yielding region. The 4 stranded controls demonstrated the characteristic sigmoidal curve common for dense connective tissue with a toe, region, linear region, yield and failure.

Discussion

A number of different fixation methods exist for tibial and femoral fixation along with a variety of graft choices. The mechanical properties of the graft are an important parameter in the reconstruction and rehabilitation. The suggestion for the use of braiding to strengthen tendon grafts appears to have been based on an assumption that braiding is used in the construction of ropes, yarns and sutures to increase strength. This however, is not the case. Indeed braiding is used extensively in the manufacture of ropes, yarns and suture, but it is to improve flexibility and handling properties. Studies by Hearle et al (2) on ropes and yarns showed a decrease in fibre bundle strength mathematically related to the angle of the twist. Strength was shown to decrease with the square of the cosine of the twist angle.

The twist angle in our samples was approximately 45° and the square of the cosine of the twist is approximately 0.5. This equates to a decrease in strength of 50%. This correlates well with our findings of a decreased strength of 54%. Moreover, the stiffness of the braided samples decreased up to 85%. This is also significant as the stiffness of the construct plays a crucial role in ACL reconstruction and overall stability of the knee.

These results indicate that braiding of tendon grafts in ACL reconstruction is not advisable as it significantly reduces both strength and stiffness of the graft. Considering, the strength of the graft is strongest immediately following reconstruction, aggressive rehabilitation following a braided construct may overload the graft and result in premature failure.

1. Sterret, W., R. Hawkins, and M. Begg. AAOS Surgical demonstration video: Braided Hamstring Reconstruction of the ACL Utilising Interference Screws... 1999.

Fig 1: Typical mid-substance failure of a braided sample.