Comparative Bio-Mechanical Study of Acute Tendon of Achilles Repair between Krackow and Uchiyama Technique in an Ex Vivo Porcine Model

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Disclosure

Mary Rose Gonzales, MD
I have no financial conflicts to disclose

Objective

This study compared the biomechanical property of krackow and uchiyama tendon repair technique and noted its mode of failure in an acute tendon rupture in an ex vivo porcine model
Introduction

• In 2009, Japanese orthopedic surgeons headed by Uchiyama conducted a study from May 2000 to April 2004 that utilized a modified technique for repair of achilles tendon ruptures. This modified technique and early rehabilitation allowed early weight bearing and early return to daily activities and sports.

• Allowed strong repair stability and subsequent early weight bearing and range of motion exercises

• evaluated a newly modified method of repair and a unified rehabilitation protocol to allow early weight-bearing and early return to daily activities

Materials and Methodology

Twenty porcine flexor digitorum tendons from the hind leg were harvested within 6 hours after death of the animal. These were wrapped in saline-soaked gauze then refrigerated at 4°C after removal of extraneous muscle tissues with a maximum storage time of 12 hours. Harvested tendons were randomly assigned to each of the 2 groups, with 10 tendons per group. A scalpel was used to transect each of the tendons transversely at the mid-substance, immediately preceding the repair. A single investigator performed the harvest, preparation and repair of all tendons.

Materials and Methodology

For the first group, Using a double-strand Krackow technique, four locking loops were spaced 5 mm from each other, 1 cm from the proximal end of the tendon. For the Uchiyama technique, each tendon end was divided into bundles approximately 5 mm wide - 2 proximal and 2 distal. The reconstruction was completed by gathering each bundle by Bunnell-like sutures. Each bundle was pulled lightly and fixed to the other end of the tendon in a linear fashion.

Biomechanical testing was conducted by a single civil engineer using a mechanical universal testing machine with each end of a sample tendon secured using metal clamps. Load to failure test was done with longitudinal traction at an advancement rate of 0.85 mm/s. Failure is defined as suture breakage and pull-through or pull-out, until no further increase in the load registered on the machine, indicating that the ultimate load has been reached. Ultimate load to failure was measured. Mode of failure was recorded, whether at the suture or tendon substance.
Results

- Krackow repair [119.18N ± 37.4]
- Uchiyama repair [112.98 ± 32.06]
- Mode of failure – Suture breakage (p=0.34)

Table of Load to failure (Newtons) of porcine tendons repaired by Krackow and Uchiyama Technique

<table>
<thead>
<tr>
<th>Krackow</th>
<th>Maximum Load to failure (Newtons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendon 1</td>
<td>135.75</td>
</tr>
<tr>
<td>Tendon 2</td>
<td>137.50</td>
</tr>
<tr>
<td>Tendon 3</td>
<td>126.88</td>
</tr>
<tr>
<td>Tendon 4</td>
<td>137.50</td>
</tr>
<tr>
<td>Tendon 5</td>
<td>135.62</td>
</tr>
<tr>
<td>Tendon 6</td>
<td>128.30</td>
</tr>
<tr>
<td>Tendon 7</td>
<td>98.00</td>
</tr>
<tr>
<td>Tendon 8</td>
<td>176.00</td>
</tr>
<tr>
<td>Tendon 9</td>
<td>63.60</td>
</tr>
<tr>
<td>Tendon 10</td>
<td>52.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Uchiyama</th>
<th>Maximum Load to failure (Newtons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendon 1</td>
<td>108.13</td>
</tr>
<tr>
<td>Tendon 2</td>
<td>75.62</td>
</tr>
<tr>
<td>Tendon 3</td>
<td>75.00</td>
</tr>
<tr>
<td>Tendon 4</td>
<td>101.87</td>
</tr>
<tr>
<td>Tendon 5</td>
<td>139.375</td>
</tr>
<tr>
<td>Tendon 6</td>
<td>156.87</td>
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<tr>
<td>Tendon 7</td>
<td>140.01</td>
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<tr>
<td>Tendon 8</td>
<td>133.09</td>
</tr>
<tr>
<td>Tendon 9</td>
<td>66.99</td>
</tr>
<tr>
<td>Tendon 10</td>
<td>132.86</td>
</tr>
</tbody>
</table>

T-test (SPSS 2017®)
Discussion

• Biomechanical systematic review of repair in cadaveric human Achilles tendons
  – a definitive recommendation on the most optimal repair technique still cannot be made due to subject heterogeneity and varied methodology
  – support the wide use of a double bundle Krackow suture technique utilizing non-absorbable braided sutures as repair option for acute Achilles tendon rupture

Discussion

• Early mobilization is encouraged as early as 2 to 4 weeks
  – Immobilized tendon sutures lose 50% of their initial strength within the first week due to tenomalacia at the suture-tendon junction

• Early full weight bearing is believed to increase the risk of rerupture and thus the longer immobilization period

## Discussion

<table>
<thead>
<tr>
<th>Krackow</th>
<th>Postoperative Management</th>
<th>Uchiyama</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 weeks</td>
<td>Duration of casting</td>
<td>2 weeks</td>
</tr>
<tr>
<td>2 weeks</td>
<td>Start of weight bearing</td>
<td>1 week</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>92 % Return to pre-injury ROM at 17 weeks</td>
</tr>
</tbody>
</table>

- Early weight bearing on the operated leg
  - quicker return to daily activities or sports
  - earlier functional recovery
  - trains the muscles on the operated side and prevents articular cartilage deterioration

Discussion

• Early passive and especially active rehabilitation programs have been shown to prevent initial weakening at the repair site by improving tendon nutrition, healing and remodeling.

• Controlled mobilization after the inflammatory phase which is approximately 1 week after injury, enhances the quality of healing tendons by stimulating fibroblast proliferation and collagen realignment.

Discussion

<table>
<thead>
<tr>
<th>Krackow</th>
<th>Repair</th>
<th>Uchiyama</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethibond ® 2</td>
<td>Type of suture</td>
<td>Ethibond ® 2-0</td>
</tr>
<tr>
<td>2</td>
<td>Number of core sutures</td>
<td>8</td>
</tr>
</tbody>
</table>

• A 50% increase in strength to failure would be expected by increasing the number of crossing strands by 50%

• 12 core repair using a 2-0 non absorbable suture was stronger than a 6 core repair using a 2 non absorbable suture


Conclusion

• Uchiyama suture technique may be an alternative to open repair of acute tendon of Achilles rupture

• With similar maximum load to failure, this may facilitate earlier range of motion for both Uchiyama and Krackow techniques of less than 2 weeks
Limitations

• Being an ex vivo biomechanical study
  – the injury was created using a sharp scalpel rather than the degenerative tendon tissue associated with clinical rupture
  – tendon repair was also done at time zero from injury
  – may oversimplify Achilles tendon repair postoperative rehabilitation

• Data be gathered is limited to ultimate load to failure and may not be comparable to hypothesized earlier range of motion and weight bearing after surgery
Recommendations

• To investigate other biomechanical properties
  – cyclic loading
  – tendon gapping
• In vivo studies may also be done to investigate other properties of the Uchiyama technique
  – greater surface contact
  – smaller caliber sutures
References


