INTRODUCTION
Early protected mobilisation is accepted as the standard postoperative rehabilitation protocol after repair of flexor tendons. However in recent years active mobilisation protocols have been utilised. Active mobilisation is thought to improve excursion and decrease adhesions (1). The increased tension of active mobilisation may also increase rate of collagen synthesis, thereby improving tendon healing (2). The utilisation of early active mobilisation postoperatively requires suture repairs that are sufficiently strong to withstand the forces involved without rupture. The quantification of the strength of the repair techniques is not a new idea. The standard method of testing repair techniques has been to apply a tensile displacement until rupture (or demonstrate significant gap formation). Considering in-vivo repairs are loaded dynamically during an active rehabilitation programme, the relevance of static load to failure testing is questioned. This study therefore utilized a cyclic loading profile designed to replicate the active rehabilitation protocol.

METHODS.
Thirty human flexor digitorum tendons from fresh frozen cadavers were transected at the level of Verdas zone 2, then repaired using one of 3 techniques: 1. modified Kessler core suture with a running epitelenon suture; 2. modified Kessler core suture with a cross stitched epitelenon suture; 3. 4-strand Savage core suture with a running epitelenon suture. Mechanical testing was performed in phosphate buffered saline in load control using a Mach-1™ Micromechanical testing system ( BiosynTech, Quebec, Canada). Each sample was tested through two consecutive loading protocols: A - 500 cycles at 0.1 Hz of sinusoidal loading to 20N; B - 500 cycles at 0.1 Hz of sinusoidal loading to 33N. Protocol A simulating passive mobilisation while protocol B simulates active mobilisation. The gap formation was recorded by direct measurement with an electronic caliper every 100 cycles. The mode of failure was noted. The gap formation of the repair was plotted against the number of cycles completed for each repair and the cumulative survival data for each repair type was plotted for initial gap formation, significant gap formation (>2mm) and failure of repair.

RESULTS.
The table below presents the survival rates with regard to significant gap formation over the duration of the testing, showing the relative survival strength of the Savage repair over the Kessler repairs.

<table>
<thead>
<tr>
<th>percent survival - gap &lt; 2mm</th>
<th>100</th>
<th>90</th>
<th>80</th>
<th>70</th>
<th>60</th>
<th>50</th>
<th>40</th>
<th>30</th>
<th>20</th>
<th>10</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>savage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kessler + O&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kessler + xs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No significant difference between the repair techniques with regard to significant gap formation or rupture were noted in the lower load protocol. Interestingly, Kessler repairs with cross stitched epitelenon suture demonstrated early minor gap formation at the lower load levels. The survival of the repairs at the higher loads differed considerably. The Kessler repairs failed more rapidly, with regard to significant gap formation and rupture over the duration of the higher force cyclic loading. The Savage repairs demonstrated less gap formation and did not rupture at the forces above the highest measured for unopposed active flexion.

DISCUSSION
This study did not attempt to quantify the highest force at which a repair would survive cyclic loading, but instead was aimed at simulating the forces and conditions involved in active mobilisation protocols, and assessing survival rates of the three repairs. Cyclic testing is a more rigorous testing protocol that more closely replicates the clinical situation. Under cyclic testing these repairs form significant gaps at lower loads than the reported ultimate load to failure seen with static testing. The testing parameters were selected to approximate the conditions of active mobilisation as close as possible. The rate of 0.1 Hz was taken from the patient exercises of flexion/extension at 5-6 times per minute. The number of repetitions (500) reflects the number of repetitions carried out by the patient in a week. The forces were higher than the maximal forces measured in situ for the active unopposed flexion of the FDP tendon for the active mobilisation simulation, and well above the maximum force for passive mobilisation in the passive mobilisation protocol (A). This testing protocol therefore represents a challenging dynamic testing regime to compare different repair techniques. The duration of the test appears critical in differentiating the repair strengths, as there is no difference between the Savage and the Kessler + running epitelenon repairs over the first 100 cycles at the higher load, however the difference after 500 cycles is greatly significant. The demonstration of survival patterns of the three repairs under these conditions strongly suggests that the Savage is much more likely to survive an early active rehabilitation protocol than the Kessler repairs.

References