Intermittent Pneumatic Compression Can Enhance Rat Achilles Tendon Repair After Immobilization
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Introduction: Achilles tendon ruptures, whether operated or not, are mostly treated with long periods of immobilization. However, accumulating data show that prolonged immobilization is associated with impaired tissue repair including reduced biomechanical properties of the healing tendon. Prolonged immobilization leads to reduced blood flow and hampers the neuro-vascular ingrowth post-rupture [1], which is vital for repair by supplying different growth factors and neuronal mediators to the healing site.

Intermittent Pneumatic Compression (IPC) treatment is based on passive increase of local blood flow by use of cyclic external pressure to reduce venous stasis, decrease venous pressure, and enhance arterial blood flow. Previous data have shown that daily IPC enhances neuro-vascular ingrowth as well as cell proliferation in a tendon rupture model [2]. However, whether IPC treatment could counteract the impairment of the healing process caused by immobilization has not previously been studied.

We thus hypothesized that daily treatment with intermittent pneumatic compression may promote the healing of Achilles tendon ruptures under immobilized conditions

Materials and Methods: A total of 48 male Sprague Dawley rats (weight 250 g) were divided into three groups of 16 (mobilized, immobilized and immobilized IPC treated). The experiment was approved by the Ethics Committee for Animal Research Stockholm North. Under anesthesia, the right Achilles tendon of the rats was bluntly ruptured. Immobilization was achieved by application of a plastic cast from the toes up to the hip. IPC treatment was applied for one hour daily under anesthesia during the experiment, starting at the first post-operative day. During treatment the casts were temporarily removed.

2 weeks post-rupture, all the rats were euthanized. In 10 rats of each group the Achilles tendons were dissected for biomechanical testing. The remaining 6 rats were perfused with Zambonis fixative and their Achilles tendons sectioned for later morphological assessments.

The length of the tendon and the sagittal and transverse diameters of the callus were measured with a slide calliper. The cross-sectional area of compression therapy, however, require further investigations.

Results: Compared to mobilization, immobilization caused a significant down-regulation (p<0.05) of peak force (80%), stiffness (77%), energy uptake (75%), tendon length (22%) and cross sectional area (47%). collagen III (83%) and organized collagen (36%). However, when immobilization was combined with IPC the values of 5 out of the 7 parameters tested demonstrated a significant increase compared to pure immobilization (Table 1). The values in energy uptake and tendon length even reached the respective levels in the mobilized group.

Table 1: Percentage change of the assessed data comparing the immobilized groups; pure immobilization was set as 0%.

<table>
<thead>
<tr>
<th>Group</th>
<th>Max Force</th>
<th>Energy at 0%</th>
<th>Stiffness</th>
<th>Length</th>
<th>Cross section area</th>
<th>Collagen III</th>
<th>Organized Coll.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immobilization</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Immobilization + IPC</td>
<td>65%</td>
<td>168%</td>
<td>31%</td>
<td>25%</td>
<td>32%</td>
<td>150%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Discussion: The present study clearly confirmed that immobilization after Achilles tendon rupture impairs tissue repair. Furthermore, daily one-hour intermittent compression treatment can improve and even reverse the values of some parameters hampered by immobilization, presumably reflecting enhancement of the entire healing process.

Immobilization impairs healing: The 80% drop in peak force two weeks of immobilization as compared to mobilization could chiefly be related to the observed 83 % decrease in collagen III. In contrast, the mobilized group attained proliferative healing with high production of scar collagen (collagen III), which exhibits the primary role in building up the healing tendon’s strength. Both the 77% decrease in stiffness and 75% reduced energy uptake of the immobilized tendon additionally reflect the impaired biomechanical properties. Reduced stiffness may be related to the down-regulated production of collagen I and III as well as related to the down-regulated production of collagen I and III as well as related to the observed 83 % decrease in collagen III. In contrast, the mobilized group attained proliferative healing with high production of scar collagen (collagen III), which exhibits the primary role in building up the healing tendon’s strength. 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Acknowledgments: This study was supported by Stockholm County Council and Karolinska Institutet (proj.nr. SL20070317).


Fig. 1: Sirius red-polarized light micrographs of longitudinal sections through the rupture site of the Achilles tendon of (A) mobilized, (B) immobilized and (C) immobilized IPC treated rats. Short green fibers denote collagen III. (I denotes intact parts of the tendon. Bar=200µm).

Fig. 2: Sirius red-polarized light micrographs of longitudinal sections through the rupture site of the Achilles tendon of (A) mobilized, (B) immobilized and (C) immobilized IPC treated rats. Short green fibers denote collagen III. (I denotes intact parts of the tendon. Bar=200µm).