Early Dynamization Does Not Improve Fracture Healing in a Rat Femoral Osteotomy Model

Bettina M. Willie, Robert Blakytny, Melanie Goeckelmann, Markus Schoene, Anita Ignatius, Lutz Claes
Orthopaedics and Biomechanics, University of Ulm, Ulm, Germany
lutz.claes@uni-ulm.de

Introduction: Dynamization is used in intramedullary fixation of fractures using interlocking nails or in fracture fixation using external fixators to improve the healing process. Early dynamization has been shown clinically (1) and experimentally (2) to stimulate the fracture healing process. The aim of this study was to test that hypothesis in a rat diaphyseal femoral osteotomy model.

Materials and Methods: Twenty-four rats underwent a mid-diaphyseal femoral osteotomy, with a 1mm interfragmentary gap. The osteotomy was stabilized by either rigid (R-group; n=8) or flexible (F-group; n=8) external fixation.

The dynamized group (D-group; n=8) had a rigid fixation for 1 week, and then a flexible fixation for the remaining 4 weeks. In vitro testing indicated that the flexible fixation design resulted in an axial stiffness of 10N/mm and an interfragmentary strain (IFS) of 25%. The rigid fixation design resulted in an axial stiffness of 74N/mm and IFS of 3%. IFS calculations assumed a 1mm gap and an axial force of 0.5 times body weight (3).

Three-point bending data, conducted in both the anterior-posterior (A/P) and medial-lateral (M/L) directions, and microCT data.

Results: The R-group had a higher number of movements compared to the D-group, which was significant after 14 days (p=0.03) and 21 days (p=0.03). The flexural rigidity was 87% (A/P) and 58% (M/L) greater in the R-group than in the F-group (p<0.01). Also, the flexural rigidity was 82% (A/P) and 93% (M/L) greater in the R-group than in the D-group (p<0.01) (Table 1). The D-group had 37% greater mineralized callus tissue volume compared to the R-group(p=0.002).

Discussion: The hypothesis could not be supported, in that early dynamization did not improve healing compared to rigid or flexible fixation. The rigid fixation had a stiffer callus with smaller callus volume, and more calcified tissue in the whole callus and at the level of the osteotomy gap. The rigid fixation had bridging in the gap more often, which explains the increased flexural rigidity measured. The rigidly fixed rats more closely regained pre-operative levels of movement than the flexibly fixed or dynamized rats. Dynamization utilized in previous studies allowed closure of the fracture gap and thereby enhanced the rate of healing (4), which was not the case in the present investigation.


<table>
<thead>
<tr>
<th>Measure</th>
<th>R-group (Mean ± SD)</th>
<th>F-group (Mean ± SD)</th>
<th>D-group (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Rigidity (N/mm)</td>
<td>34100 ± 5520</td>
<td>4490 ± 6190</td>
<td>12592 ± 13278</td>
</tr>
<tr>
<td>Operated Femur-A/P</td>
<td>2836 ± 7100</td>
<td>2109 ± 1094</td>
<td></td>
</tr>
<tr>
<td>Operated Femur-M/L</td>
<td>1063 ± 4590</td>
<td>1096 ± 4904</td>
<td></td>
</tr>
<tr>
<td>Fract Femur-A/P</td>
<td>1758 ± 3665</td>
<td>1573 ± 2958</td>
<td></td>
</tr>
<tr>
<td>Fract Femur-M/L</td>
<td>1758 ± 3665</td>
<td>1573 ± 2958</td>
<td></td>
</tr>
<tr>
<td>Volume (mm³)</td>
<td>0.164 ± 0.026</td>
<td>0.193 ± 0.039</td>
<td>0.226 ± 0.059</td>
</tr>
<tr>
<td>Osteotomy Gap</td>
<td>0.017 ± 0.003</td>
<td>0.029 ± 0.009</td>
<td>0.025 ± 0.011</td>
</tr>
<tr>
<td>Bone Mineral Density (g/cm²)</td>
<td>0.56 ± 0.026</td>
<td>0.61 ± 0.05</td>
<td>0.70 ± 0.09</td>
</tr>
<tr>
<td>Osteotomy Gap</td>
<td>0.017 ± 0.003</td>
<td>0.029 ± 0.009</td>
<td>0.025 ± 0.011</td>
</tr>
</tbody>
</table>

Image 1: An in vivo radiograph of a flexibly (A) fixed osteotomized femur and microCT images of a rigidly (B) and flexibly (C) fixed femur, after 5 weeks of healing (sagittal plane).