Mesenchimal Stem Cell Improved Bone Regeneration around a Hip Prosthetic Uncemented Stem

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Introduction: Non-cemented prosthetic stem is the gold standard for hip replacement (1). Long term stability depends on the integration between bone and prosthesis; in presence of poor quality bone (age, osteoporosis, osteonecrosis) methylmethacrylate cement is necessary (2). To avoid the use of cementation, we tested the ability of a cell based composite (3) to enhance bone ingrowth mediated secondary fixation around a hip prosthetic titanium uncemented stem.

Materials and Methods: Twelve cross-breed female adult sheep were divided into 2 groups. Group I (6 sheep, control group) received unilateral uncemented hip arthroplasty. The femoral stem was made of titanium with sand blast treatment. The design was tapered with sharp angles to achieve a good primary stability, while the acetalular cup was a unipolar endoprosthesis.

In Group II (6 sheep, study group) after femoral stem preparation, a composite material made of type I collagen, autologous platelet-rich plasma (PRP) and mesenchymal stem cells (MSC), was injected into the femoral canal followed by a press fit insertion of the uncemented stem. Radiographs were evaluated post-operatively and at sacrifice (2 months).

New bone formation inside the medullary canal around the prosthesis and bone remodelling of the femoral cortex was evaluated, together with the measurement of the bone contact to the femoral stem. Histology and histomorphometry was performed in non-decalcified specimens, divided in 3 transverse cuts (Fig. 1).

Results: The roentgenograms in group I showed 2 cases of peri-prosthetic fracture and one case of incorrect positioning of the femoral stem, which was inserted in the cortex. These animals were not evaluated histologically. In group II we had one case of dislocation with necrosis of the limb and one case of subsidence of the prosthesis. Both of these animals were not evaluated histologically. Histology was performed in 3 animals of group I and in 4 animals of group II, it showed bone healing in the intertrochanteric area in both groups due to microcracks caused by the proximal canal preparation and prosthetic stem insertion, however in all sections new bone formation was more evident in Group II, especially in the distal section. In the cortex there were no differences on new bone regeneration between the two groups (Fig. 2). Histomorphometry showed a higher percentage of newly formed bone inside the medullary canal in group II (19.65% in the proximal cut, 18.47% in the intermediate and 18.04% in the distal one) in comparison to group I (5.23% in the proximal cut, 5.26% in the intermediate and 3.36% in the distal cut). Inside the cortex the percentage of new bone was not very high, with no differences between the 2 groups: 0.93%, 1.11% and 1.77% respectively in proximal, intermediate and distal cut in group II, and 0.28%, 0.42% and 0.8% in group I.

The bone contact to the titanium femoral stem was higher in group II than in group I, where no bone contact was detected (Tab 1).

Histomorphometrical raw data

<table>
<thead>
<tr>
<th>GROUP</th>
<th>New bone inside the medullary canal (mm^2)</th>
<th>New bone inside the cortex (mm^2)</th>
<th>Bone/Prosthesis contact (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proximal Cut</td>
<td>Medial Cut</td>
<td>Distal Cut</td>
</tr>
<tr>
<td>I</td>
<td>44.03</td>
<td>25.74</td>
<td>9.91</td>
</tr>
<tr>
<td>II</td>
<td>16.57</td>
<td>15.57</td>
<td>11.34</td>
</tr>
</tbody>
</table>

Discussion: The cell-based substance is able to fill the space between old bone and the uncemented stem with new bone while improving bone remodelling in a two months sheep model; moreover it improves the contact between newly formed bone and the titanium stem. The results suggest that the addition of a composite material based on collagen, PRP and mesenchymal stem cells can improve the secondary fixation of a hip uncemented femoral stem.