DEVELOPMENT OF A BIOLOGIC PROSTHETIC COMPOSITE FOR CARTILAGE REPAIR
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Introduction
Damaged cartilage is a frequent problem in our population. Unfortunately, damaged articular cartilage has a limited ability to heal (1). Young patients with a large focal osteochondral defect due to trauma or avascular necrosis, where the defect of both bone and cartilage are too large to accept any regenerative procedure, have no clinically proven treatment options. Clinicians and researchers have been striving to develop cartilage repair techniques, through the use of transplanted chondrocytes (2) mesenchymal stem cells (3) or undifferentiated tissues containing stem cells (such as periosteum or perichondrium). Periosteum regenerates both cartilage and bone, and has been used successfully in biological resurfacing for the repair of damaged articular cartilage (5).

A new porous scaffold made of tantalum has recently been developed for potential application in reconstructive orthopedics and other surgical disciplines. The material has an unusually high and interconnected porosity with a very regular pore shape and size. It can be made into complex shapes and used either as a bulk implant or as a surface coating. This material has been shown to permit physiologic bone in growth and healing (6). In transcortical implant studies, new bone infiltrated rapidly the material (7). The pore size and high volume porosity of this material supports vascularization and rapid secure soft tissue ingrowth (8).

The purpose of the present study was to evaluate the feasibility of developing a biologic and prosthetic composite using this new porous tantalum scaffold and the chondrogenic potential of periostem. We hypothesize that porous tantalum scaffold may be used as a primary support and shape specific interface between the periosteal explant and the subchondral bone allowing biological resurfacing mediated by trabecular metal.

Materials & Methods
A standard periosteal explant culture technique was used on 24 explants. Explants (3 mm / diameter) were harvested from the medial proximal tibiae from 6 two-month-old New Zealand white rabbits as previously described (4). In the experimental groups, explants were sutured to porous tantalum disks (3 mm diameter x 5 mm thick) with the cambium layer facing up (Group I / 4 explants) or down (Group II / 4 explants) to the porous tantalum. Both experimental groups were cultured for 42 days using a periostal chondrogenesis culture model with 10% fetal bovine serum and linearized with TGF-β1 (100ng/ml) for the first 2 days. In a third experimental group (Group III / 4 explants) were sutured to the porous tantalum disks with the cambium layer facing up and cultured in a different chondrogenic medium with: 10% FBS, 10 ng/ml TGF-β1, 5 μg/ml Growth Hormone (GH), 50 ng/ml basic Fibroblast Growth Factor (bFGF) and 3.3 μl/ml ITS+ (0.625 mg/ml insulin, 0.625 mg/ml transferrin, 0.625 μg/ml selenious acid, 0.125 mg/ml BSA and 0.535 mg/ml linoleic acid). Two positive control groups were used to culture the explants in the two chondrogenic medium conditions described above but without porous tantalum to evaluate a possible negative effect of this material on chondrogenesis (Group IV and V / 4 explants per group). Negative control explants were not exposed to either exogenous administration of growth factors (Group VI / 4 explant) or tantalum. A standardized cartilage yield assay was performed after 6 weeks in culture. The control explants (Group IV, V and VI) were weighed and embedded in paraffin, sectioned, stained with safranin O/fast green. The tantalum/periosteum groups (Group I, II and III) were embedded in methyl methacrylate. These samples were sectioned using the Exakt™ System and stained with safranin O/fast green. Two samples from group III were detached from the tantalum and cultured after 6 weeks of culture and processed as described for the controls. The simple histological-histochemical cartilage scoring system validated previously in our lab (9) was used to analyze all the histological slides. [Table I]. In samples that were attached to the tantalum piece, we evaluated the thickening of the new cartilage overgrowth from the tantalum using a new proposed qualitative score [table II].

<table>
<thead>
<tr>
<th>Score</th>
<th>Thickness of cartilage overgrowth</th>
<th>Qualitative thickness score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;0.5 mm</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.5-1 mm</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1-2 mm</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>&gt;2 mm</td>
<td>3</td>
</tr>
</tbody>
</table>

TABLE II: Qualitative score for thickening of the cartilage grown up over the tantalum

Discussion
We can conclude that periosteal chondrogenesis is not hindered by the presence of the tantalum when the periosteum is stitched with the cambium layer facing away from the tantalum. Therefore biological resurfacing of large osteochondral defects may be feasible using a porous tantalum/autologous periosteal construct. However, in vivo experiments using biological resurfacing of large osteochondral defects with a porous tantalum/autologous periosteal construct will be necessary in further explore this possibility.

References

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