INTRODUCTION:
The reproducible repair of articular cartilage is an intensely researched area in orthopaedics today. A number of studies have shown the utility of various absorbable polyesters for cartilage tissue engineering and as devices for cartilage repair (Freed et al). Our laboratory has developed a novel off-the-shelf arthroscopically deliverable device that promotes cartilage repair by providing a framework for cell attachment and remodeling. When placed in a 4 mm full thickness defect in the rabbit trochlear groove, the implant was replaced with hyaline-like cartilage (Grandes et al). The goal of this study was to compare two different polymer scaffolds for their ability to promote chondrogenesis in a large animal model by investigating the osteochondral (OC) healing response at 8 weeks.

METHODS:

Thirteen adult, skeletally mature, neutered male, Boer-cross goats were randomly assigned to the three groups in the study. All the in vivo procedures were approved by the IACUC at the animal care facility (Thomas Morris Inc., Baltimore). The animals were anesthetized and draped in sterile fashion and the knee joint approached via lateral para-malleolar incisions. The skin and subcutaneous tissue were dissected and the joint capsule incised. The deep capsular layer was incised and the cruciate ligaments were exposed using hemostats. The cruciates were transected using a spinal needle. The joint was cleaned with normal saline and the synovial fluid aspirated. The anterior cruciate ligament was used to retract the lateral femoral condyle and lateral side of meniscus. A central 1.5mm drill hole was placed into the tibial tubercle and the bone surface smoothed with curettes so that the bone would support the implant. The notch for the implant was made using a sharp curette to the depth of the osseous defect. Instruments were used to create 7mm diameter osteochondral defects in both TG and MFC. The defects penetrated the subchondral bone by 1mm with a central 1.5mm hole extending 4mm further into the bone to facilitate implant fixation. A circular implant was then inserted into the central drill hole. The implants were composed of either a Vicryl nonwoven (NW) (Group 1; n=5) or a composite Vicryl NW and elastomeric foam-PGA/PCL material (Group 2; n=5). Both implants were attached to a bioabsorbable anchor. The control group (Group 3; n=3) consisted of OC defects, which were left empty. The patella was placed to its anatomical position and the arthroscopy was closed in a standard layered fashion. Two ml of hyaluronic acid (ArthrexHA, DePuy International) was injected in the right stifle of Group 1 animals immediately post-op and at 2 and 3 weeks post-op. The operated limb was immobilized in a modified Thomas-Schroeder splint to allow reduced-weight bearing mobilization for two weeks, after which all animals had their splints removed and returned to ad lib activity. The animals were sacrificed at eight weeks post-operation. The stifles were dissected and assessed grossly for the extent and quality of OC repair. The OC blocks were excised, fixed in formalin, decalcified, processed for histology and five-micron mid-sagittal sections were stained with H&E. The histological evaluation was performed using a grading scale, which was based upon the O’Driscoll system with modifications for the presence of a subchondral anchor [Gahunia et al 2002].

RESULTS:
The splint removal, all animals exhibited lameness for a few hours, and up to two days afterward. Aside from transient lameness due to joint stiffness, there were no long-term effects of the splint on joint mobility. At sacrifice, gross observation showed that the control defects typically contained a red-pigmented repair tissue similar to fibrin clot. MFC defects showed a poor repair tissue fill with depressed center. The OC blocks were excised, fixed in formalin, decalcified, processed for histology and five-micron mid-sagittal sections were stained with H&E. The histological evaluation was performed using a grading scale, which was based upon the O’Driscoll system with modifications for the presence of a subchondral anchor [Gahunia et al 2002].

The defect repair tissue in experimental groups showed varied combination of fibrous or fibrovascular tissue with evidence (Safranin-o positive staining) of fibrocartilaginous to hyaline-like repair tissue with the Vicryl NW scaffold. The margin integration was better in the defects with the Vicryl NW implant than with the foam/Vicryl composite implant. The defect margin integration with native cartilage comprised of fibrovascular, fibrocartilaginous, and/or cartilaginous repair tissue. Figure 1A depicts a typical empty control response at 8 weeks with dense fibrovascular repair tissue fill in the defect. Figure 1B represents the OC repair response seen with the Vicryl NW implant at 8 weeks. Note how the horizontal and vertical component of the anchor is present in the area of the subchondral bone repair. Figures 1C and 1D are higher magnifications of 1B, indicating the presence of cartilaginous repair tissue which are capable of synthesizing glycosaminoglycans. The repair tissue integration with the native cartilage is cartilaginous above the tidemark and ossaceous below the tidemark as shown in Figures 1B & D.

DISCUSSION:
The results obtained in this experiment demonstrate that hyaline-like cartilage tissue repair can be achieved with an optimized scaffold material without the need for the addition of cells or growth factors. The more porous Vicryl NW matrix appeared to outperform the more dense foam/Vicryl composite matrix, however, both matrices showed potential for cartilage repair when compared to empty controls. The fate of the empty controls is known to be mechanically inferior [Schwartz et al 2002]; however, the long-term fate of the hyaline-like repair tissue observed in the defects treated with implants is unknown. It is imperative, therefore, that long-term studies be performed to investigate how the implant supported new tissue will function with time. These results demonstrate a positive first step in the development of an “off-the-shelf” device for cartilage repair that allows reproducible restoration of focal cartilage defects and promotes hyaline-like cartilage repair in an open procedure. Additional work will be required to refine the surgical procedure for arthroscopic delivery of the implant.

REFERENCES:

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