ARTICULAR CARTILAGE DEGENERATION OCCURS OPPOSITE TO LESIONS OF MENISCUS AND CARTILAGE IN THE RABBIT KNEE

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INTRODUCTION: Altered mechanical loading of joints can lead to osteoarthritis. Studies on the pathogenesis of cartilage degeneration would be aided by knowledge of the precise location of early stage and irreversible changes in well-defined animal models. Previous ink staining studies of joint damage after anterior cruciate ligament transection have revealed staining and erosion of apposing cartilage surfaces [1]. Also, meniscal injury and repair leads to many changes in articular cartilage [3]. We hypothesized that the articular cartilage opposing surgical lesions made during experimental in vivo studies in rabbits would demonstrate site-specific morphological changes indicative of early degeneration. The objective of this study was to examine the extent and location of staining of articular cartilage with Indian Ink in the regions of (1) the tibial plateau and femoral condyle after partial medial meniscectomy and (2) the tibial plateau after injury and/or repair of the medial meniscal condyle.

METHODS: Rabbit Surgery. All studies were performed on adult New Zealand White (NZW) rabbits in procedures approved by the UCSD Institutional Animal Care and Use Committee. Control. Five normal, uninjured, and untreated animals (NL) were used as controls. Partial Meniscectomy. The knees of four rabbits were subjected to partial medial meniscectomy (PMx) by removal of central third of the medial meniscus. These animals were allowed ad libitum caged activity for six months before sacrifice. Osteochondral defect. The tibial plateaus of eighteen NZW rabbits were obtained from previous studies on osteochondral defects [2]. All rabbits received a 3.7 mm diameter by 3 mm deep defect centered on the medial meniscal condyle of each knee. In one group of animals (n = 8), a polylactic acid (PLA) core press fit into the defect of one knee (PLA) and a PLA core seeded with autologous perichondrium cells was press fit into the defect of the contralateral knee (PLA+Allo). These animals were sacrificed at 3 months. In another group of animals (n = 10), a PLA core seeded with autologous perichondrium cells was press fit into the defect of one knee (PLA+Auto), while the contralateral knee was left with an unfilled defect (Hole). These animals were sacrificed after one year.

Imaging of Cartilage Degeneration. The ink-staining patterns of femora and tibiae were determined by digital imaging and analysis as previously described surfaces [1]. Briefly, the femora and tibiae were harvested, oriented to expose a majority of the femorotibial articulating cartilage surfaces, aligned according to surface contours, swabbed with a 1:5 dilution of Indian Ink in phosphate buffered saline with proteinase inhibitors, and digitally imaged. Light reflectance from regions encompassing most of the cartilage of the medial and lateral femoral condyle (MFC, LFC) and tibial plateau (MTP, LTP) was measured in each of the individual specimen images and normalized according to gray scale standards to zero (darkest) and one (brightest). Digital averages of the registered femoral and tibial images from each experimental group were computed. To highlight and localize differences in ink staining among the study groups, the NL average image was subtracted from the average image of each of the other experimental groups.

Statistical Analysis. Light reflectance data are reported as mean ± SD. ANOVA and DUNNETT's post-hoc test were used to assess the differences between each experimental group and NL.

RESULTS: PMx at 6 months. The reflectance from the cartilage of ink-stained PMx knees at 6 months (Fig. 1) was significantly lower (darker, more degenerate) than NL in the MFC and LFC (p < 0.005), as well as the MTP and LTP (p < 0.0001). The average and difference images (Fig. 2) revealed extensive degeneration in the medial and posteriormedial aspects of the MTP, corresponding to the regions of the remaining meniscus, and somewhat milder degeneration in a broad area (anterior to posterior) of the MFC. There was diffuse degeneration over the LTP and LFC.

The reflectance from the cartilage of the ink-stained tibia after osteochondral injury and/or repair of the MFC varied with the duration after surgery (Fig. 3). PLA and PLA+Allo at 3 months. At three months comparison of the PLA and PLA+Allo reflectance scores to NL showed no significant difference for the MTP or LTP (p > 0.5). Difference images, correspondingly, revealed no regions of localized degeneration. Hole and PLA+Auto at 12 months. When compared to NL, both the Hole and Auto/PLA tibial scores were significantly lower (more degenerate) for the MTP and LTP (p < 0.001). The difference images (not shown) revealed degeneration encompassing the majority of the MTP and LTP.


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Fig. 1. Effect of PMx. Fig. 2. Average and contrast-enhanced difference images of PMx knees. Fig. 3. Effect of Femoral Defect

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