Allograft meniscus transplantation in the dog

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We studied transplantation of a fresh meniscus in 25 knees in 15 adult dogs. On 2 tables and with 2 surgical teams the medial menisci were explanted, exchanged and implanted into the opposite dog's knee. The animals were killed 4–12 months postoperatively, and the transplants were studied histologically. Complete healing in the host's capsular tissues was found in 18 knees, incomplete healing in 3, and healing by massive fibrovascular scar tissue in 4 knees. In the 4- and 5-month specimens the transplants were found to be narrower, thinner, and of changed color and consistency, while in the 8- and 12-month specimens most of the allografts appeared grossly normal. Histologically, the allografts had normal general microarchitecture, but a marked decrease in the number of cells. In the 8- and 12-month specimens the cells had increased but the number of cells in general was still less than in the controls. Although some degenerative changes of the medial tibial articular cartilage were noted in most knees, there were less changes beneath the allografted meniscus.

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We report transplantation of fresh meniscal allografts and their fate in dogs.

Material and methods

The experiment was carried out in 15 adult mongrel dogs of both sexes weighing 14–20 kg. The medial menisci of both knees were replaced in 10, and of only one knee in 5 dogs, so altogether there were 25 transplanted menisci available for study. In the same session 2 dogs of similar sizes were operated on at the same time on 2 tables with 2 operative teams. The dogs were anesthetized with intramuscular Ketamin hydrochloride (Ketalar), and using sterile technique an identical surgical procedure was done on both animals. The knee was approached through a medial parapatellar incision. The medial collateral ligament was severed near its femoral attachment and thus an extensive medial arthrotomy was made to expose the entire medial meniscus, which was then carefully explanted and exchanged with the other team. The meniscal allograft from the other dog was then sutured into the recipient bed, using 4–0 nylon sutures. Usually 3 tangentially placed posterior, medial and anterior sutures were taken out through the capsule and tied extraarticularly. The medial collateral ligament was then reattached, the capsule and periarticular tissues were closed anatomically using absorbable sutures, and the skin was closed. Postoperatively the limbs were not immobilized and the dogs were allowed to move and exercise freely. In 10 animals with the bilateral operation the period between two surgical procedures was at least 3 weeks. The animals recovered after the surgery rather uneventfully. They protected the operated on limb for several days, and by 3 weeks they had only a moderate degree of lameness, and by 6–8 weeks all of them appeared to have a normal gait. There was no postoperative infection. In 5 specimens a permanent lateral dislocation of the patella was found, but there appeared to be no obvious effects related to this complication.

The dogs were killed after 4–12 months, the knee joints were immediately opened, dissected and carefully observed, and then the proximal end of the tibia, 1 cm thick, together with transplanted medial and intact lateral meniscus which served as a control, was removed and fixed in 10% formalin. The 5 nonoperated knees were not examined. At the conclusion of the study there were 5 transplanted menisci taken 4 months after the operation, 4 after 5 months, 6 after 7 months, 6 after 8 months, and 4 after 12 months. After the careful macroscopic study of both the menisci and articular cartilage, the specimens were decalcified in 10% formic acid at room temperature. The transplanted menisci were embedded in paraffin, and 7 micron-thick sections were made in the transverse and vertical planes, mounted on glass slides, stained with hematoxylin-eosin, orcein, Mallory and Man-Dominici's methods, and examined under light microscopy.

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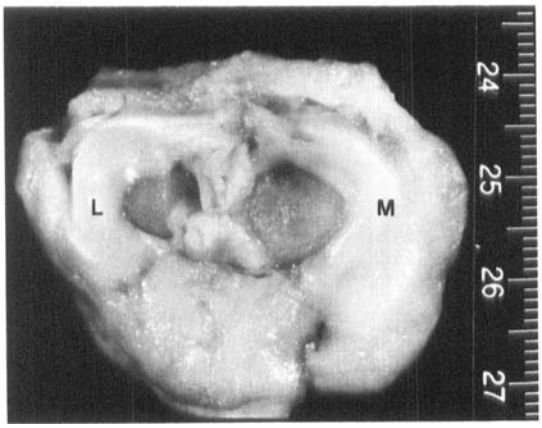

Figure 1. Tibial surface of a dog's knee 4 months after the transplantation of the fresh medial meniscus. The transplant (M) is completely healed to the peripheral capsular tissue. In comparison with the control lateral meniscus (L) it is narrower, thinner, and less shiny. Note the moderate degenerative changes in the uncovered articular cartilage of the medial condyle.

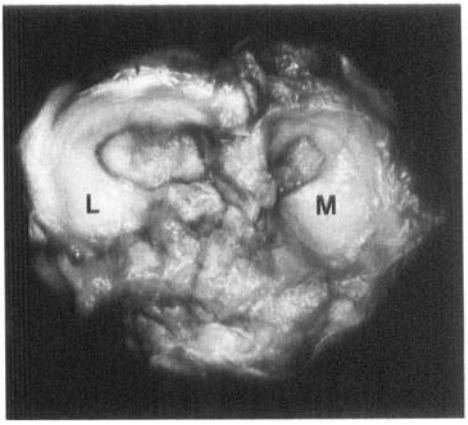

Figure 2. Proximal articular surface of a dog's tibia 12 months following transplantation of a medial meniscus. The allograft (M) appears normal and could hardly be differentiated from the control lateral meniscus (L).

Results

In all operated on knees the allografts were found to be accepted and healed to the host capsular tissues. Firm and complete healing was noted in 18 knees, and incomplete healing in 3 knees; in 2 of these the posterior and in 1 the anterior horn attachment of the transplanted menisci were disrupted. Although a moderate, proliferative synovitis and thickened capsule were noted in a number of specimens, there was no evidence of a serious inflammatory process or graft rejection. In 4 knees the anterior half of the allograft healed to the capsule by massive fibrovascular scar tissue. Comparing the results in animals with bilateral and unilateral operations, no obvious difference was noted.

Grossly the healed menisci appeared firm and well preserved. However, in the 4- and 5-month specimens the allografts were somewhat narrower, thinner and of different color and consistency (Figure 1). 8 and 12 months after transplantation, most of the allografts appeared normal; they were healed to their normal attachment sites and no change in size or gross appearance could be detected (Figure 2).

In all dissected knees some wear of the medial tibial articular cartilage was observed, notably in areas of cartilage not covered by the transplanted meniscus. However, in specimens taken 8 and 12 months after the surgery the degenerative changes were rather moderate, and the articular cartilage of the medial plateau did not differ much from the normal controls.

Microscopically the general histologic architecture of transplants was normal. Under the gliding surface, in an extracellular substance, there were typical interwoven, wave-like collagen fiber bundles (Figure 3). However, as a characteristic feature, the number of viable cells diminished in all allografts. In 4- and 5-month specimens an overall cellular depopulation was obvious (Figure 3). The majority of the remaining

Figure 3. Photomicrograph of a cross-section of the medial part of a meniscal allograft 4 months after the transplantation, showing the typical, interwoven bundles of collagen fibers under the gliding femoral surface, however, without cellular elements, HE, × 100.

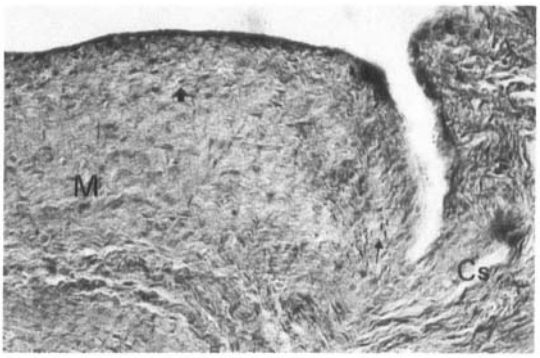

Figure 4. Photomicrograph of a cross-section of the pericapsular part of a meniscal allograft at 5 months. There is a typical groove in the gliding surface between the meniscus (M) and the capsule (Cs). The meniscus has undoubtedly healed to the capsule. Note the typical chondroid cells (thick arrow) situated mostly in the subsurface layers and the fibrous cells (thin arrow) near the capsular attachment, HE, × 100.

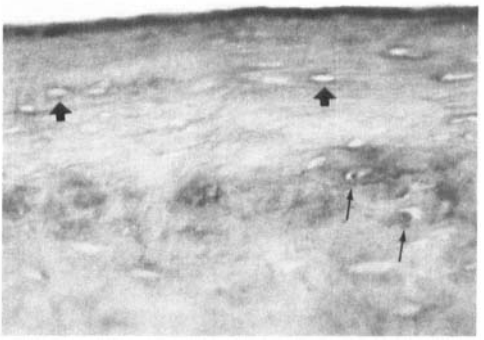

Figure 5. Photomicrograph of a vertical section of the medial part of an allografted meniscus 12 months after the operation. The number of viable cells (thin arrow) is still very limited and there are a number of ghost cells (thick arrow), HE, × 250.

cells were located in the subsurface layers and in the periphery adjacent to the capsular attachment (Figure 4). The 8- and 12-month specimens showed similar cellular distribution, but an increased cellularity was noted, although the overall number of viable cells was still less than normal. A number of ghost cells were also observed (Figure 5).

Discussion

Our results confirm that transplantation of meniscal allografts is possible; similar results were reported after transplantation of fresh menisci in goats (Keating et al. 1988), and also after transplantation of preserved meniscal allografts (Canham and Stanish 1986, Schmidt et al. 1986, Wirth et al. 1986, Milachowski et al. 1987, Wirth et al. 1987, Milachowski et al. 1989, Arnoczky et al. 1990, Arnoczky and Milachowski 1990).

The fresh menisci used in our study did not appear to elicit any type of rejection or immunogenic response. This finding, like those in other studies (Canham and Stanish 1986, Keating et al. 1988, Arnoczky and Milachowsky 1990, Arnoczky et al. 1990), might be explained by the fact that the allograft cells which harbor the major histocompatibility antigens on their surface, are isolated from the host's immune system by a dense extracellular matrix. In that way, meniscal tissue, like articular cartilage, appears to be immunologically privileged (Arnoczky and Milachowski 1990, Arnoczky et al. 1990). However, like Milachowsky et al. (1987) we observed remodeling of the allografted menisci. This remodeling included shrinkage in size and a change in gross appearance. A substantial cellular depopulation within the transplanted allografts is also believed to be a part of this remodeling phenomenon. The majority of cells observed in all allografts were located near the surface of the meniscus. This observation, as suggested by Arnoczky et al. (1990), could be explained by saying that diffusion of nutrients may have been initially limited to the superficial layers of the allograft. The cellular repopulation of the transplants over time has been observed in several studies (Arnoczky et al. 1988, Arnoczky and Milachowski 1990, Arnoczky et al. 1990), and it was noted also in our study, although it was not so convincing as in the experiment by Arnoczky et al. (1990). It is still unclear whether the cellular repopulation of the allografted menisci is the result of donor cell proliferation, a migration and proliferation of host cells into the allograft, or a combination of both (Arnoczky et al. 1990). The results of a study reported by Arnoczky et al. (1988) suggest, however, that the transplanted tissue is repopulated with cells predominantly from the host synovium. This opinion is supported by our finding that the number of cells, mostly of fibrous type, was higher in the pericapsular parts of the allografted menisci (Figure 4).

Although the degenerative changes in the articular cartilage were noted in most of our specimens, these changes were less than those reported after plain meniscectomy (Fairbank 1948, Cox et al. 1975, Lutfi 1975, Mikic et al. 1987). As it was noted in our study and several others (Canham and Stanish 1986, Milachowski et al. 1987, Arnoczky et al. 1990), the degenerative alterations directly underneath the transplant were less marked than those in the cartilage not covered by the meniscus. It was also noted that the degen-

erative changes were less pronounced in specimens taken 8 and 12 months after the transplantation than in the specimens taken 4–6 months after the surgery. It is possible that the more apparent changes observed in the earlier group were due to the postoperative stress and hemarthrosis, and not only to excessive wear. At any rate, apparently the articular cartilage may recover, provided that it is protected by a meniscus (Arnoczky et al. 1990).

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