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Meniscal repair by synovial flap transfer

Healing of the avascular zone in rabbits

Jordi Cisa[1], Jordi Basora[1], Prometeo Madarnas[2], Andre Ghibely[1] and Antonio Navarro-Quilis[3]

We studied repair of a longitudinal incision of the right medial meniscus in 44 rabbits after the transfer of a pedunculated synovial flap, without immobilization of the knee. The left medial meniscus was used as the control, after creating the same lesion without synovial flap. Healing was analyzed by histologic studies, including India ink perfusion after 8, 12, 24, and 48 weeks. In three quarters of the cases, the meniscus showed healing with vascularization of an originally avascular zone.

Departments of [1]Orthopedics and [2]Pathology, Universite de Sherbrooke, Quebec, Canada; and [3]Catedra de Cirurgia Ortopedica i Traumatologia, Universitat Autonoma de Barcelona, Spain.
Correspondence: Dr. Jordi Cisa, Laurentian Hospital, 41 Ramsey Lake Rd., Sudbury, Ontario, P3E 5J1, Canada
Tel +1 705-522 2200. Fax -523 7017
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We studied in rabbits whether healing of a meniscal incision in its avascular zone could be induced through vascularization from a pedunculated synovial flap.

Material and methods

44 full grown New Zealand white rabbits of both sexes, with a mean age of 10 (8–13) months and a mean weight of 3.2 (3.2–3.6) kg were used for the study.

The rabbits were anesthetized with Ketamine/Xylazine i.m. Under standard aseptic conditions, a medial longitudinal parapatellar approach was used in both knees. A 5–6 mm longitudinal, full-thickness incision was created identically in the avascular zone in the medial third of both medial menisci resembling a bucket-handle tear. By drawing the meniscus forward by its anterior horn before creating the incision, care was taken not to interfere with the joint cartilage. In the right knee, a pedunculated synovial flap was transferred inside the meniscal lesion and then sutured to the medial collateral ligament (Figure 1). The left knee was used as the control, with an identical meniscal incision, without a synovial flap. After surgery, the knees were not immobilized and the rabbits were allowed to move freely in their cages.

Groups of 11 rabbits were killed at 8, 12, 24, and 48 weeks. Both knees were examined to assess the range of motion and stability, measuring flexion, extension, and valgus at 0 and 30 degrees. Femoral artery dissection was performed and 35 cc of India ink was perfused on each side to stain black the vessels of the lower extremities. Arthrotomy was performed and the collateral and cruciate ligaments were sectioned. Both medial menisci were inspected. The menisci were excised and fixed in 10 percent neutral-buffered formalin, embedded in paraffin, sectioned transversally and perpendicularly and examined histologically with hematoxylin-eosin (H & E) and Masson's trichrome staining techniques. All the menisci were studied by the same pathologist, without knowledge of group or side.

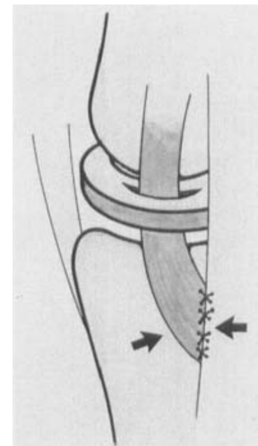

Figure 1. Diagram of a medial meniscus with the artificial lesion. A 5–6 mm longitudinal, full-thickness incision was created identically in the avascular zone of both medial menisci resembling a bucket-handle tear in the medial 1/3 of the meniscal body. A synovial flap was then passed inside the tear and attached to the medial collateral ligament (arrows).

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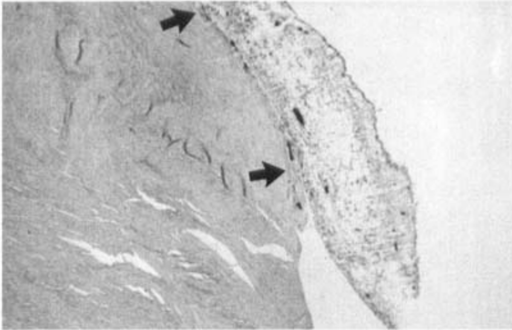
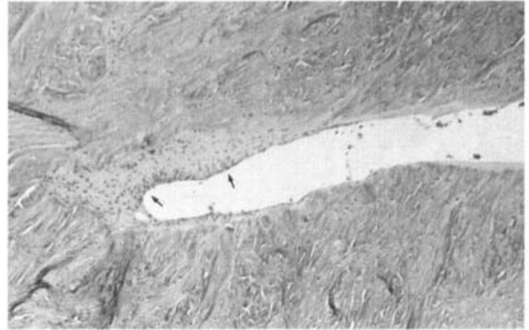
Figure 2. Transverse section of menisci with and without insertion of a synovial flap (HE).

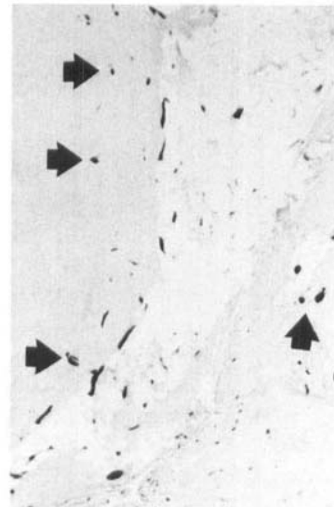


Meniscus with synovial flap at 8 weeks. The meniscus on the left side and the attached synovial flap (arrows; ×4).



Incised meniscus without synovial flap at 24 weeks. Persistence of the synovial metaplasia proliferating on wound surface (arrows), but no meniscal repair is observed, ×10.

Meniscus with synovial flap at 24 weeks. The meniscus on the left side. On the right side, the healing tissue attached to the meniscus and in the right lower part, bone metaplasia within the healing area (arrows; ×10).



Meniscus with synovial flap at 24 weeks. Artificial incision filled with adipous synovial flap and the avascular meniscal area on the left side with vessels stained black on both sides of the incision (arrows; ×10).

Results

Mobility and stability. All the right knees had a complete range of motion and normal stability. 5 control knees had an extension blockage of 15 (10–25) degrees, supposedly due to bucket-handle dislocation. All knees had normal stability.

Gross examination. All the menisci in control knees showed macroscopic persistence of the lesion in all groups. In the menisci with the synovial transfer, the flap could be identified at 8 weeks, but not after 12 weeks.

Histologic examination (Figure 2; Table 1). No signs of repair were observed in the control menisci.

Table 1. Healing of meniscal lesions with (+) and without (–) synovial flap

	Weeks after surgery							
	8		12		24		48	
	+	–	+	–	+	–	+	–
New vascularization	7	–	10	–	8	–	7	–
Healing tissue	6	–	7	–	6	–	6	–
Healing tissue with bone metaplasia	1	–	3	–	2	–	1	–
Presence of synovial flap	2	–	–	–	–	–	–	–
No healing	1	9	–	9	–	8	1	9
No conclusion	1	1*	1	2	3	3	3	2

*One rabbit was excluded because of infection.

In the menisci with synovial flap, the majority had healing tissue at the site of the lesion. Vessels were always found in the normally avascular zone of the meniscus, and the synovium did not invade the fibrocartilage.

Discussion

The knee meniscus heals only in the peripheral zone (King 1936, Benedetto et al. 1985, Day el al. 1985, Mackenzie et al. 1985, Huang et al. 1991). The perimeniscal capillary plexus originates in the capsular and synovial tissues and penetrates the peripheral third of the meniscal tissue. Longitudinal incisions in the avascular portion of the meniscus do not heal (Arnockzy and Warren 1983, Hede et al. 1991). To our knowledge, no spontaneous healing of the avascular zone has been reported (Henning et al. 1987). In the absence of bleeding, a different mechanism of repair may be at work (King and Vallee 1991). Clustered chondrocytes have been found near the margin of an incision in the rabbit meniscus because of an expansion of the synovial margin. But healing of incisions far from the synovium is not possible (Heatley 1980).

Similar studies with synovial flaps and carbon fiber implants for artificial lesions of the meniscus in rabbits showed signs of total or almost total repair at 14 weeks (Veth et al. 1983). In another similar study, transverse and T-shaped cuts were made in the menisci of 12 sheep and a flap of synovium was sutured into the wound. At 3 months, 10 of the 12 menisci healed showing that the typical cell found in the repair tissue had the morphology of a chondrocyte (Ghadially et al. 1986). An identical surgical technique was used for the lateral meniscus in dogs with external fixation across the knee or a cast. With the external fixator most of the tears healed in 10–12 weeks (Gershuni et al. 1989).

In our study, the transfer of a synovial flap induced varying degrees of neovascularization in the avascular meniscal body and this response promoted fibrous tissue ingrowth, with healing of most of the lesions. In 15 percent of the cases, bone metaplasia was also observed within the healing area. This represents a new phenomenon in the repair process. Further studies with a refined technique should be carried out in a larger animal model, more representative of the human knee.

Acknowledgements

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