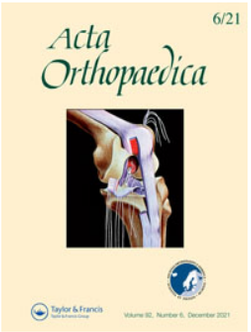

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Articular cartilage after meniscectomy: Rabbit knees studied with the scanning electron microscope

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Articular cartilage after meniscectomy

Rabbit knees studied with the scanning electron microscope

Ten rabbits had a medial meniscectomy in both knees. The articular surface was studied with a scanning electron microscope 2, 4 or 12 weeks after the operation. Three sham operated and two unoperated rabbits served as controls.
Progressive articular cartilage damage was observed on the weight-bearing areas of the medial condyles. The findings are compatible with clinical observations after meniscectomy; they confirm that meniscectomy is not a harmless operation.

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It has been observed that after meniscectomy of the knee complaints may appear with increasing frequency as time progresses (Böhler 1955, Jackson 1968, Tapper & Hoover 1969, Appel 1970). Meniscectomized knees may show flattening of the femoral condyle and narrowing of the joint space as a sign of joint surface affliction (Fairbank 1948, Tapper & Hoover 1969, Lauttamus et al. 1979).

Articular changes have been observed directly as well as by light microscopic techniques on the meniscectomized side of the knee (Moskowitz et al. 1973, Cox et al. 1975, Dandy & Jackson 1975, Lutfi 1975, Casscells 1978). An experimental study using scanning electron microscopy (SEM) was undertaken in an attempt to characterize the early cartilage changes.

Material and methods

Both knees of 13 adult rabbits were operated on under general barbiturate (Hypnorm®) anaesthesia. The medial menisci of both knees of ten rabbits were removed atraumatically and with small instruments. Three animals formed a sham surgery group: the same vertical incision of the skin, fascia and synovia was made as on the meniscectomized animals, but the menisci were left intact. The three layers were closed in all cases with interrupted sutures.

After the operation the animals were allowed to move freely in their cages without external splintage. One meniscectomized rabbit was excluded from the series because of infection in one of the operated knees.

The meniscectomized rabbits were killed 2 weeks (two rabbits), 4 weeks (two rabbits) or 12 weeks (five rabbits) after the operation. The three sham surgery animals were all killed 12 weeks after the operation, together with two unoperated control animals. The femoral and tibial condyles were cut free and processed for SEM in 3-mm thick tissue blocks.

The samples were first rinsed in physiological saline and fixed overnight at 4°C in 2.5 per cent glutaraldehyde in 0.1 M phosphate buffer, pH 7.2. The tissue samples were then rinsed in several changes of the same buffer and postfixed for half an hour in 1% OsO_4, also in 0.1 M phosphate buffer. The specimens were then rinsed again in the same buffer and dehydrated in a graded series of ethanol. Critical point drying (Anderson 1951) was done in a Sorvall apparatus and the specimens were coated with gold in a JEOL JFC 1100 ion sputter. The specimens were viewed and photographed in a JEOL JSM T20 scanning electron microscope at 10 kV.

Results

The sham surgery knees showed smooth, undisturbed articular coverage. The weight-bearing surfaces looked the same as other locations of the joint surface (Figure 1). There were no visible differences from the unoperated knees. Normal cartilage was classified as Grade 0 and the changes of the surface morphology were graded I–IV (Table 1).

Figure 1. Smooth femoral articular surface of a rabbit which has undergone sham surgery. Note the epiphyseal plate, which is seen as a light line crossing the condyles. (×80)

Table 1. Grading of the articular surface damage, as seen after medial meniscectomy

Grade 0	=	Normal cartilage
Grade I	=	Initial exposure of collagenous fibres with partial loss of ground substance
Grade II	=	Exposure of collagenous fibres with marked loss of ground substance. Partly detached fibres and lamellae show prominence in the joint space
Grade III	=	Grade II lesions with fissure formation of the articular cartilage
Grade IV	=	Islands with exposure of the bony substance with total loss of cartilage

Two weeks after the meniscectomy (Figure 2), the articular surface in most cases showed initial exposure of collagenous fibres with partial loss of ground substance. After 4 weeks, the changes were usually more pronounced (Figures 3 and 4). Grade III changes with more extensive surface damage and microfissuring of the cartilage dominated after 12 weeks of observation (Figure 5). The exposure of bony substance as an indicator of arthrosis was seen in one knee 12 weeks after the meniscectomy (Figure 6), classified as Grade IV (Tables 1 and 2).

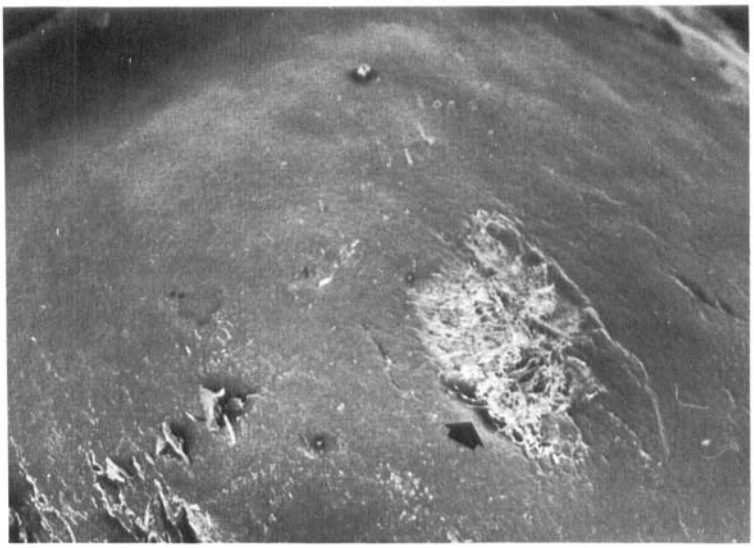

Figure 2. The femoral articular surface of a rabbit meniscectomized 2 weeks earlier. Note the slight irregularity of the surface as a "waving contour" and the initial exposure of the collagen fibres (arrow), indicating partial loss of ground substance and surface destruction. Grade I articular surface damage. (×80)

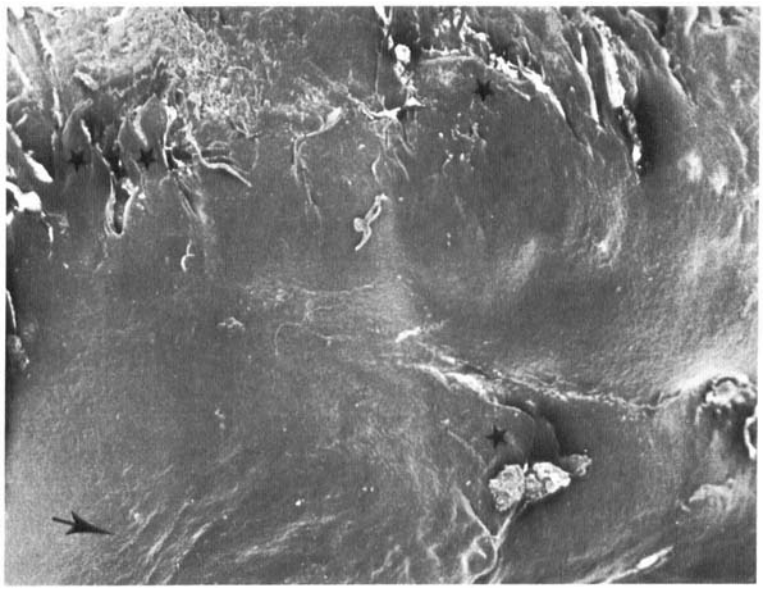

Figure 3. The femoral weight-bearing area 4 weeks after meniscectomy. The loss of ground substance is indicated by the appearance of collagen fibres under the intact superficial layer (arrow) and by wide lamellar detachment of the cartilage (asterisks). Grade II articular damage. (×80)

Discussion

Normal articular surface cartilage is composed of tightly woven fibre bundles of varying size (Redler & Zimny 1970, Clarke 1971, 1974, Puhl 1974). Fibrillation of the articular cartilage is considered an initial sign of arthrosis (Redler 1974, Sokoloff 1982, Stanescu & Leibovich 1982), the disruption of the surface fibres being combined also with disruption of subsurface collagen (Redler & Zimny 1970). Microfissures in the cartilage are clearly a sign of advanced joint destruction, leading to wider erosion of the cartilage and unmasking of the subchondral bone (Carabba et al. 1982, Gattone et al. 1982, Williams et al. 1982).

The relative overloading of the articular cartilage of the meniscectomized side (Krause

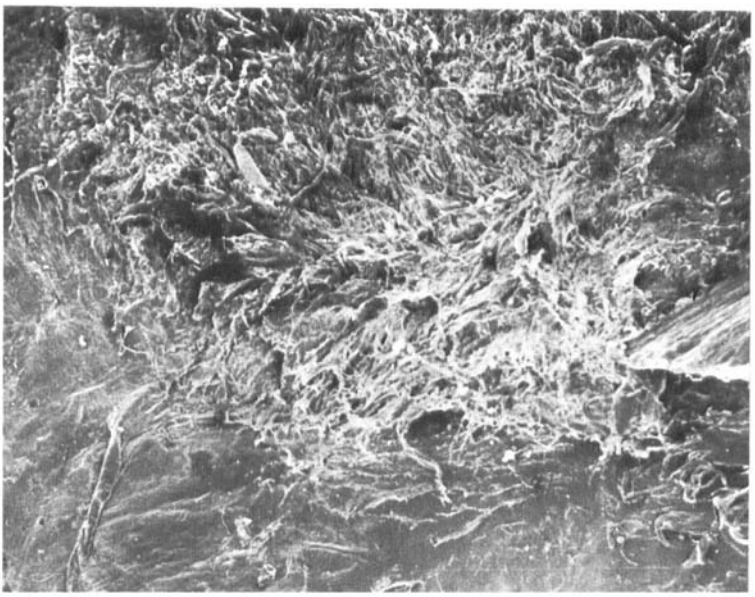

Figure 4. A detail from the tibial articular surface 4 weeks after meniscectomy. Extensive disorganization and partial detachment of the collagen fibres are evident. Grade II articular damage. (×120)

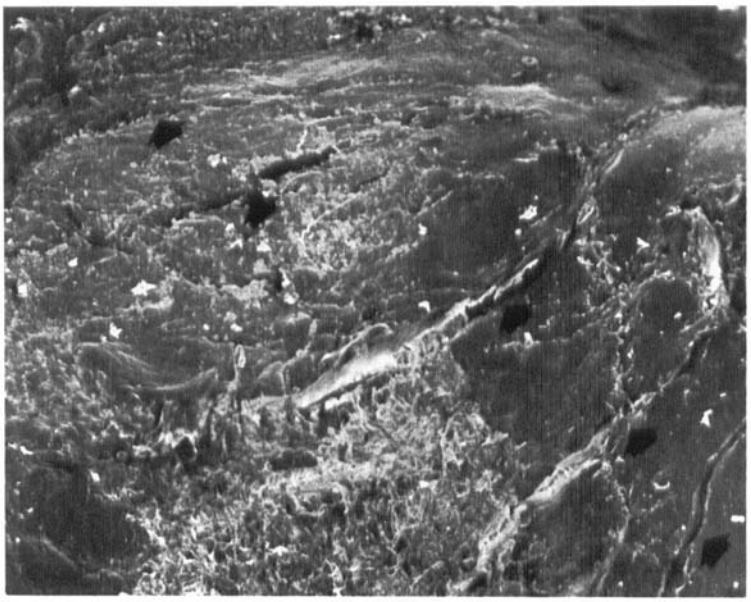

Figure 5. The tibial weight-bearing area 12 weeks after meniscectomy. The corresponding findings as in Figures 3 and 4 are combined with formation of microfissures (arrows). Classification as grade III articular damage. (×80)

et al. 1976), as well as the small but significant immediate laxity of the knee after meniscectomy (Oretorp et al. 1978) suggest a major role for mechanical factors as a trigger for the arthrosis process. In this respect it was interesting to confirm that the cartilage damage was concentrated in the weight-bearing areas of the femoral and tibial condyles.

Our observations confirm that an intact meniscus should not be removed (Noble & Erat 1980). However, severely torn menisci left in position may induce degenerative changes at about the same rate and intensity as does excision of the meniscus (Shapiro & Glimcher 1980). It appears that suture of fresh or even old meniscus tears will become feasible (Hamberg et al. 1983).

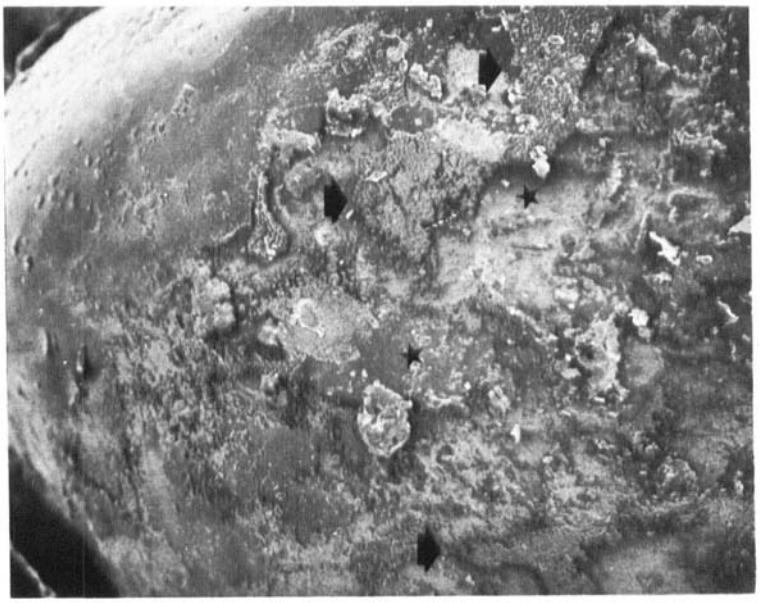

Figure 6. Femoral condyle with extensive erosion of the cartilage, where the subchondral bone is visible (asterisks), 12 weeks after meniscectomy. Areas of *de novo* cartilage formation are visible (arrows). Grade IV articular damage. (×80)

Table 2. Classification of the operated knees according to grades of articular damage. The severity of the lesion increased with the observation period

	Sham surgery controls (six knees)	Two weeks after meniscectomy (four knees)	Four weeks after meniscectomy (four knees)	Twelve weeks after meniscectomy (ten knees)
Grade 0	6	1	–	–
Grade I	–	3	1	–
Grade II	–	–	2	3
Grade III	–	–	1	6
Grade IV	–	–	–	1

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