Arthrodesis by percutaneous fixation: patellofemoral arthrodesis in rabbits without debridement of the joint.

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Arthrodesis by percutaneous fixation

Patellofemoral arthrodesis in rabbits without debridement of the joint

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ABSTRACT – Arthrodesis is usually performed with joint resection or at least with removal of cartilage. Our recent experience with successful fusion in all 11 rheumatoid ankles treated only with percutaneous fixation questions the necessity of debridement of the joint before arthrodesis.

In this rabbit study we tested the hypothesis that joints fuse because of rigid fixation. 9 skeletally mature loop-ear dwarf female rabbits were operated on. With the knee in about 45 degrees of flexion, two 1.5 mm cortical screws were inserted through the patellofemoral joint in an anterior-posterior direction with the lag screw technique. 3 rabbits were excluded due to technical problems. Of the remaining 6 rabbits, 5 underwent bony fusion and 1 fibrous healing. Fusion was confirmed with Micro-CT in 2 cases and by histological examination in all 5 cases. In those 5 cases, bony fusion was seen in almost all areas with close contact. Therefore, fusion occurred not only in relation to the screws, but also between the screws and in the periphery of the patella.

Our findings show that bony fusion can occur in a healthy joint without joint resection or debridement.

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Arthrodesis is usually performed with joint resection or at least with removal of cartilage. It is believed that the best conditions for bony fusion are obtained when two cancelleous bone surfaces are aligned and compressed with stability. A case of successful percutaneous ankle arthrodesis in a rheumatoid patient, treated without debridement of the joint, was reported in 1997 (Borril et al. 1997). We reported successful fusion of all 11 rheumatoid ankles treated with percutaneous fixation only (Lauge-Pedersen et al. 1998). Our first arthrodesis using percutaneous fixation was performed in 1993 on a rheumatoid patient with a history of septic arthritis and a painful ankle with almost no cartilage left in the joint. To minimize the risk of reinfection, 3 screws were inserted over the joint percutanously under fluoroscopic control. The patient became not only pain-free after this procedure, but the joint showed bony fusion on radiographs 6 months later. We have therefore now done 18 ankle arthrodeses using the percutaneous technique on rheumatoid patients with success in 17 cases. In at least some of the ankle joints, there was a visible joint space on radiographs at the time of the operation, that later disappeared. In one case, we confirmed the presence of residual joint cartilage at the time of operation, because we had to perform a small arthrotomy to remove an anterior osteophyte that hindered dorsiflexion.

The question arose whether fusion after percutaneous fixation occurs only in rheumatoid patients, whose subtalar joints sometimes fuse spontaneously, or if bony fusion can also be initiated in a healthy joint merely by rigid stabilization.

In this rabbit study, we tested the hypothesis that joints can fuse after rigid fixation.

Animals and methods

We followed institutional guidelines for animal protection.

9 skeletally mature lop-ear dwarf female rabbits, 6–9 months old, and with a mean weight of 3.25 (2.7–3.7) kg were operated on. They were kept in our animal facilities for at least 1 week before the experiments started (22 °C; 1 rabbit in each cage, free access to food pellets and water). Radiographs of the hind limb showed closed growth plates in all animals.

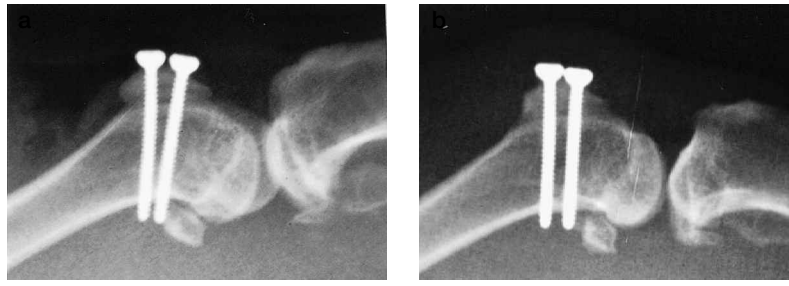

Figure 1. Patella fixated to femur, postoperative (a) and after 3 months (b). Note changes in contour at proximal and distal poles.

The rabbits were anesthetized with intramuscular Hypnorm 0.9 mL and subcutaneous 0.5 mL lidocaine 20 mg/mL in the operation area. The operative sites were shaved and disinfected with chlorhexidin solution.

Surgery

The operation was performed on the right hind limb. A longitudinal incision was made over the patella. The anterior surface of the patella was visualized and the bony edges defined. With the knee in about 45 degrees of flexion, two 1.5 mm cortical screws were inserted through the patellofemoral joint in an anteroposterior direction with the lag screw technique. The patella and quadriceps tendons were then divided close to the patella to minimize the risk of motion in the arthrodesis, but the medial and lateral retinaculae were saved. After the operation, we took radiographs to confirm the alignment of the arthrodesis and the position of the screws (Figure 1).

Radiographs

Radiographs of the knees were taken after 20 weeks in the first 3 rabbits and after 13 weeks in the others .

Specimen preparation and analysis

After the radiographs were taken, the rabbits were killed with an overdose of pentobarbital. We tested the clinical stability of the arthrodesis after removing the screws. The arthrodesis site with the entire patella and the adjacent bone was cut out with a saw and fixed in 4% buffered formalin.

Micro-CT was performed on 2 randomly selected specimens among those which were clinically fused. The specimens were then decalcified, serially sectioned in the sagittal plane and stained with hematoxylin and eosin.

Results

5 arthrodeses subsequently showed bony fusion. This was confirmed by Micro-CT in 2 cases and by histological examination in all 5 cases (Figures 1–3). 1 arthrodesis showed fibrous healing confirmed by histology. 2 arthrodeses failed because of early fractures of the screws and the patella. 1 rabbit was killed after surgery because of paralysis of its hind limbs. In the cases in which the fixation was initially successful, fusion occurred in 5 of 6 attempts. Histology showed fusion to a variable degree in 5 of 6 rabbits. In the failed case, we found chondrolysis and fibrous union. Bony fusion occurred in the other cases in almost all areas where there seemed to have been a close contact between the cartilage surfaces. In areas where there was a gap between the cartilage surfaces the cartilage had remained. In one case, contact was seen only at the lateral rim of the patella. It had fused only there, and not at the screw canals.

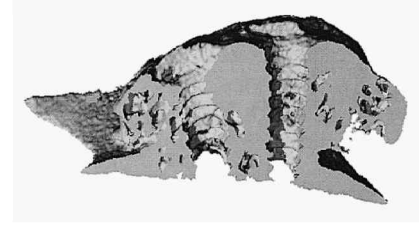

Figure 2. Micro-CT of specimens 3 months after fixation. Screws are removed. Anterior aspect of femoral condyles at the bottom.

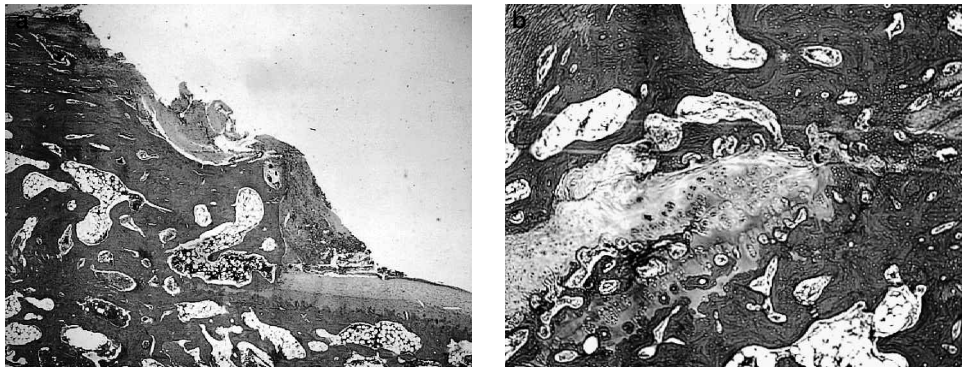

Figure 3. Patella, fused to underlying femur (a). Femoral cartilage to the right is proximal to the patella. Ongoing fusion (b). Endochondral ossification within the approximated cartilage layers.

Hardly any islands of cartilage remained inside the bone in the fused areas.

Discussion

In patients with rheumatoid arthritis, subtalar joints sometimes fuse spontaneously, but this almost never in the ankle joint. The success of percutaneous ankle arthrodesis in such patients may be partly due to synovitis which has a deleterious effect on cartilage. Our present findings, however, suggest that even a healthy joint can fuse without joint resection or debridement.

Incomplete joint immobilization damages cartilage and causes chondrolysis, cloning of chondrocytes and invasion of the tide mark in rats, rabbits and dogs (Kahanovitz et al. 1984, Smith et al. 1992, Kim et al. 1995, Shevtsov and Asanova 1995, Hong and Hendersson 1996, Jortikka et al. 1997, Fu et al. 1998). Compression of the knee joint in rabbits results in chondrolysis and erosion of the cartilage (Gritzka et al. 1973). These changes are typical of osteoarthritis.

Our findings suggest that bone invades the cartilage from either side of the joint. The cartilage in the congruent part of the arthrodesis is deprived of its oxygen supply and nutrition from the synovial fluid. This damages the cartilage and eventually causes chondrocyte death. This may prevent the cartilage from inhibiting vascular invasion and ossification.

The transport of osteoprogenitor cells through the drilling canal during the operation is hardly the only reason for bony fusion, because bony bridges are also present between the screw holes and in the periphery of the joint.

In clinical practice, we often fuse joints having posttraumatic arthritis or rheumatoid arthritis with almost normal alignment, but a painful range of motion. In these cases, percutaneous fixation without debridement of the joint would cause the patient less pain postoperatively, reduce the risk of malpositioning, be shorter and the anesthesia would take less time for the patient.

The reduction of the joint space in the rheumatoid patient is often concentric, but in the patient with osteoarthrosis, it is often not congruent. We know that rheumatoid ankles fuse with the percutaneous technique and have a healing time comparable to that for open techniques. It is uncertain whether the osteoarthrotic joint, despite good alignment, would fuse with this technique as satisfactorily as in the rheumatoid joint. However, the simplicity of the technique and the above-mentioned advantages for the patient may justify a somewhat lower fusion rate.

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