CAN ILIZAROV JOINT DISTRACTION DELAY THE NEED FOR AN ARTHRODESIS OF THE ANKLE?

A PRELIMINARY REPORT

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We applied joint distraction using an Ilizarov apparatus in 11 patients with post-traumatic osteoarthritis of the ankle to try to delay the need for an arthrodesis. Distraction for three months resulted in clinical improvement in pain and mobility for a mean of two years, with an increase in the joint space.

We considered that these effects may be produced by the absence of mechanical stress on the cartilage combined with the intra-articular hydrostatic pressures during distraction. We measured these pressures during walking with distraction, and found levels very similar to those reported to improve osteoarthritic cartilage when applied in vitro.

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Osteoarthritis is characterised by destruction of articular cartilage with changes in the underlying bone (Hernborg and Nilsson 1973; Radin and Rose 1986), and is an important cause of disability in the elderly. In most cases the origin is unknown (primary osteoarthritis), but in a few there is an obvious cause which is usually trauma such as a fracture (secondary osteoarthritis) (Mankin, Brandt and Shulman 1986; Brandt and Mankin 1993).

Clinically, there is pain, a limited range of movement,

and swelling (Altman et al 1986). The origin of the pain is varied and multiple, including microfractures, stretching of nerve endings in the periosteum around osteophytes, distension of the joint capsule, inflammation of the synovium and muscle spasm (Moskowitz 1988). Reduced mobility may be caused by pain, joint deformation and the fibrosis and stiffness of the capsule (Walter and Spector 1991). The radiological changes include joint-space narrowing, the presence of osteophytes and subchondral cysts and sclerosis of the subchondral bone (Menkes 1991).

The abundant extracellular matrix of articular cartilage has two principal components: collagen which provides shape and tensile strength, and proteoglycans which are responsible for the compressive properties (Kuettner et al 1992). The metabolic activity of the chondrocytes determines the turnover of the components of the matrix. Biochemically, the most evident alterations in the cartilage in osteoarthritis are the disruption of the collagen network and loss of proteoglycans (Maroudas and Venn 1977) due to an imbalance between their synthesis and release (Hardingham and Bayliss 1990). Unfortunately, there appears to be little correlation between these biochemical changes and the clinical diagnostic criteria (Katz 1988), particularly in the early stages of the disease in which medication and therapy are most helpful (Hart, Leedham-Green and Spector 1991).

Treatments have included medication to decrease inflammation and pain and exercise under reduced load (Altman et al 1988). Drilling of the remaining cartilage to subchondral bone and joint lavage have also been used, but none of these gives prolonged improvement or cure (Videman 1987). Progression to complete destruction of the articular cartilage cannot be prevented and arthrodesis or replacement arthroplasty becomes necessary.

We have tried a new approach for the treatment of severe post-traumatic osteoarthritis of the tibiotalar joint. Patients who were being considered for an arthrodesis were offered joint distraction using an Ilizarov external fixation apparatus. This aimed to provide short-term distraction of the talus and tibia, preventing contact between the articular surfaces. Initially, the rationale for starting this treatment was to correct the position of the foot but the early results indicated that relief from mechanical stress on the cartilage

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Fig. 1a

Fig. 1b

The Ilizarov apparatus applied for ankle distraction (a) and radiograph showing position of the pressure-sensitive catheter in the joint space (b).

by the distraction would delay the need for an arthrodesis.

We recently reported that intermittent hydrostatic pressure applied to human osteoarthritic cartilage in tissue culture significantly enhanced the synthesis of matrix proteoglycan (Lafeber et al 1992b) and concluded that when applied in the absence of mechanical stress it could result in reparative activity by chondrocytes in osteoarthritic cartilage.

We therefore studied retrospectively 11 patients who had had Ilizarov joint distraction for osteoarthritis and measured the intra-articular hydrostatic pressure in the ankle.

PATIENTS AND METHODS

The 11 patients with post-traumatic osteoarthritis of the ankle had been treated in the University Hospital Leuven (5), the OLV-Middelares Hospital Deurne, Antwerp (5) and the University Hospital, Utrecht (1). There were four women and seven men with a mean age of 35 ± 13 years (20 to 70). All had developed osteoarthritis of the ankle after fractures and were initially considered for an arthrodesis. Five of them (Table I) had an equinus deformity which was partly corrected during distraction.

Operative technique. Under general anaesthesia, two pins (1.5 mm in diameter) were drilled through soft tissue and bone, approximately 5 cm below the knee and 5 cm above

the ankle. They were tensioned (1.3 kN) and fixed to Ilizarov rings around the leg which were connected by screw-threaded rods to stabilise the leg. Two pins were drilled through the calcaneus. They were tensioned (1.3 kN) and fixed to a half ring around the heel. Two pins were then drilled through the metatarsals and tensioned to a half ring over the forefoot. Both half rings were connected to each other by angle plates and straps by which the foot was stabilised. Finally, the fixation of the tibia and the foot was connected at four places by Ilizarov lengthening rods which allowed controlled distraction of the talus and tibia (Fig. 1a). Distraction was carried out over a distance of 5 mm (0.5 mm twice daily for five days), starting the day after application of the apparatus. Patients were allowed to walk within a few days after surgery.

During this treatment all the patients showed an enlarged radiographic joint space on films taken fully weight-bearing and it can reasonably be assumed that cartilage surfaces did not come into contact during the period of distraction. Between 6 and 12 weeks (mean 8 ± 2) after surgery hinges were constructed in the fixation apparatus which allowed flexion of the joint. Care was taken to preserve distraction and this was again confirmed radiologically. After 12 to 22 weeks (mean 15 ± 3) the external fixation apparatus was removed under general anaesthesia.

Retrospective study. Data were collected from charts and radiographs before and after treatment. At the time of the

Table I. Results of Ilizarov joint distraction in 11 patients with osteoarthritis of the ankle

Case	Institute of treatment*	Equinus deformity	Follow-up (mth)	Improvement in pain†	Mobility †	Joint-space widening‡
1	L	+	9	+	+	=
2	L	+	15	++	+	=
3	L		20	++	=	++
4	L		14	+	++	+
5	L	+	19	+	+	=
6	A	+	28	+	-	NA‡
7	A	+	20	++	=	NA
8	A		15	+	++	NA
9	A		60	++	=	NA
10	A	?	20	++	+	NA
11	U		10	+	=	++

* L, Leuven; A, Antwerp; U, Utrecht

† see text

‡ radiographs not available

study the patients from Deurne and Leuven were no longer under medical supervision. Because patients from Deurne had not been checked for more than three months after discharge they were recalled for a final review. The patient from Utrecht was still under treatment. The mean follow-up period was 20 ± 6 months (10 to 60). Changes in pain and in the range of movement were recorded individually by a rheumatologist and a medical biologist. Radiographs were graded for changes in joint-space narrowing. The information was recorded as worse (-), similar (=), improved (+) and greatly improved (++)

Pressure measurements. In three patients treated in Utrecht (two additional patients not included in the retrospective study because their follow-up period was less than two months) we measured the intra-articular hydrostatic pressure during the distraction. A hydrostatic pressure-sensitive catheter (CTC/6F/B; Galtec Ltd, Scotland) was passed through a small lateral incision in the joint capsule and placed in the joint with the pressure-sensitive tip in the joint space (Fig. 1b). The catheter was tunnelled subcutaneously to the middle of the lower leg. Pressure recordings were started the following day. For pressure registration we used a data-acquisition program (MKR version 4.2; Biomed Engn, University Hospital, Utrecht).

During the five-day period there was a fall in the intra-articular hydrostatic pressure due to decreasing operative oedema and each time that distraction was performed there was a transient decrease. After five days, when maximal distraction had been reached, the hydrostatic pressure was recorded while standing for one minute with full-body loading alternating with relaxation for one minute. The average pressure ($\pm$ SD) over the one-minute periods of loading and relaxation was calculated.

RESULTS

Clinical evaluation. The changes in pain, range of move-

ment of the foot and joint-space widening for each patient are shown in Table I. Pain decreased in all patients and five were completely free from pain. The range of movement improved in 55% of the patients; it decreased in only one. Joint-space widening was seen in 50% (3 out of 6) (Fig. 2). In two patients the joint space appeared to increase with time after treatment. In five cases the radiographs were not available. An increase in joint space seemed to occur more often in patients with a normal foot posture, and these had more clinical improvement than those with an equinus ankle.

Pressure measurements. The results of measurement of the intra-articular pressure during joint loading are shown in Figure 3. Loading of the treated ankle resulted in a significant increase in hydrostatic pressure with a return to the preloading value during relaxation. This was repeated several times. For each patient the measurements of the first two loading cycles are shown. The mean intra-articular hydrostatic pressure of the three patients over the two cycles was 3.0 ± 0.5 kPa during relaxation and 10.3 ± 0.6 kPa during loading.

DISCUSSION

The aim of joint distraction in patients with severe osteoarthritis of the upper ankle is to delay the need for an arthrodesis. We have treated only 11 patients in this way and studied them retrospectively and we conclude that short-term ankle distraction delays the need for an arthrodesis.

At the start of the retrospective analysis we attempted to grade pain at night during load and on palpation, to grade joint swelling and to measure the range of movement of dorsal and plantar flexion. We also tried to score radiographs for joint-space narrowing, sclerosis of the subchondral bone, and the formation of osteophytes and subchondral cysts. It proved, however, that only gross

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Case 3. Radiographs of the contralateral ankle (a) and the osteoarthritic ankle before treatment (b), during treatment (c) and 20 months after treatment (d) showing joint-space widening.

Fig. 3

Pressure registration during loading of the treated ankle. Each graph starts with pressure-values measured with the patient lying in bed followed by full-body loading and relaxation of the treated ankle when standing. Means of one-minute measurements $\pm$ SD are shown for three individual patients (A, B and C respectively) for two days (1 and 2).

changes in pain, range of movement and joint space could be reliably retrieved from the charts and radiographs. This information was sufficient, however, to show that joint distraction is a promising method to delay the need for an arthrodesis in patients with post-traumatic osteoarthritis of the ankle. A longer period of follow-up will be necessary to see if distraction can indeed be used as a treatment for osteoarthritis.

This retrospective study included control subjects to exclude a placebo effect. It is unlikely, however, that clinical improvement over a period of 20 months after three months of treatment can be attributed to a placebo effect.

The persistent joint-space widening after short-term distraction suggests repair of articular cartilage which may be related to clinical improvement. Recently, we have reported that intermittent hydrostatic pressure (0 ± 2 kPa to 13 ± 2 kPa; 0.33 Hz) on human osteoarthritic cartilage tissue cultured in vitro produced an improvement in the cartilage. During culture the cartilage was not subjected to mechanical stress, but the synthesis of proteoglycans which are essential for resilience increased by more than 50% (Lafeber et al 1992b). These findings raise the question as to whether intermittent hydrostatic pressure could be responsible for the improvement in osteoarthritis of the ankle after joint distraction.

During distraction joint surfaces do not appear to come into contact, even under load, and there is therefore no mechanical stress on the cartilage surfaces. During transient loading of the distracted joint, as in walking, there is intermittent increase in hydrostatic pressure due to the

flexibility in the apparatus and the stiffness of the joint capsule (Meyers and Palmer 1972; Geborek, Moritz and Wollheim 1989). Determination of the intra-articular hydrostatic pressure during distraction and weight-bearing produced values almost identical to those which improved osteoarthritic cartilage in vitro (3.0 ± 0.5 kPa to 10.3 ± 0.6 kPa and 0 ± 2 kPa to 13 ± 2 kPa, respectively). During easy walking the treated ankle is loaded about once every two seconds which is comparable with the frequency which we used in vitro (0.5 Hz and 0.33 Hz, respectively). This suggests that Ilizarov joint distraction may lead to cartilage repair. Animal experiments in which cartilage biopsies are taken during the distraction period and subsequently analysed biochemically would be helpful in addressing the problem.

The involvement of hydrostatic pressure in the growth of cartilage in tissue culture has been reported previously for articular as well as growth-plate cartilage (van Kampen et al 1985; Lippiello et al 1985; Klein-Nulend et al 1987; Veldhuijzen et al 1987). A promising clinical effect has to our knowledge not been shown before. An explanation for the anabolic effect of intermittent hydrostatic pressure in vitro and during joint distraction may be an increase in the nutrition of the cartilage (Maroudas and Evans 1974). The absence of mechanical stress on the tissue may help the increased reparative activity under these conditions.

This concept is substantiated by a recent study by Aldegheri, Giampaolo and Saleh (1994) which showed that distraction of the hip significantly improved osteoarthritis. They suggested that the creation of space combined with

the circulation of synovial fluid allowed increased nutrition of cartilage. Short-term distraction may be followed by a long-lasting improvement of the cartilage, but the reasons which we suggest are speculative. It has been reported that chondrocytes in the damaged layer of osteoarthritic cartilage appear to be phenotypically dedifferentiated (Lafeber et al 1992a). They do not contribute to proteoglycan synthesis, are proliferating and produce a different type of collagen (Ronzière et al 1990; Lafeber et al 1992a). They also respond differently to growth factors and cytokines like TGF β (Lafeber et al 1993). As has been suggested for TGF β , intermittent hydrostatic pressure applied for a relatively short period could redifferentiate the altered chondrocytes in osteoarthritic cartilage (van Kampen et al 1985). Once redifferentiated they may restore the balance between the synthesis and the breakdown of cartilage, resulting in long-lasting repair.

Conclusions. Short-term Ilizarov joint distraction of an osteoarthritic ankle delays the need for an arthrodesis as a result of clinical improvement. We suggest that the intermittent hydrostatic pressure induced by the distraction, in combination with the absence of mechanical stress, may stimulate actual repair of osteoarthritic cartilage.

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