PERICHONDRAL GRAFTING FOR CARTILAGE LESIONS OF THE KNEE

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Twenty-five patients with 30 chondral lesions of the knee were treated with an autogenous strip of costal perichondrium. The graft was fixed to the subchondral bone with Tissucol (Immuno, Vienna), a human fibrin glue. The leg was then immobilised for two weeks followed by two weeks of continuous passive motion. Weight-bearing was permitted after three months.

The mean knee score (Ranawat, Insall and Shine 1976) changed from 73 before operation to 90 one year after; in 14 patients evaluated after two years there was no decrease. In 28 cases the defect was completely filled with tissue resembling articular cartilage. We conclude that in most cases perichondral arthroplasty of cartilage defects of the knee gives excellent results.

With the increasing use of the arthroscope, chondral lesions of the knee are being diagnosed more frequently (Gillquist, Hagberg and Oretorp 1977; Dandy 1981; Johnson-Nurse and Dandy 1985; Bauer and Jackson 1988; Dzioba 1988). Until recently, treatment was limited to abrasion and drilling of the subchondral bone, resulting in repair tissue which is fibrocartilaginous (Pridie 1959; Mitchell and Shepard 1976; Furukuwa et al 1980). Perichondrium, taken from the cartilaginous part of a rib, can develop into normal hyaline cartilage when placed in a joint (Skoog and Johansson 1976; Enqkvist and Ohlsen 1979). Woo et al (1987) demonstrated that this newly-formed tissue had the same visco-elastic properties as hyaline cartilage, and Amiel et al (1988), one year after perichondral grafting, found neocartilage with histological and biochemical qualities similar to those of normal articular cartilage. In clinical practice this method of arthroplasty has been successfully used in many other joints (Skoog and Johansson 1976; Tajima, Aoyagi and Maruyama 1978; Pastacaldi and Engkivist 1979; Enqkvist and Johansson 1980; Sully, Jackson and Sommerlad 1980; Hvid and Andersen 1981; Jackson et al 1981). Nearly all these studies dealt with small joints in which the whole articular surface was reconstructed. Perichondral grafting of large full thickness lesions in larger joints, like the knee, seemed to be a problem because a biological method of graft fixation was not available. Widenfalk et al (1986) however, used fibrin glue for fixation; this is non-toxic, non-allergic and biodegradable. It has a low initial adhesive strength, but this increases rapidly. We have used this method successfully in the rabbit knee (Hominga et al 1989) and we now report our results in patients.

PATIENTS AND METHODS

From November 1986, patients with a symptomatic cartilage lesion of the knee were treated with an autogenous costal perichondral graft. They were selected after diagnostic arthroscopy and those with radiological and arthroscopic evidence of arthritis were excluded. Most of the patients had been treated conservatively first, and the mean time between the onset of symptoms and operation was 37 months (range 2 to 144). Thirty cartilage lesions were treated in 25 patients: 12 right and 13 left knees in 20 men and five women. The mean age at the time of operation was 31 years (range 18 to 45). Ten lesions were of traumatic origin; three were from osteochondritis dissecans which had been treated unsuccessfully by drilling, and in five, chondromalacia was the supposed cause of a cartilage lesion of the patella. In seven instances degeneration of cartilage had taken place; in two of these there was chondrocalcinosis, but in five the cause was not identified. Eleven patients had had operative treatment previously, mainly consisting of removal of degenerated cartilage and drilling of the
underlying bone. Lateral release had been performed in three cases of chondromalacia patellae.

We studied the type of lesion, its location, any fibrillation or flap tears, exposure of the bone and extent of the lesion. If necessary a hook was used to assess whether the chondral lesion extended to the underlying bone. All 30 lesions were classified according to Bauer and Jackson (1988) and are listed in Table I. Most were situated in the anterior and lateral intercondylar regions of the medial femoral condyle, or in the medial and central areas of the patella (Table II).

The size of the perichondral grafts varied from 1 to 5 cm² (mean 2.13 cm²). In two cases a ruptured anterior cruciate was diagnosed; it was associated with signs of instability. Before operation anteroposterior, lateral and axial radiographs of the affected knee were taken; in seven, osteophytes were present.

Table I. Classification of the 30 cartilage lesions, according to Bauer and Jackson (1988)

<table>
<thead>
<tr>
<th>Type of lesion</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>I Line crack</td>
<td>0</td>
</tr>
<tr>
<td>II Stellate fracture</td>
<td>0</td>
</tr>
<tr>
<td>III Flap</td>
<td>4</td>
</tr>
<tr>
<td>IV Crater</td>
<td>6</td>
</tr>
<tr>
<td>V Fibrillation</td>
<td>12</td>
</tr>
<tr>
<td>VI Degrading</td>
<td>8</td>
</tr>
</tbody>
</table>

Table II. Locations of the 30 cartilage lesions

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial femoral condyle</td>
<td>15</td>
</tr>
<tr>
<td>Patella</td>
<td>11</td>
</tr>
<tr>
<td>Lateral femoral condyle</td>
<td>3</td>
</tr>
<tr>
<td>Intercondylar groove</td>
<td>1</td>
</tr>
</tbody>
</table>

Technique. General anaesthesia is used and the affected leg is exsanguinated. Through a medial parapatellar incision the knee is opened and the patella dislocated laterally. The chondral lesion is identified and cleaned as far as the subchondral bone. The lesion is extended into the sound surrounding cartilage, creating a sharp border with a vertical edge.

An oblique incision is made over the lower part of the left side of the chest. The fascia of the rectus muscle is split transversely and the muscle in the line of its fibres. A piece of perichondrium is dissected from the cartilaginous part of one of the lower ribs and removed together with its chondrogenic layer. The graft is cut to match the size of the defect; it is sometimes necessary to use two pieces of perichondrium.

Tissucol, a human fibrin glue, is prepared by mixing fibrinogen (70 to 110 mg/ml) with aprotinin (3000 KIE/ml) and thrombin (4 IE) with calcium chloride (40 mmol/l). After heating these mixtures to 37°C they are brought together and applied to the defect. The perichondral graft is placed on the subchondral bone with the chondral side facing the joint; it is firmly pressed to the underlying bone with a wet gauze for one minute.

After closing the wounds, a Robert Jones bandage is applied and also a dorsal plaster slab. Two weeks later continuous passive motion is started; for grafted lesions of the patella or the intercondylar groove, flexion is restricted to 30°. From the fourth week onward the patient is allowed to walk with crutches without putting weight on the affected leg; active movements are encouraged. Weight-bearing is permitted from three months after the operation.

In two patients with instability due to a torn anterior cruciate ligament, perichondral arthroplasty was combined with reconstruction of the ligament using the central portion of the patellar tendon.

RESULTS

The results were assessed by means of arthroscopy in all 25 patients, biopsy of the graft in three, change of knee score after one year in all 25, and again after two years in 14, and by radiological examination in all.

Arthroscopy. This was performed in all 25 knees at three to 12 months after transplantation (average 10). Of the 30 grafted cartilage defects, 27 had completely filled with tissue resembling cartilage. In two cases an unchanged defect of the weight-bearing part of one femoral condyle was seen and one patella graft was covered with white tissue, though the surface was fibrillated. A hook was always used to assess the consistency of the graft. After three months the newly-formed tissue looked white and was elevated above the surrounding cartilage. The surface was still soft, but the deeper layer felt solid. After one year the grafted area strongly resembled the surrounding cartilage.

Biopsy. The three biopsies were taken one year after grafting and kept in neutral formalin, decalcified, embedded in paraffin, sectioned at 10 μm and stained with haematoxylin-eosin and Alcian blue (the second specimen was not decalcified so that calcium staining by Kossa's method was possible). Macroscopically the biopsies formed a solid core of bone firmly attached to a thick layer of cartilage. Microscopy revealed disruption of cartilage and bone in two cases; in the third there was uninterrupted contact between the two tissues.

The predominant tissue in the biopsies was cartilage. No mitosis or clustering of chondrocytes were seen. With Alcian blue a diffuse blue staining of the intercellular ground substance (matrix) was seen, indicating the
presence of acid mucopolysaccharides, exclusively produced by chondrocytes. The cells looked like normal chondrocytes with pericellular lacunae (Fig. 1). With the Kossa staining, the subchondral bone stained black as well as part of the basal layer of the cartilage. No signs of ossification were present in this layer.

Knee score. One year after operation all the patients were questioned and examined. The mean pre-operative knee score was 73 (s.d. 9), which increased to 90 (s.d. 10) after one year (paired t-test, p < 0.001); thus the mean change in knee score was 17 (s.d. 9), (range, −14.5 to 35). One year after operation 18 patients were completely free of symptoms: they had resumed their previous work and sports activities. Using the classification of Ranawat et al (1976), most patients changed from good (70 to 84 points) to excellent (85 to 100 points), some from fair (60 to 69 points) to excellent and a minority from good to perfect (100 points). One patient changed from poor (< 60 points) to good, one from poor to excellent and one from fair to good. Two patients remained good and two remained excellent (these last two had complained of pain at work but were able to resume work four to five months after operation).

The first 14 patients operated upon were evaluated again after 17 to 32 months (mean 23.5). This was done to assess whether the condition of the graft and subsequently of the knee might deteriorate with time. The mean knee score after this period of time was 87 (range 67 to 100), whereas it had been 85 (range 75 to 100) after one year; thus there was no statistical difference (paired t-test: NS). Three patients with a relatively low knee score after one year had a decreased score after two years, but those with no complaints after one year remained excellent in the following year.

Radiological examination. One year after operation anteroposterior, lateral and patellar axial radiographs in 30° of flexion were taken of all knees; these were compared with the pre-operative films of the same knee. In none was there an increase of joint space narrowing, or of the number of osteophytes, nor was any increase of subchondral bone density or cysts seen. In 20 knees some density was seen in the region of the graft, suggesting increased mineralisation of the cartilage.

It is possible that with increasing age the chondrogenic capacity of perichondrium decreases, and this might influence the result. We therefore studied the relation between the age of the patient at the time of operation and the knee score. With increasing age a decrease in knee score was found before as well as one year after operation; however, the result of the operation, as measured by the difference in knee score before and after, was not influenced by the age of the patient (Fig. 2). The Spearman rank correlation coefficient for this relationship was 0.0172 (NS). For the relationship between age and postoperative knee score the Spearman rank correlation coefficient was −0.2656. It may be concluded that the results were not related to age.

It also seemed possible that the duration of the lesions before operation might affect the condition of the rest of the articular cartilage of the same joint and so jeopardise the result. Most of our patients had had symptoms for a considerable period of time (mean 37 months, range one month to 12 years). The relation
between the pre-operative delay and the change in knee score is shown in Figure 3. The Spearman rank correlation coefficient was $-0.3822$. Figure 4 shows that with increasing pre-operative delay the result is prejudiced.

We also considered whether the location of the defect (and the graft) might influence the result and this relationship is shown in Figure 5. No significant difference in change of knee score between the grafts was found (Kruskall-Wallis test statistics = 2.96; level of significance = 0.5650).

DISCUSSION

Chondral lesions of the knee not only interfere with work and sport but also predispose to arthritis (Ficat, Ficat and Gédéon 1978). Spontaneous healing is by fibrocartilage which cannot withstand much force. It seemed reasonable, therefore, to try grafting the defect with an autologous piece of perichondrium from a rib, and to anchor it with fibrin glue. This material has been used to reunite nerves, blood vessels, tendons and chondral flake fractures (Ascherl et al 1984; Schlag and Redl 1988). For the fixation of cartilage or perichondral grafts of larger joints, immobilisation of the joint is necessary (Claes et al 1981; Braun, Schumacher and Heine 1984; Widenfalk et al 1986). In our study we followed this by a period of continuous passive motion which is said to promote regeneration of articular cartilage (Salter et al 1980; O'Driscoll, Keeley and Salter 1988), though whether this influenced the final result we cannot say. Weight-bearing was not allowed during the first three months after operation because the superficial layer of the graft remains soft and vulnerable during this time. Movement was encouraged; but, with a graft in the patellofemoral joint, this movement was limited to 30°.

Arthroscopy in the first few months showed a slightly elevated tissue, resembling articular cartilage, which could be recognised by its white colour and its soft superficial layer. Grafts in the weight-bearing area of the medial femoral condyle were more nearly level with the joint surface after one year than those in low-friction areas or where an old osteochondritic lesion had previously been drilled. Most grafted defects had an intact subchondral bone plate which was only scraped until point haemorrhages became visible, but in seven cases the graft was placed on to cancellous bone. No difference was found in cartilage formation or in change of knee score in relation to the presence or absence of the subchondral bone plate. This differs from the view of Engkvist and Johansson (1980) that cartilage regeneration from perichondrium can only occur when the perichondrium is placed on to cancellous bone.

Radiographs taken after one year showed density in the grafted areas and histology showed increased uptake of calcium in the basal layer of cartilage, but ossification of this basal layer did not take place. It must be assumed that the mineralisation of the basal layer of newly formed cartilage is increased compared with normal cartilage, as suggested by Plenk and Passl (1980). What impact this increased mineralisation will have on the visco-elastic properties of the cartilage and on its durability is still unclear. No relation between the change of knee score and the age of the patient was found as was suggested by Seradge et al (1984) who grafted joints in the hand and concluded that over the age of 40 the results of perichondral arthroplasty became worse. In our cases the results for young and older patients were not statistically different.

In summary, we concluded that perichondral grafting of cartilage defects of the knee results in the formation of cartilage and gives good to excellent clinical results. Long-term results of larger numbers of patients are, however, still needed.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.
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REFERENCES


