Osteochondral resurfacing of the knee joint with allograft

Clinical analysis of 33 cases

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Summary. *This retrospective clinical study describes three years of experience with cryoprotected-cryopreserved allograft transplantation. During this period 33 knee joints were operated on for different reasons including osteoarthritis, osteochondritis dissecans and post-traumatic surface irregularity. The mean follow-up was nearly two years and the mean age of the patients was 48 years. The grafts were harvested and processed at the West Hungarian Tissue Bank according to the criteria promulgated by the European Association of Tissue Banks. All the operations were performed in the same way. Three types of grafts were used: cylindrical or mushroom-shaped for the femoral condyle and patellar and shell allografts for resurfacing the tibial plateau. Bone matrix gelatine (BMG) and fibrin sealant (Tissucol®) were used locally to enhance the revascularisation and to improve the decreased osteoinductivity of the frozen cancellous bone. According to the modified Bentley score, the success rate of the short term follow-up was similar to that of other reported series. An analysis of four biopsies showed that the BMG and fibrin sealant did not appear to affect the viability of the articular cartilage. We conclude that application of these materials is not contra-indicated in allograft surgery.*

Résumé. *Les auteurs présentent une étude retrospective de l'utilisation des allogreffes cryoprotégées-cryopréservées pendant les trois dernières années. Nous avons opéré 33 genoux pour des raisons différentes, arthrose, osteochondrites dissequante, ou sequelles traumatiques. Le temps de surveillance moyen était pres de deux ans et l'âge moyen des patients était de 48 ans. Nous avons obtenus les greffes à la Banque*

de Greffes de Tissus Régionale de Hongrie occidentale, et nous les avons utilisées selon les normes de l'Association Européenne des Banques de Tissus. Les interventions chirurgicales ont été exécutées de la même façon. Nous avons implanté trois sortes de greffes: de forme cylindrique et en forme de champignon pour le remplacement du condyle fémoral, et de la rotule, ou des greffes en forme de coquille, pour refaire les surfaces du plateau du tibia. Nous avons utilisé localement de la gélatine de matrice d'os (BMG) et de la colle de fibrine (Tissucol®) pour favoriser la révascularisation, et pour augmenter l'osteoinductivité de l'os spongieux. Selon le schéma Bentley, le pourcentage de succès clinique enregistré à court terme était semblable à celui décrit par d'autres auteurs. En analysant les quatre échantillons de biopsies, le BMG et la colle de fibrine n'a pas influencé la viabilité du cartilage articulaire. En tirant les conclusions de ces résultats de court terme, on note que l'utilisation de ces matériels ne marque pas de progrès dans la chirurgie avec allogreffe.

Introduction

Resurfacing procedures with fresh or cryopreserved osteochondral allografts are not used routinely in the management of disorders of the knee joint. Despite some large series with quite good clinical results [4, 5, 9, 10–13] only a few centres in Europe perform osteochondral allograft transplantation.

The main problems with cryopreserved-cryoprotected osteochondral allografts are the slow revascularisation of the cancellous bone and the low survival rate of the chondrocytes [9–11]. Immunological events do not play an important role but biochemical aspects are relevant [9–13]. The chances of disease

transmission are very low if properly selected donors are used [3, 4].

The aim of our retrospective clinical study, based on more than three years experience, was to analyse our clinical results using cryopreserved-cryoprotected osteochondral allografts combined with bone matrix gelatine and fibrin sealant. We compared our findings with those of other similar series in order to show any relative improvement in our results.

Materials and methods

Osteochondral allografts were harvested and cryopreserved at the West Hungarian Regional Tissue Bank in accordance with the criteria promulgated by the European Association of Tissue Banks (EATB [3]). They were retrieved from cadaver donors aged less than 45 years within 24 h of death, with the bodies stored at plus 4° C. Blood samples taken from the subclavian vein were tested for HIV-1 and 2 antibodies, HIV-AG, HCV, HBsAg and Treponema pallidum.

After the removal of soft parts under strict aseptic conditions, the grafts were incubated for 2 h at 4° C in a cryoprotective medium consisting of sterile vacuum filtrated RPMI 1640 medium, 10% glycerol as cryoprotectant, 1 mg/l ceftazidime, 100 IU/ml penicillin and 40 mg/l amphotericin. The grafts were covered with glycerolised gauze and wrapped in sterile double plastic bags. Cryopreservation was performed with a freezing rate of 1° C/minute. At minus 100° C the bags were transported, submerged and stored in liquid nitrogen (minus 196° C).

Human bone matrix gelatine (BMG) was produced using cortical bone at the West Hungarian Regional Tissue Bank.

The criteria for selection of patients for allograft transplantation were:

- Age between 18 and 65 years.
- Unicompartamental disease.
- No other illnesses.
- Nearly full range of knee motion, normal muscle strength, intact joint stability.
- Co-operation of the patient

The indications for resurfacing are shown in Table 1. Single-shot antibiotic prevention was used in all instances (Mandokel®, Lilly). The grafts were thawed in 10% glycerol solution. The proper shapes of the grafts were determined by standard techniques in accordance with the location of the defects to be replaced. For the femoral condyle, according to the size of the defect, one, two or three cylindrical plug-shaped allografts [5] were used. Each graft was 12 mm or 17 mm in diameter and the thickness of the cancellous bone was 1.5–2 cm. For whole tibial condyle replacement, shell allografts were employed [10, 12, 13] and for the entire patellar surface, re-

placement mushroom-shaped allografts [1] were used. The grafts were transplanted orthotopically and had the same size as the damaged surfaces which had previously been removed. Cylindrical plug-shaped and mushroom-shaped allografts were press-fitted with no additional metal fixation, but we usually applied two malleolar AO lag screws for tibial plateau allografts. In every instance, bone matrix gelatine (BMG) and fibrin sealant (Tissucol®, Immuno AG) were applied in thin layers.

Immediately after the operation, treatment with a continuous passive motion device (CPM) was commenced. When patellar resurfacing was performed, weight-bearing was allowed on the second post-operative day. Femoral and tibial replacements necessitated non-weight-bearing for up to three months. Active exercises were started on the first postoperative day and protective braces with a full range of motion were used in all patients for 4 weeks.

Between December, 1993, and July, 1996, 33 resurfacing procedures were performed. The mean patient age was 48 years (21–64 years), and the mean time of follow-up was 19 months (10–38 months). Regular physical and radiographic examinations were performed, with occasional CT or MRI studies.

The clinical results in the short-term were evaluated according to the Bentley score [2]. The questionnaire enquired as to pain, instability, joint swelling, crepitus, movement and activity. The preoperative and postoperative scores were compared in order to assess the effectiveness of the resurfacing procedure. Our cases were all suitable for analysis.

Results

The radiological assessment of graft incorporation was based on the criteria described for cancellous bone chips by Itoman [6] in which three phases of normal graft healing were distinguished:

1. First phase: the graft contour becomes indistinct (Fig. 1).
2. Second phase: remodelling, the graft becomes sclerotic (Fig. 2).
3. Third phase: restoration of the normal internal structure.

The radiographic signs of failed allografts are sclerosis, narrowing or obliteration of the joint space and the formation of osteophytes.

During more than three years, 33 osteochondral allograft transplantations were performed. In 31 patients unicompartamental-unipolar, and in two instances unicompartamental-bipolar resurfacings were car-

Table 1. Summary of 33 cases

Location	Indication	No. of cases		Fragmentation (failure)		Excellent/ good	Fair/ poor
Femoral condyle	Osteoarthritis Post-traumatic osteoch. dissec.	12	3	3	0	6/7	3/2
		<u>18</u>	3	<u>4</u>	0		
			3		1		
Tibial condyle	Post-traumatic	<u>5</u>		<u>1</u>		1/2	1/1
Patella	Post-traumatic chondromalacia	<u>8</u>	3	<u>1</u>	0	2/4	2/0
			5		1		
Bipolar	Osteoarthritis	<u>2</u>		<u>2</u>		–	0/2

Fig. 1. Cylindrical plug-shaped femoral allograft after 3 months (arrow)

Fig. 2. Cylindrical plug-shaped femoral allograft after 18 months (arrow)

Fig. 3. Failed femoral allograft on the medial condyle at 6 months after transplantation

Fig. 4. X-ray after 12 months. Despite tibial osteotomy the fragmentation had progressed

Fig. 5. MR image of the failed femoral allograft 18 months after transplantation

Fig. 6. Lateral tibia plateau fracture

Fig. 7. Pre-operative planning by CT

Fig. 8. Post-operative X-ray after 12 months – normal bony structure

ried out. In three patients patellar replacements were combined with partial femoral condyle grafts. These procedures were regarded as unicompartmental-unipolar resurfacings for the purposes of analysis.

Operations upon the femoral condyle were undertaken in 18 patients. There were 4 failures and 5 poor or fair clinical results. In 3 patients medial femoral condyle transplantation was performed upon moderate varus knees (10° – 15°), without realignment. Each graft disintegrated within six months (Figs. 3–5). In 3 other patients varus alignment was corrected simultaneously with allograft transplantation. All the grafts healed with good or excellent clinical results. One graft sank because of a technical failure. All the patients with poor or fair clinical results were over 40 years of age. The mean success rate with femoral replacement was 72%.

In 8 patients the whole patellar surface was replaced with mushroom-shaped allografts. In 6 instances simultaneous lateral releases were carried out. One graft failed because of hyper-pressure of the pa-

Fig. 9. MR image of an osteochondral defect on the lateral femoral condyle

Fig. 10. Post-operative MR image after 24 months

Fig. 11. Patella resurfacing after 12 months on MR image – complete revascularisation

tello-femoral joint. Another patient reported a fair clinical result although the transplanted graft healed satisfactorily. The mean success rate was 75%. The only fragmentation in this group occurred in a patient aged over 45 years.

In five post-traumatic patients, tibial condyle replacements were undertaken with shell allografts and additional metal fixation with AO lag screws (Figs. 6–8). Three grafts were transplanted with success. One graft disintegrated in a short time. Another graft was implanted in a technically incorrect way and the clinical result was poor. The two unsuccessful grafts were both in patients aged over 40 years. The overall success rate was 60%.

Two bipolar allograft transplantations were performed, both in the medial compartment (unicompartmental-bipolar type). Each disintegrated within six months with a very poor clinical result. Both patients were over 45 years of age.

Three successful femoral allografts and two patellar allografts were followed for nearly two years by MR imaging. At the last examination each femoral graft showed decreased signal intensity compared with the surrounding cancellous bone, but both patellar grafts integrated totally (Figs. 9, 11).

Radiographic studies of the 33 osteochondral allograft transplantations showed 25 successes and 8 failures. There was a slight difference in comparison with the clinical outcome in which 10 patients reported poor or fair clinical results. The age of each patient in whom operation was unsuccessful was over 45 years (mean 53 years).

There was no sepsis or complications with wound healing. One patient experienced a hyperergic reaction on the fifth postoperative day but recovered within two days on steroid and calcium derivative therapy.

Discussion

Pap and Krompecher were the first Hungarians to study the possibilities of osteochondral resurfacing [16]. They drew basic conclusions from their animal trials and clinical experience, and postulated that normal joint function is essential for maintenance of the viability of the transplanted chondrocytes. Any abnormal stress or malposition of the graft might lead to disintegration. Grafts which were not loaded under normal functional stress would disintegrate and be eliminated by the host environment. Thus, proper implantation of the grafts and immediate active and passive motion of the operated joint is essential to maintain the viability of chondrocytes.

According to the Bentley score we had 9 excellent and 13 good clinical results (i.e. 69% of the 33 cases) (Fig. 12). There is no significant difference between our clinical success rate and those of other series [4, 5, 9, 10, 12, 13].

In our 11 post-traumatic cases, the clinical results were good or excellent in 9. Only one graft fragmentation occurred and the other poor result was caused by technical failure. Better results in post-traumatic cases are reported in other series [9–13] and could be explained by the differences between post-traumatic and degenerative disorders. On the basis of these observations, post-traumatic surface irregularity could be the main indication for allograft resurfacing.

The most obvious difference between femoral and patellar grafts is that the latter show better and faster revascularisation. According to our clinical and radiological findings, integration of the mushroom-shaped patellar allografts is superior to the others. The reasons might be the lower mechanical stresses acting on the patella grafts and the relatively larger bony sur-

Fig. 12. Preoperative and postoperative Bentley scores

Fig. 13. The tibial plateau in a patient aged 45 years was replaced by cryopreserved allograft. Minimal early cystic degeneration is evident at the 10th post-operative month. Most of the chondrocytes are still normal but the hyalin cartilage will subsequently be replaced by fibrocartilage. HE 400×

faces in comparison with the femoral plug-shaped allografts.

Biomechanical factors play an important role in graft healing [10, 12, 13, 16]. Three femoral allografts were implanted in the medial femoral condyles in moderate varus knees (10° – 15° varus) and all failed. These early disappointing results were followed by three operations in which malalignment was corrected simultaneously with allograft transplantations. All grafts healed and good clinical results were obtained. It is evident that normal joint alignment is crucial for successful allograft transplantation.

We have no explanation for the failure of two bipolar allografts, but poor results in osteoarthritic patients are well documented [10, 12, 13].

Analysis of failed allografts shows that only a low clinical success rate could be expected in any type of allograft transplantation beyond the age of 40 years. In our series we had 11 patients with poor or fair results; all were middle-aged.

Four biopsies were obtained, two of them from failed allografts and two from incorporated allografts.

In each instance, hyalin cartilage was partly or entirely replaced by fibrocartilage (Fig. 13).

Theoretically, the application of BMG (bone matrix gelatine) and fibrin sealant (Tissucol, Immuno AG®) should improve the revascularisation of the cancellous bone [7, 8, 14, 17]. Neusel and Graf [16] demonstrated the influence and importance of subchondral vascularisation on the integrity of chondral surfaces. Further comparative study is needed to verify the hypothesis that the blood supply of the graft could be an important factor in preserving the viability of the chondrocytes. To date, our histological and clinical findings have not supported this theory.

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