We describe a prospective survival analysis of 63 consecutive meniscal allografts transplanted into 57 patients. The lateral meniscus was transplanted in 34, the medial meniscus in 17, and both menisci (combined) in the same knee in six. For survival analysis we used persistent pain or mechanical damage as clinical criteria of failure. A total of 13 allografts failed (5 lateral, 7 medial, 1 medial and lateral).

A significant negative correlation (\(p = 0.003\)) was found between rupture of the anterior cruciate ligament (ACL) and successful meniscal transplantation. A significant difference (\(p = 0.004\)) in the clinical results was found between lateral and medial meniscal transplants.

The cumulative survival rate of the lateral, medial and combined allografts in the same knee, based on the life-table method and the Kaplan-Meier calculation, was 76\%, 50\% and 67\%, respectively. The survival of medial meniscal allografts may improve when reconstruction of the ACL is carried out at the same time as meniscal transplantation in an ACL-deficient knee.

In 1995 we published the preliminary results of human meniscal transplantsations with follow-up for two to five years.\(^1\) The short-term findings showed that meniscal chondrocytes can survive cryopreservation and transplantation by revascularisation of the graft. The results were better in patients with an intact anterior cruciate ligament (ACL) and normal alignment of the knee. After this study we altered our indications for surgery, which are now as follows: a patient under the age of 45 years with pain, disabling compartmental osteoarthritis after total meniscectomy, normal alignment of the knee, and a stable joint.

In this study we have sought to determine the survival of meniscal transplants and to establish whether the Knee Assessment Scoring System (KASS) is a useful addition to the Lysholm score.

Patients and Methods

Between 1989 and 1999 we transplanted cryopreserved unmatched human meniscal allografts into 57 patients, all of whom were included in the survival analysis. All had completed a six-month postoperative rehabilitation programme, except for one whose graft failed four months after operation.

There were 40 men and 17 women with a mean age of 39 years (26 to 55). The lateral meniscus was transplanted in 34 patients, the medial meniscus in 17, and both menisci in the same knee in six. The mean interval between total meniscectomy and transplantation was 16 years (2 to 33) and the mean follow-up was for 60 months (4 to 126).

The preoperative planning, collection, preparation, implantation of the allograft and postoperative management were described in detail in 1995.\(^1\) Briefly, an open technique was used to implant the cryopreserved, unmatched meniscal allograft. No bone blocks were used to fix the transplant, and no immunosuppression was given. In this study we changed from non-absorbable to absorbable sutures and reduced the length of hospital stay from ten to seven days.

The clinical criteria for failure of an allograft were persistent pain, an unsuccessful KASS result, a poor Lysholm score, or a detached allograft. According to the KASS, a successful score requires an improvement of at least 10 points or the maintenance of a score of 75 points or higher. The Lysholm score defines excellent as over 94 points, good as 84 to 94 points, fair as 65 to 83 points and poor as less than 65 points. Persistent pain was defined as pain without failure of the allograft. An allograft which failed mechanically was defined as an unsuccessful KASS result, or a poor Lysholm score, with an abnormal allograft which showed tears, or an allograft-capsular detachment at

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We transplanted 63 meniscal allografts into 57 patients. The mean follow-up was 60 months (4 to 126). The mean age, the mean time from meniscectomy to transplantation, and the mean preoperative Lysholm score showed no difference for lateral, medial or combined allografts. Patients with lateral meniscal allografts had a longer mean follow-up compared with those with medial and combined allografts (Table I).

Both the KASS and the Lysholm score identified the same recipients as unsuccessful (KASS) or poor (Lysholm score), and successful (KASS) or excellent, good or fair (Lysholm score). Preoperatively, 21 patients demonstrated instability, either due to deficiency of the ACL, or following total meniscectomy. A total of 36 patients had stable knees before and after operation, including four with lateral and two with medial meniscal transplants. Two of the 36 patients had instability because of the use of non-absorbable sutures. These were removed during the second-look arthroscopy. Thereafter, absorbable sutures were used and no further granuloma developed. In two patients, a second, minor complication occurred with pain at the site of the portals after second-look arthroscopy. For this procedure we used a central portal through the patellar tendon in order not to compromise the allograft. One patient became free from pain after infiltration of the portal with local anaesthetic and corticosteroids, the other required excision of the scar tissue under local anaesthesia.

There was no significant difference in male and female recipients of allografts, but such difference was found between the clinical results for lateral and medial meniscal transplants (two-tailed t-test, p = 0.004). A comparison between lateral and combined, and medial and combined transplants did not show a significant difference, probably because of the small sample size of the combined group (n = 6).

**Survival analysis.** Using the clinical criteria for failure, 13 patients were considered failures. Lateral meniscal transplantation failed in five, medial in seven and combined transplantation in one. Persistent pain was the cause of failure in eight patients (5 lateral, 2 medial and 1 combined). The allograft itself failed in five recipients of a medial meniscal allograft, of which four had rupture of the ACL. Taking the worst case and clinical criteria for failure, the cumulative survival rate for the lateral allografts was 76% (95% confidence interval (CI) 82 to 92; Table II) for the medial 50% (95% CI 55 to 83; Table III) and for the
combined 67% (95% CI 58 to 94; Table IV). The mean survival time for the lateral, medial and combined allografts was 111, 69 and 89 months, respectively. Failure of the lateral allografts occurred at a mean of 53 months after surgery and for medial allografts at a mean of 25 months. The Kaplan-Meier survivorship curve for combined allografts could not be drawn since there was only one valid survival function value per group. Figures 1 and 2 show the Kaplan-Meier survivorship curves when clinical criteria for failure were used for the lateral and medial allografts.

When survival of the allograft was used as an endpoint, the cumulative success rate was 88% (95% CI 85 to 92) for the lateral and 63% for the medial allografts (95% CI 55 to 83). The cumulative success rate for combined allografts did not change.

Discussion

In 1995, we published the preliminary results with follow-up of two and five years for our first 25 meniscal allografts. These are included in this survival analysis. Murray et al stated that survival analysis is a powerful tool for evaluating results, especially when data from patients with different lengths of follow-up are entered and can be withdrawn from the trial at any stage, and for whatever reason. For the analysis it is assumed that all patients had their operation simultaneously. Initially, meniscal transplantations were undertaken in arthritic knees which had undergone total meniscectomy. Chondral degeneration of grade 4 and malalignment are now considered to be contraindications to meniscal transplantation. As this and earlier studies have
shown, the knee should be stable, or able to be stabilised by appropriate ligament reconstructions. 

There is no agreement in the literature concerning the most accurate technique for imaging meniscal allografts. Our allografts were sized by radiography of the donor and recipient knees. Pollard, Kang and Berg demonstrated a reproducible radiological relationship between each meniscus and established bony landmarks. Other Tissue Banks use CT or MRI for sizing the allograft and advise that the recipient should be sized by using the same technique. In a study of 12 cadaver knees which underwent sequential radiographs, MRI and arthrotomy, none of these techniques was sufficiently accurate to measure individual meniscal dimensions. Using less stringent criteria for accuracy, within 5 mm, radiography and MRI became more reliable. The latter is certainly better than radiography in predicting the three-dimensional geometry of the meniscus. The most appropriate, and practical, sizing technique is currently still based upon measurements on bone. In a study in which 16 patients had a meniscal transplantation matched by radiographs and in which the clinical results were evaluated by MRI and arthroscopy, no mismatch of the size was noted. In our study there were no failures because of mismatch of the allograft. We think that alignment, stability and fixation of the allograft are more important to the clinical result than matching the size.

When the KASS was compared with the Lysholm score, the same patients were identified as unsuccessful (KASS) or poor (Lysholm score) and successful (KASS) or excellent, good and fair (Lysholm score). The KASS did not add to the Lysholm score. Since the KASS only discriminates between successful and unsuccessful, and the Lysholm score further categorises the successful results into excellent, good and fair, we no longer use the KASS. Although the International Knee Documentation Score (IKDS) is only validated for the evaluation of injuries to knee ligaments we added this score to our assessment protocol. Since there is no validated scoring system to evaluate the results of meniscal transplantation, we now use the IKDS in combination with the Lysholm score and consider that this is the best available scoring system at present. Since pain is considered to be the major indication for meniscal transplantation, a visual analogue scale for the severity of pain has been added to the protocol. The results for combined transplantation should be interpreted with caution as the number of joints remaining in follow-up is an important variable and determines the reliability of the data. With numbers as low as ten the possible error is of the order of 20%, which is often larger than the cumulative failure rate.

Although lesions of the medial meniscus occur three times more frequently than those of the lateral meniscus, we transplanted more lateral than medial allografts. Medial meniscal lesions occur more often because the medial meniscus is firmly attached to the tibia and capsule of the knee, whereas the lateral meniscus has loose peripheral attachments. There are anatomical and functional differences between the lateral and medial meniscus. Levy, Torzilli and Warren concluded that the medial meniscus is a secondary stabiliser and of more importance to joint stability than the lateral meniscus. The biomechanical interplay between the ACL and the medial meniscus was confirmed in two recent studies. Hollis, Pearsall and Niciforos and Papageorgiou et al showed that anterior tibial translation and medial meniscal strain were restored to normal levels after reconstruction of the ACL. Primary anterior and posterior translations were not affected by lateral meniscectomy before or after resection of the ACL. The lateral meniscus is of more importance to load transmission in the knee. Because of the greater role in stress protection of the lateral meniscus, lateral meniscectomy will be followed by a higher incidence of osteoarthritis compared with medial meniscectomy. As pain is a
 symptom of osteoarthritis, and the main indication for meniscal transplantation, more lateral than medial meniscal allografts were transplanted.

Our study shows that the lateral allografts lasted longer and had fewer failures than the medial allografts. The stability of the knee improved significantly after meniscal transplantation, especially when it was caused by anterior translation resulting from total meniscectomy. We agree with Noyes, Grood and Torzilli that if anterior laxity is used to describe only anterior translation, it is preferable to use the term anterior translation. Only ten recipients still showed instability after meniscal transplantation, including five with deficiency of the ACL.

The difference in the clinical results between lateral and medial allografts can be explained by the anatomical and functional differences between both menisci, and by the difference in frequency of rupture of the ACL in both groups. Only two recipients of a lateral allograft had a rupture of the ACL which did not impair the clinical result. By contrast, six recipients of medial allografts had rupture of the ACL with significant deterioration of the clinical outcome. The reason for failure was instability because of deficiency of the ACL, leading to secondary detachment of the allograft. Two patients with a failed medial meniscal allograft had a second similar procedure. This was combined with an autogenous bone-patellar-tendon-bone reconstruction of the ACL. At follow-up, both knees were stable. One was considered to be a success and the other a failure because of persistent pain. Several studies on meniscal repair have shown that meniscal healing occurs in up to 96% of stable joints, and that the results are significantly worse in ACL-deficient knees. There is no distinction made between lateral and medial meniscal repair. As with meniscal allografts there could, perhaps, be a significant difference between the results of lateral and medial meniscal repair in an ACL-deficient knee.

Our preliminary results in a follow-up of two to five years showed that the outcome was better in knees with an intact ACL and normal alignment of the joint. Since 1995, meniscal allografts have been transplanted only in knees with an intact ACL and normal alignment. In two knees we transplanted a medial meniscal allograft in combination with reconstruction of the ACL.

In this study, the results after lateral meniscal transplantation are satisfactory. A significant negative correlation was found between a rupture of the ACL and a successful transplantation. The survival of medial meniscal transplantation will improve when it is undertaken at the same time as reconstruction in an ACL-deficient knee. Anterior tibial translation and strain on the medial meniscal allograft will then be reduced to the levels in an intact knee.

Although the same technique was used to transplant medial and lateral allografts, the results were significantly different. This can be explained by the differences in anatomy, biomechanical function, and subsequently by the difference in frequency of these meniscal lesions, ruptures of the ACL and the incidence of postmeniscectomy osteoarthritis. It is thus not possible to compare the results of lateral and medial meniscal allografts.

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