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ORIGINAL STUDY

Survival of autologous osteochondral grafts in the knee and factors influencing outcome

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The primary aim of this retrospective study was to determine the medium-term survival of autologous osteochondral grafts (mosaicplasty) in the knee. The secondary aims were to evaluate any reason for failure, and to ascertain if age, gender, BMI, previous or associated knee surgery, site or size of the osteochondral graft had any influence on outcome. Fifty-five patients undergoing an autologous osteochondral graft procedure between 1999 and 2008 were evaluated, with a mean follow-up of 5.9 years (range 0.5 to 10.5). Loosening, graft degeneration or subsequent surgery in the form of arthroplasty, revision autologous osteochondral graft or any other osteochondral procedure, and an Oxford knee score above 49.7 (see text) were considered as failure. Kaplan-Meier analysis demonstrated an 87.5% survival at 8 years (95% CI 72% to 97%). The mean Oxford score at follow-up was 16.3% (95% CI 10.6% to 22.1%) at follow-up. Two of 6 failures occurred in patients with varus malalignment. Linear regression analysis demonstrated an improved outcome in Oxford knee score in younger patients. Gender, BMI, previous or associated knee surgery, site and size of the graft had no influence on outcome. The authors consider autologous osteochondral grafting as a reliable method of treatment in the medium term for young patients with small contained articular cartilage lesions up to 4 cm². Careful attention should be paid to the mechanical axis (varus) prior to grafting. Long-term studies are necessary.

Keywords : knee joint ; hyaline cartilage ; autologous osteochondral graft ; mosaicplasty ; Osteochondral Autograft Transplantation System (OATS) ; survival analysis ; Oxford knee score ; risk factors.

INTRODUCTION

Isolated cartilage lesions of the knee can be very disabling, and quality of life can be affected to the same extent as for patients scheduled for knee replacement surgery (*14*). There are various modalities of treatment for isolated osteochondral defects, and there are several drawbacks to many of these ; none of them has the ability to restore normal native hyaline cartilage.

Treatment of osteochondral defects can include microfracture, osteochondral autograft transfer, allograft, autologous chondral cell implantation with or without natural and synthetic scaffolds, or unicompartmental arthroplasty (*1,3,4,6,10,13,18,19,23, 25,31,36,37*). There is little evidence in the literature to ascertain the long term efficacy of osteochondral autograft transfer (*26*).

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When considering osteochondral grafting it is necessary to evaluate the possible survival and the patient factors which may influence outcome, in order to guide appropriate decision making and to modulate surgeon and patient expectations.

This study is a level 4 retrospective case series study. It intended to assess the survival and medium term outcome of osteochondral autografts. Age, gender, BMI, previous or associated knee surgery, lesion site and size were also assessed to ascertain if any of these factors influenced outcome.

MATERIALS AND METHODS

The authors reviewed the theatre records of all patients undergoing Osteochondral Autograft Transplantation System (OATS) (*20*) treatment between 1999 and 2008, under the care of three senior surgeons.The medical records were reviewed for patient demographics and precipitating cause for the osteochondral lesion. The date of OATS surgery, age, height, weight, BMI (above or below 25), site (medial, lateral or patellofemoral), size of the lesion (cm^2) and any previous or subsequent surgery were recorded (Table I).

All patients were treated with the OATS system (Arthrex, Naples, USA). Grafts were harvested from the lateral and medial edge of the trochlear groove and then from the notch if additional graft material was required. Graft harvest, and implantation with care to ensure a surface flush with the adjacent cartilage, were carried out either arthroscopically with a small incision or through a more formal arthrotomy. OATS grafting was carried out in association with ACL reconstruction in 4 patients, tibial tuberosity transfer in 2, lateral meniscal repair in one, lateral release in one, and medial meniscal trimming in one.

Previous surgery had been performed on 12 : ACL reconstruction in 4, lateral release in 2, medial meniscal repair in 2, medial meniscal trimming in one, lateral meniscal trimming in one, autologous chondrocyte implantation in one and PCL reconstruction in one.

Postoperatively all patients were permitted passive range of movement exercises, and thereafter toe touch weight bearing for 4 weeks, progressing to full weight bearing. Follow-up was routinely performed at 6 weeks, 3 and 6 months postoperatively.

Patients were contacted by postal questionnaire to ascertain if they had undergone any subsequent surgery, and what that entailed. They were also asked to complete an Oxford knee questionnaire (*8*). Non responders were contacted by telephone for the same information. We excluded patients who developed a subsequent degenerative osteochondral lesion in a different site to the original OATS surgery, provided the original OATS graft was intact.

Failure of the OATS graft was defined as degeneration of the articular surface (Outerbridge grade 2, 3 or 4) (*28*), loosening of the OATS graft, or any subsequent osteochondral regeneration / reconstruction procedure such as microfracture or revision OATS surgery. Limb realignment surgery, such as a tibial or femoral osteotomy, any form of arthroplasty or a poor Oxford knee score were also considered as failures. The Oxford questionnaire was used as described by Pynsent *et al* (*32*), where an increase in pain or disability relates to an increase in score. An Oxford score above the 75th percentile for unicompartmental replacements (in the authors' institution), in other words above 49.7%, at more than one year postoperatively, was considered to be a poor score and therefore a failure. Thus, if a patient had an Oxford score within this category, it would be in keeping with the worst quarter of all unicondylar knee arthroplasties performed at the institution. Although the Oxford knee score has not been validated for cartilage lesions, it was deemed the most appropriate way to discern a patient reported threshold level of OATS failure, rather than only considering revision surgery as a proof of failure.

Seventy-one patients were identified as having undergone OATS surgery. From this group 16 patients were excluded : 4 because they had undergone OATS and a PFJ replacement, 6 who underwent an allograft or MEGA OATS procedure, and 6 who had degeneration elsewhere in the knee while the original OATS graft was intact, leaving a total of 55 patients.

Kaplan-Meier statistical analysis was used to provide a survival curve with 95% confidence intervals. Regression analysis was used to investigate if there was any linear relationship between Oxford score to age and size of the lesion using the R statistical package (*33*). The Oxford knee score was compared with qualitative variables (gender, BMI, previous and associated knee surgery, site) using the confidence intervals. Failures were also evaluated to ascertain if there was any pre-existing reason for the poor outcome. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Fifty-five patients (Table I) were available for final analysis. There were 18 females and 37 males

Table I. — Patient demographics

Mean age (yrs) (range)	Gender (n)	Cause (n)	Site (n)	Mean size (cm^2) (range)	Mean BMI (range)
32 (15-17)	Males 37 Females 18	Trauma 27 OCD 17 Unknown 11	Medial femoral condyle 36 Lateral femoral condyle 12 Trochlear groove 5 Patella 2	2.2 (0.5-5)	27.2 (20-38.3)

n = number ; OCD = osteochondritis dissecans ; BMI = body mass index.

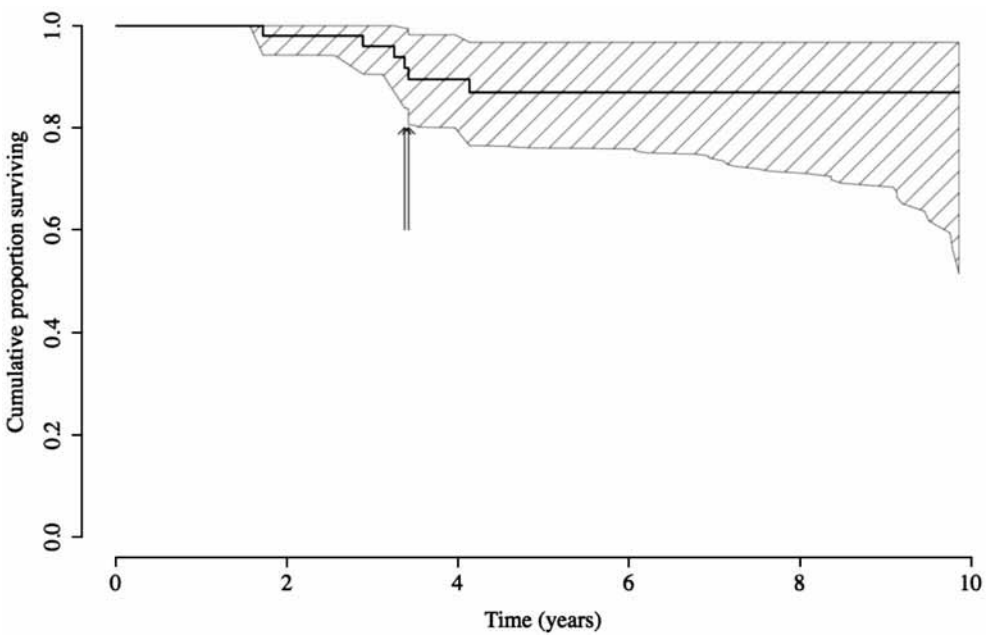

Fig. 1. — Kaplan-Meier survival analysis showing the cumulative proportion of OATS grafts surviving and time of failure. Survival 87.5% at 8 years (95% CI 72% to 97%). The arrows mark where two patients failed due to a poor Oxford score.

with a mean age of 32 years (range, 15 to 57). Possible causes : 27 patients mentioned a history of trauma, 17 had osteochondritis dissecans, and 11 had no obvious precipitating cause. The mean BMI was 27.2. The mean size of the defect was 2.2 cm^2 (range, 0.5 to 5 cm^2), and the mean follow-up was 5.9 years (range, 0.5 to 10.5 years). OATS grafting was performed to either the medial femoral condyle (n = 36), the lateral femoral condyle (n = 12), the trochlear groove (n = 5) or the patella (n = 2).

Survival period

The Kaplan-Meier survival analysis (Fig. 1) demonstrates a survival of 87.5% (95% CI 72% to 97%, n = 15) at 8 years. The analysis includes 6 failures : 4 of these were due to revision surgery and 2 to a poor Oxford score (above 49.7) as shown by the 2 arrows. Of the 4 patients who required revision surgery, 2 had a medially localised cartilage lesion and varus malalignment, which was not appreciated as a risk factor for graft failure at the

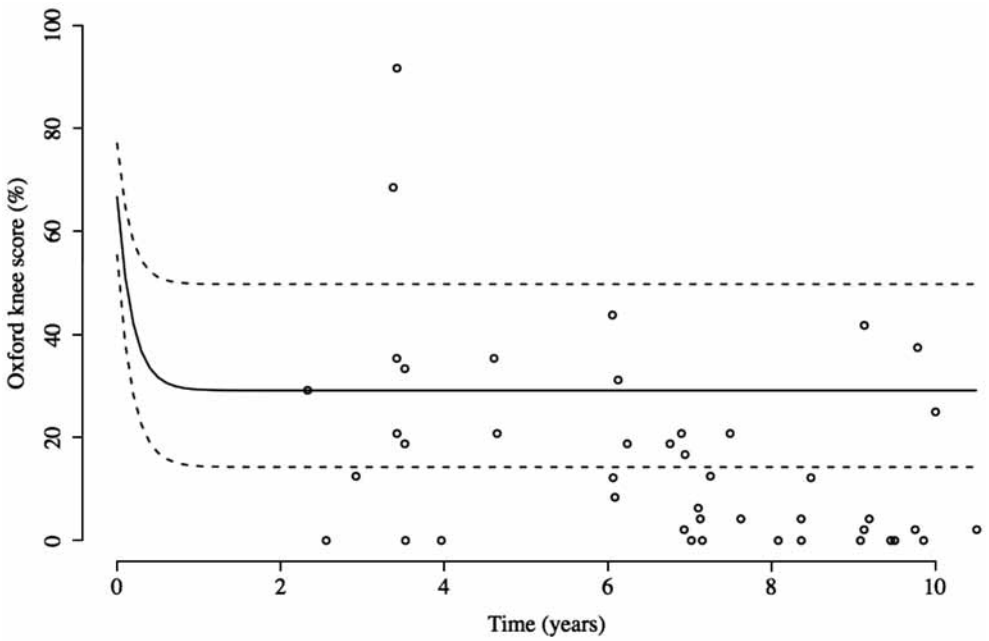

Fig. 2. — Oxford knee score versus time for each OATS patient (100 = worst possible outcome). Two patients (top) scored above the 75th percentile for unicompartmental replacements in the authors' institution (upper dashed line) : they were classified as failures.

time of grafting. One of these 2 patients had revision OATS grafting and a high tibial osteotomy, the other underwent a unicompartmental knee replacement. Revision surgery was also required for 2 other patients. One of these had undergone chondrocyte cell implantation 9 years prior to OATS grafting and had grade 3 wear extending beyond the osteochondral defect at the time of OATS surgery. This patient went onto a total knee replacement. The second patient had revision OATS grafting 3.5 years after primary OATS grafting due to wear of the original OATS transfer.

Oxford knee score and factors influencing its outcome

The mean Oxford knee score after OATS grafting was 16.3% (95% CI 10.6% to 22.1%) at last follow-up. Oxford knee scores at varying follow-up times are shown against unicompartmental knee replacement Oxford knee score percentiles in figure 2. It shows the 2 patients who scored above the 75th percentile : they were classed as failures. Of these 2 patients, one claimed disability living allowance, the other had a previous PCL reconstruction.

The influence of age and size on Oxford knee score was investigated using linear regression (Fig. 3, 4). An improved outcome was noted in younger patients ($p = 0.008$, slope coefficient 0.48, R^2 0.14), but size was not a significant predictor of outcome.

Analysing the qualitative variables against Oxford knee scores showed there was no relationship between gender, BMI (above or below 25), previous or associated knee surgery, or site of osteochondral lesion. The mean Oxford score was 15.7% (95% CI 9.5% to 22%) in males, versus 17.5% (95% CI 5.3% to 29.6%) in females. The mean Oxford score was 7.5% (95% CI 0.7% to 14.4%) in patients of normal weight (BMI below 25), and 18.3% (95% CI 12.8% to 23.8%) in overweight patients (BMI above 25). The mean Oxford score in patients with *previous* ipsilateral knee surgery was 17.4% (95% CI 1.6% to 33.3%), and 16.08% (95% CI 9.8% to 22.3%) for those without : the difference was not significant. The mean Oxford score for

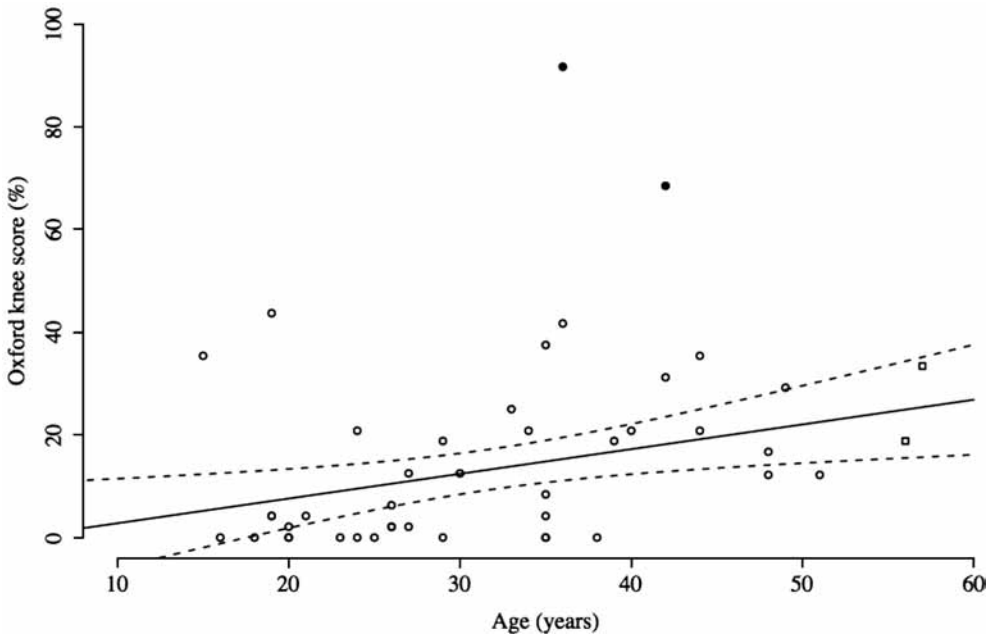

Fig. 3. — Oxford knee score versus age of patient (years)

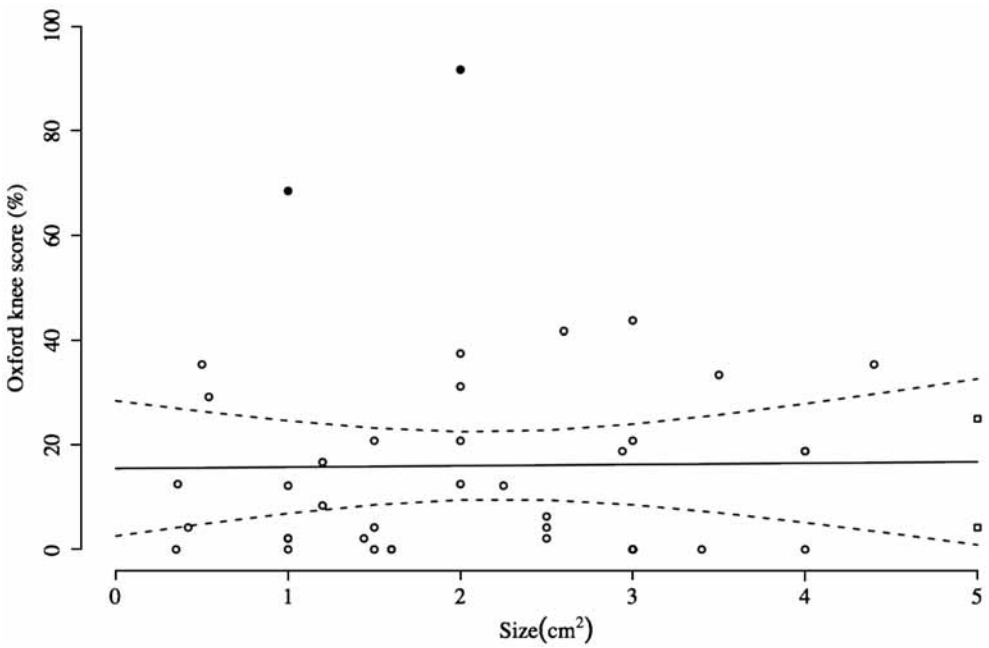

Fig. 4. — Oxford knee score versus size of osteochondral lesion (cm^2)

those with *additional* surgery was 12.1% (95% CI 10.5% to 23.7%), and 17.1 (95% CI 1.7% to 22.5%) for those without additional surgery : the difference was not significant. As to the site of the osteochondral lesion, the mean Oxford score was 18.2% (95% CI 10.1% to 26.3%) for the medial femoral condyle, 12.3% (95% CI 3.0% to 21.5%) for the lateral femoral condyle and 13.3% (95% CI 5.1% to

21.6%) for the patellofemoral joint : the difference was not significant.

Repeat surgery

Repeat arthroscopy was performed in 19 patients for pain or mechanical symptoms between 0.5 and 4 years postoperatively ; 3 of these demonstrated graft failure to a grade 4 chondral lesion. They were classified as failures and treatment was as previously described. Of the other 16 patients, intervention included one patient who had a tibial tuberosity transfer for anterior knee pain (this patient's graft in the lateral femoral condyle was intact at arthroscopy), one patient undergoing ACL reconstruction, one patient who had meniscal trimming and one having arthrolysis for stiffness.

DISCUSSION

Autologous osteochondral transfer with several grafts (mosaicplasty) was first described by Matsusue *et al* (*24*) in 1993, and has been reported since that time with variable outcomes in the literature (*2,6,7,10,12,13,15,16,17,27,29,35*).

Our institution previously reported on the outcome of OATS grafting in 2006 when the average follow-up was 36.9 months (*17*). At that time there was no relationship between the functional outcome and age, site or size.

Medium- to long-term results of OATS

There is a paucity of literature concerning the long-term outcome of osteochondral grafting, as highlighted in the NICE guidance in 2005 (*26*). NICE yielded no major safety concerns, but stated that this technique should not be used without informed consent, due to uncertainties about the efficacy. NICE also stipulated that osteochondral grafting should be used only if audited or as a part of ongoing research.

Hangody *et al* (*10*) reported on 303 patients treated with knee mosaicplasty in three institutes, with a mean follow-up of 9.6 years. They found no difference in outcome for gender, but patients older than 30 years or with patellofemoral grafts had lower success rates. Also patients with a larger lesion or with an uncorrected varus malalignment had an inferior outcome. Several of these points are in keeping with the current study, which also showed less good results in older patients, but no relationship to graft site, which perhaps reflects the small number of cases where osteochondral grafting was performed in sites other than the medial femoral condyle. Similarly, of the 4 failures in the authors' study, 2 were due to varus malalignment : this stresses the importance of a thorough evaluation of the mechanical axis prior to OATS treatment.

Solheim *et al* (*35*) evaluated the results of mosaicplasty at 5 to 9 years in 69 patients. They reported an improvement at short and medium terms, but there was deterioration of the Lysholm score and the visual analogue pain score between 12 months and 5 to 9 years post-operatively. They undertook a re-look arthroscopy in 23 (33%) patients due to insufficient improvement, one to 5 years after the mosaicplasty. In 6 of these 23 patients the mosaicplasty was not intact, due to loss of one or more of the transplanted grafts, and in another 6 patients a new full thickness chondral lesion was found. A new full thickness lesion was used as an exclusion criterion in the current study. The Solheim group found an improved outcome in younger patients, but gender or size of the grafted area played no role. BMI was not evaluated.

Consistent with the report of Solheim *et al* (*35*), deterioration of osteochondral grafting after short term follow-up was also demonstrated by Bentley *et al* (*4,5*). In a prospective, randomised comparison between autologous chondrocyte implantation (ACI) and mosaic- plasty for osteochondral defects in the knee, statistically significant superior results were demonstrated for ACI. Failure was defined as a clinically poor result with arthroscopic evidence of failure of the graft or with revision surgery to the defect. At 10 years the failure rate was only 17% in the ACI group, compared to 55% in the mosaicplasty group with the predominant reason for failure in the mosaicplasty group being revision to ACI. Better functional outcomes were also seen in the surviving grafts for the ACI group, but the assessors did not appear to be blinded. Nevertheless they found failure of mosaicplasty after 2 years of

satisfactory progress. These findings are not in keeping with the results presented in the current study : although failure did begin to occur 2 years after OATS grafting, it was found to be only 12.5% at 8 years.

Outerbridge *et al* (*27*) reported on 10 patients in whom the lateral patellar facet was used to repair a large osteochondral defect (mean size 5.3 cm^2) in either of the femoral condyles. The mean follow-up was 6.5 years. Five of the 10 patients had a post-operative arthroscopy which showed the graft to be incorporated. There were no failures in this small case series.

Short-term results of OATS

Other studies report outcomes in the shorter term. Most authors have found no relationship with patients' age or with size of the osteochondral lesion (*2,7,16,17,20,29*). For instance, Marcacci *et al* (*22*) noted, at 2 year follow-up, 78.3% good and excellent results in 37 patients treated with mosaicplasty for a mean grade 4 defect of 2.1 cm^2. Associated procedures such as ACL reconstruction were performed in 23 patients ; patients with associated surgery had better clinical results than those who did not have associated surgery. This differs from the current study where associated surgery had no influence on outcome. Nineteen patients with chronic osteochondral lesions had undergone knee procedures more than 12 months previously ; included in this number were 5 patients who had undergone some form of cartilage repair. In keeping with the authors' findings, no difference in outcome was found whether patients had previous knee surgery or not. The Marcacci group found better results in patients with lateral condylar defects. Younger patients also had a better clinical outcome than older patients.

Comparison of OATS with other techniques

Hangody *et al* (*11*), comparing microfracture, Pridie drilling, abrasion arthroplasty and osteochondral transfer by mosaicplasty found a better clinical outcome for the latter, as opposed to the other methods of treatment, especially after several years.

Horas *et al* (*15*) had findings in agreement with this. In a small randomised trial comparing osteochondral transplantation and autologous chondrocyte implantation, they reported significantly better results for osteochondral treatment at 24 months based on postoperative Lysholm (*21*) scores.

In a multicentered randomised trial, Dozin *et al* (*9*) comparatively evaluated mosaicplasty and autologous chondrocyte implantation. They noted complete recovery in 88% of mosaicplasty patients and in 68% of the ACI treated group. The difference was not significant as the study was underpowered. They did find however that 1/3 of the patients spontaneously improved after simple débridement : these patients received neither mosaicplasty nor ACI. This called into question the need for prompt surgical treatment of full thickness chondral lesions.

Effect of BMI

While the negative effect of age on outcome has been well documented by other studies, there is little information about the effect of BMI on osteochondral grafts. Pearsall *et al* (*30*) evaluated a mixed cohort of patients undergoing autologous or allograft osteochondral transfer in 48 patients. Although they found no relationship between failure rate and increased BMI, they no longer performed osteochondral transplantation in patients with BMI above 30. Similarly, the current study did not demonstrate any difference in outcome between normal and overweight patients. Furthermore, the Pearsall group found no difference between autografts and allografts at an average follow-up of 37.1 months. They noted an improvement in male patients and, like other studies, in those less than 35 years of age.

Limitations

The current study has several limitations. Assessment was by Oxford knee score rather than by arthroscopic evaluation or by the more usual cartilage scoring systems such as the KOOS

score (*34*), despite the fact that the Oxford knee score has not been validated for cartilage lesions. The Oxford score was chosen as it allowed to quantify failure without findings of graft loosening, revision OATS, realignment surgery after OATS grafting or any subsequent cartilage regenerative procedure. A cut-off value for failure was chosen : worse than the 75th percentile for Oxford knee scores after unicompartmental knee replacements performed in the authors' unit, namely 49.69. This also enabled direct comparison for unicompartmental disease using the same outcome measure, which was deemed appropriate prior to data analysis. It is acknowledged that scores could have been worse if using a validated cartilage scoring system, however a threshold score level for failure would still need to be decided upon. The method used therefore enabled failure to be recognised by a patient reported measure as well as failure due to revision surgery.

The OATS graft was not routinely evaluated by arthroscopy in the subsequent years, as it was felt that this would not have been appropriate in asymptomatic patients, although it is acknowledged that graft failure may have occurred in patients reporting an Oxford score below the 75th percentile for Oxford unicompartmental arthroplasty (49.69).

Several patients had previous surgery or associated surgery to the knee at the same time as OATS grafting, which may have influenced the results. Nevertheless, there was no difference in Oxford scores between these groups, with overlap of the 95% confidence intervals.

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