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ORIGINAL STUDY

Is MRI useful in the early follow-up after autologous osteochondral transplantation ?

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The study was carried out to evaluate MRI findings following osteochondral auto-grafting in femoral condyles and talus, and to correlate these with the clinical outcome. Thirty-three patients (20 knees, 13 ankles) were examined 1 to 4 years after operation using MRI, Lysholm Knee Score and Foot and Ankle Osteoarthritis Score. Clinical examination showed pain relief and improved function and MRI images demonstrated graft incorporation. Radiological criteria such as articular step-off, subchondral lamina irregularity, subchondral oedema and inhomogeneity of the graft interface opposed to the host tissue do not correlate statistically with the clinical outcome. MRI is a well-recognised, useful diagnostic tool to assess the articular surface but it has a limited clinical significance in the early post-operative stages after autologous osteochondral transplantation. The long-term prognostic significance of unsatisfying MRI results is unknown.

Keywords : autologous osteochondral transplantation ; magnetic resonance imaging.

INTRODUCTION

Osteochondritis dissecans is a condition whereby articular cartilage and the adjacent subchondral bone become separated from the remaining joint surface. Various aetiologies have been reported including trauma, ischaemia, genetic and endocrine factors (*28*). Osteochondral defects will stimulate a corresponding chondral and bony repair. However, the lack of chondral blood supply limits the response of cartilage to injury. Various surgical options to treat osteochondral lesions have been described such as removal of loose bodies, lavage and debridement, re-fixation of loose bodies with bioresorbable pins or small osteochondral grafts, antegrade drilling, micro fracture, abrasion arthroplasty, autologous chondrocytes implantation and allogenic osteochondral grafting (*2,3,7,19,25*). In addition, osteochondral autografting attempts to

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restore the articular surface and subchondral bone by replacing the bone-cartilage defect with an autologous osteochondral plug (*5*). Growth factors and gene therapy are also promising approaches to promotion of cartilage repair (*6,24*).

Magnetic resonance imaging is a non-invasive, accurate and reproducible method, which has been used for imaging of cartilage lesions, both for the initial diagnosis and for subsequent monitoring after operative treatment (*16*).

The purpose of the study was to evaluate MRI appearance and in particular to assess graft incorporation, articular step-off, subchondral lamina, subchondral oedema and inhomogeneity of the graft - host tissue interface. The correlation between MRI findings and the functional outcome was also assessed.

PATIENTS AND METHODS

Thirty-three patients, who underwent autologous osteochondral transplantation for defects of the femoral condyles or the talus, were retrospectively studied. Sixteen women and 17 men with an average age of 38.4 years (range, 16 to 58 yrs) participated in our follow-up. Twenty osteochondral defects involved the femoral condyles (14 medial and 6 lateral) and 13 the talus (2 lateral and 11 medial). The average weight was 78 kg (range, 54 to 126 kg). The average height was 174 cm (range, 163 to 192 cm). Thirteen patients gave a history of trauma (7 knees and 6 ankles). All patients had followed a conservative treatment programme including physiotherapy, analgesics and intraarticular injections in the pre-operative stage. We used the Lysholm knee score (*4*) for the evaluation of the knee and the Foot and Ankle Osteoarthritis Score (FAOS) (*21*) for assessment of the ankle. All patients underwent an MRI scan. The average follow-up time was 2.5 years : 9 patients were examined within a year of the operation, 8 patients between 1 to 2 years, 9 patients between 2 to 3 years and 7 patients 3 to 4 years following the procedure. The average lesion size was 37×26 mm (range – 13×10 to 53×39 mm). We did not routinely perform MRI scans to evaluate the donor site unless the patient was symptomatic.

Procedure

Autologous grafts were harvested from the anterolateral region of the lateral femoral condyle of the ipsilateral knee in both knee and talus cases. The selected donor site represents a region with low interference with patellar tracking and absence of contact with the meniscus or the tibia plateau during joint motion (*3*). We systematically used an open approach. The talus was approached through a medial malleolar osteotomy. The same orthopaedic team, consisting of 2 surgeons, performed the procedures. An insider motorised rinsing diamond bone-cutting system was used (DBCS Merck Biomaterial GmbH, Germany). This system guarantees non-traumatic and precise bone cutting while rinsing with sterile physiological saline preserves the viability of the graft and the surrounding tissue. Mega OATS (*1*) were performed in all cases. The average number of cylinders used in each operation was 3.3 and the average graft size was 20 mm in depth and 15mm in diameter (range – 15×10 to 30×20 mm). The donor site was filled with artificial bone substitutes. A cutting instrument one size smaller was used to prepare the recipient site for a press fit implantation technique. The grafts were implanted via manual pressure (fig 1).

Table I. — Demographic data

	Knees	Ankles
Sex	11 female, 9 male	5 female, 8 male
Age	42.3	34.5
BMI	26.502	25.037
Trauma	6 patients	7 patients
Location	14 medial, 6 lateral	11 medial, 2 lateral
Average duration of symptoms	2.3 years	7 months
Prior arthroscopy	6 patients	1 patient
Average size of lesion	41×29 mm	33×23 mm
Average follow-up	2.8 years	2.2 years

MRI

MRI follow-up was performed using a 1.5T Philips magnetom. High resolution sequences were performed including T_1 weighted, fat suppressed T_1 weighted, fat suppressed T_1weighted with better contrast (PDW/SPIR/TSE) and fat suppressed T_2 weighted sequences. That was part of our standard knee imaging protocol. Cartilage contour interruption was graded as a step-off of 0-1 mm, 1-2 mm, 2-3 mm or > 3 mm. The inhomogeneity (markedly higher or lower signal

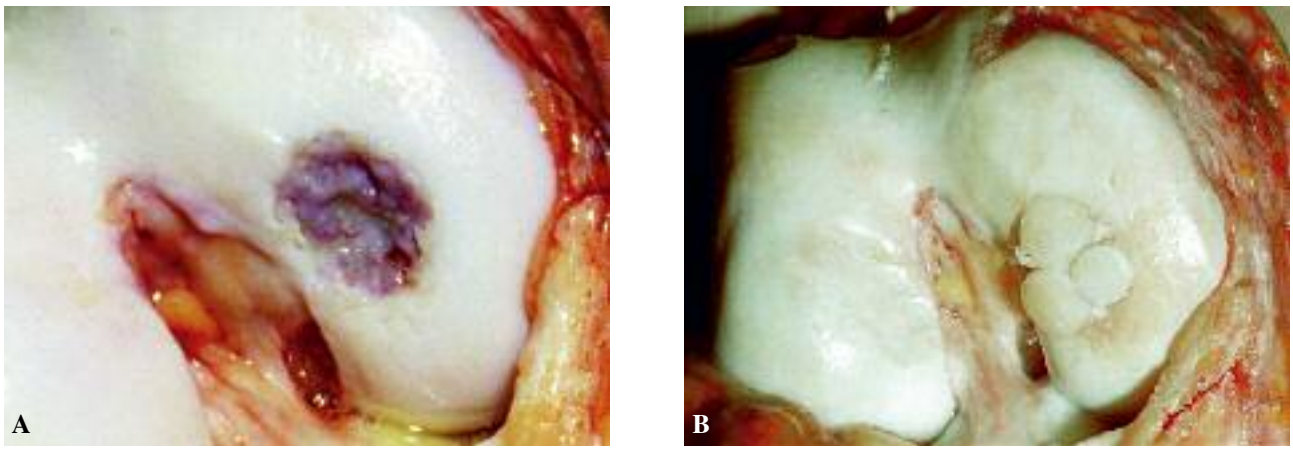

Fig. 1. — Intraoperative view before (A) and after (B) autologous osteochondral transplantation in the femoral condyle

intensity of graft-cylinder tissue in comparison with adjacent tissue, depending on the sequences used) was evaluated as the percentage of graft interface opposed to the host tissue. The subchondral lamina was assessed for the presence of a step-off and subchondral oedema was graded as absent, mild or obvious. Grafting was considered to have failed when plug tilt or loosening (> 5 mm gap between graft and adjacent tissue) were present.

RESULTS

Clinical Outcome

The median Lysholm knee score was 74 (0-100). Three patients had excellent results (> 90), 9 good (70 to 90), 5 fair (50 to 70 and 3 patients poor results (< 50). The pre-operative values of the clinical scores were available only for a small number of patients so that they could not be used for the purpose of this study. The FAOS score revealed an average score of 75 in the subscale of Symptoms, 65 in the Pain-subscale, 69 in the Function and Daily Activity-subscale, 57 in Function, Sports and Recreational Activities and 84 in Quality of Life (0-100) (fig 2).

Twenty-five (75%) of the operated patients were satisfied with the outcome of the surgery and would undergo the same operation again.

MRI Outcome

Four (12%) patients had an articular step-off of 0 to 1 mm, 13 (40%) of 1 to 2 mm, 6 (18%) of 2 to 3 mm and 10 (30%) greater than 3 mm.

Nine (27%) patients demonstrated inhomogeneity of less than 25% of the graft interface opposed to the host tissue, 5 (15%) of 25 to 50%, 11 (33%) of 50 to 75% and 8 (24%) of 75 to 100%.

Three (9%) patients had no subchondral oedema, 28 (85%) had mild (1-5 mm from the subchondral line) and 2 (6%) an obvious oedema (> 5 mm) (fig 3).

Nineteen (58%) patients had a subchondral lamina step (fig 4).

Graft loosening or graft tilt were never found (gaps between graft and host tissue were never greater than 5 mm), indicating no evidence of failed plug integration in our series.

The presence of MRI changes such as articular step-off, subchondral lamina irregularity, subchondral oedema and inhomogeneity of the graft interface opposed to the host tissue, although somewhat disturbing, does not correlate statistically with the clinical outcome ($p > 0.05$, Spearman correlation test).

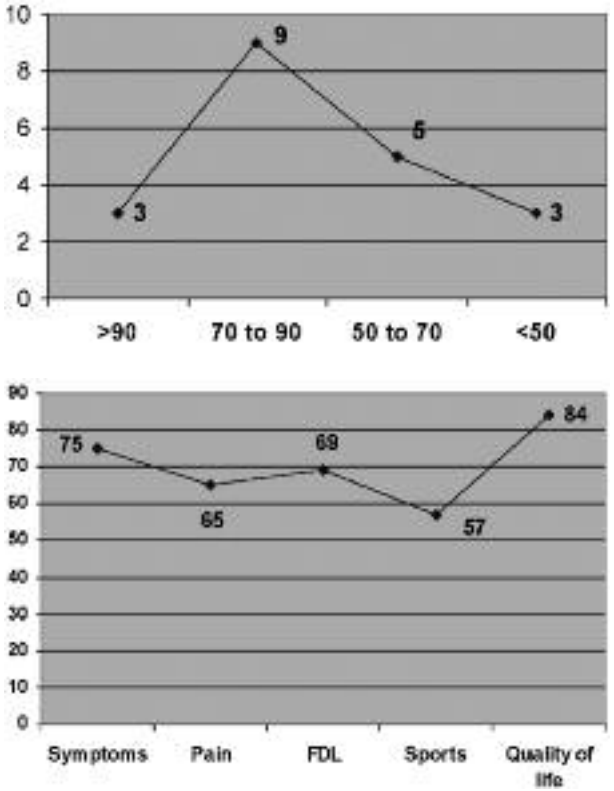

Fig. 2. — (A) Lysholm Knee Score (y = number of patients, x = Lysholm score). (B) Foot and Ankle Osteoarthritis Score (median and interquartile ranges).

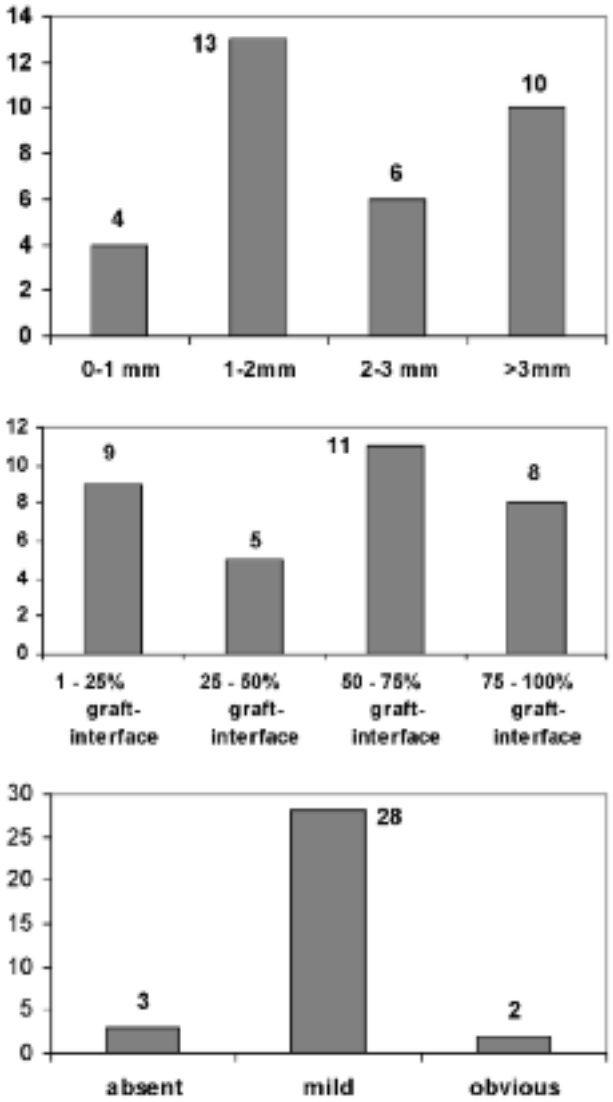

Fig. 3. — (A) articular steps (B) inhomogeneity (C) subchondral oedema.

DISCUSSION

Successful osteochondral autografting depends on the union of the osseous layer within the graft and the surrounding bone graft so it can function as a platform for bridging by intermediate cartilage tissue. Therefore accurately extracted osteochondral cylinders and an exact three-dimensional orientation and fit into the defect zone are supposed to be of great value.

MRI revealed an articular step-off of > 2 mm in 16 (48%) of the investigated patients of this study. Cartilage contour interruption results from the presence of intermediate chondral tissue between host and donor cartilage. It has been reported in the presently available short-term studies on osteochondral transplantation, as of limited clinical significance, but possibly leading to osteoarthritis in the long term (*22*). Link *et al* reported that only 7 of 45 cylinders presented incongruity at the cartilage-cartilage interface (16%) 1 to 3 years after osteochondral transplantation (*13*). The absence of arthroscopic follow-up and the short-term character of our study did not allow to assess the relation to osteoarthritis. Long-term follow-ups are essential for this purpose.

A subchondral lamina step-off was present in 58% of our patients resulting from non-matching of the osseous layers between the graft and the recipient tissues. Similar results were found by Link *et al*

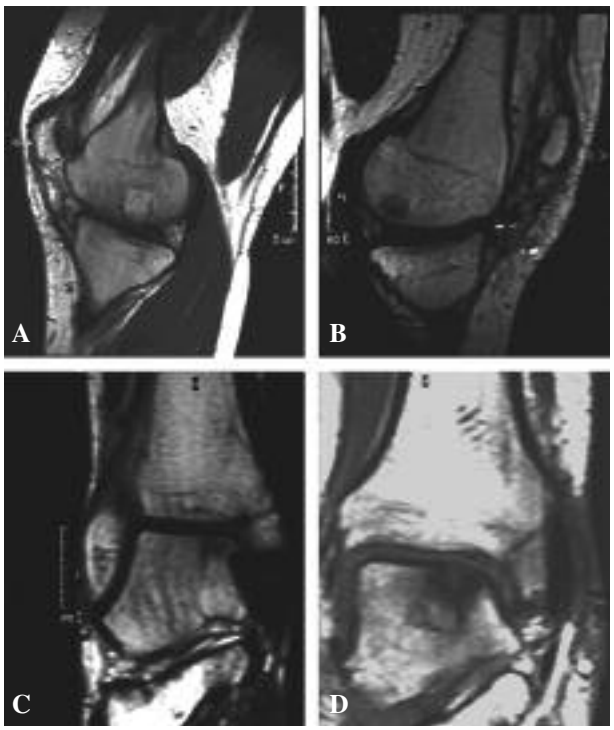

Fig. 4. — (A) T1 weighted image demonstrates 75 to 100% inhomogeneity of cylinder graft interface and the remaining host tissue. (B) T2 weighted MRI shows a smooth articular surface without any articular steps. (C) T1 weighted MRI shows irregularity of the subchondral lamina. (D) T1 weighted image shows subchondral oedema.

where 52 of the 105 cylinders (50%) had incongruity of the bone-bone interface. Link *et al* suggests that this finding is to be expected since the plugs are harvested in areas where the cartilage thickness may differ from the thickness of the articular cartilage in the implant site (*13*). However, the subchondral lamina irregularity may lead to graft loosening in the long term as it contributes to a less strong "platform" for the bridging of intermediate cartilage. Hangody and Modis reported that 80% of full thickness defects in weight bearing areas lead to early osteoarthritis in a 5-10 years period (*10*).

Inhomogeneity of more than 50% of the graft interface opposed to the host tissue was shown in 19 (57%) patients. Macarini *et al* reported similar results (*14*).

This could be a result of growth of hyaline-like or fibrocartilage. It could also be due to fluid collection between the graft and the adjacent tissue, following damage to host hyaline cartilage during the recipient site preparation (*5*). Interaction of chondrocytes with osteocytes in presence of non-matching layers may also contribute to degeneration of cartilage causing MRI inhomogeneity (*22*).

Two (6%) patients were shown to have an obvious subchondral oedema while mild oedema was present in 28 (85%). This MRI sign could be interpreted as a failed incorporation or a loss of graft viability. However, in the early post operative period it can also be a result of inflammation of the subchondral area secondary to the heat development when pre-cutting the defect (*27*). Increased levels of activity post surgery can lead to subchondral bone oedema on MRI (*23*). The radiological persistence of bone oedema adjacent to the graft sites is consistent with previous reports : bone oedema may persist for many months following injury (*17*). Link *et al* showed that although 28 of 55 patients (51%) had bone marrow oedema one year after osteochondral transplantation, only 2 of 13 patients (15%) had the same MRI appearance after 3 years (*13*). None of these studies demonstrated a correlation between oedema and post-operative pain. In our study there was no statistically significant correlation (Spearman test $p > 0.05$).

Despite the large size of the plugs, there was only one patient with symptoms at the graft extraction site with subchondral oedema on the corresponding MRI image. This is a result of the site selection on a less weight bearing area of the knee. Outerbridge *et al* reported anterior knee pain in 4 of 10 patients (*18*). Laprell and Petersen found 5 of 35 patients to have pain while squatting after using the anterior knee as the harvesting site (*12*).

Link *et al* described 25 of 45 patients to have high signal MR appearance in the donor region (*13*).

There was no graft integration failure. Similar results have been reported following osteochondral auto-grafting (*1,9,15,22,23*). Gautier *et al* detected one case of failed graft incorporation out of 11 patients (*8*), while Link *et al* found 6 of 55 patients to show partial or no enhancement in the cylinder-grafts after contrast administration, which is consistent with graft necrosis (*13*).

Articular step off, subchondral lamina irregularity, subchondral oedema and inhomogeneity as

demonstrated on MRI do not correlate statistically with the clinical outcome and the patient's satisfaction. Sanders *et al* reported that surface irregularity of the graft does not correlate with the clinical outcome on the short term (*23*). Link *et al* found no consistent association of clinical outcome and MRI findings such as irregularity of the cartilage contour, bone marrow oedema and osteochondral autograft necrosis (*13*). Marlovits *et al* concluded to a statistically significant correlation of functional outcome and MRI evaluation variables such as changes in the subchondral bone and repair tissue as well as filing of the defect (*15*). Other studies reported on the low statistical correlation between MRI and clinical scores following autologous chondrocytes implantation (*11,20,26*). This finding might also be influenced by the small number of patients.

Limitations of our study include the different age groups with diverse activity levels, the small number of patients and the various time intervals between surgery and radiological follow-up. These drawbacks underline the importance of a multicentre study.

CONCLUSION

MRI appearance in the early follow-up after osteochondral autografting in our series does not correlate with the clinical outcome. However, MRI gives useful information about implant integration. Long-term radiological and clinical studies are needed to determine whether the early MRI findings following osteochondral autografting are prognostic indicators of the clinical outcome on the long-term. To date the short term relief of symptoms and improved functional outcome are the only useful clinical indicators for the assessment of the autologous osteochondral transplantation.

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