Acta Orthop. Belg., 2010, **76**, 208-218

ORIGINAL STUDY

Osteochondral autograft transplantation for osteochondritis dissecans of the knee
Preliminary results of a prospective case series

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To evaluate the short-term outcome of osteochondritis dissecans (OCD) treated with mosaic osteochondral autograft transplantation (OAT), 7 male patients (mean age 33.4) with 8 OCD lesions on the lateral border of the medial femoral condyle were prospectively followed. Patients were evaluated by the International Knee Documention Committee (IKDC) score and the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaires preoperatively, at 6 months and 1 year after surgery. MRI evaluation using the modified Sanders score was performed at 1-year follow-up.

The IKDC subjective score and all subscales of the KOOS improved significantly. MRI evaluation showed good surface congruency, no oedema or protuberance of the osteocartilaginous cylinders, good similarity of cartilage thickness and a non-complete osseous integration. With the small numbers of patients available, no correlation could be found between MRI findings, percentage of defect coverage and patient satisfaction.

Mosaic OAT appeared in this study as a valid treatment option in selected cartilage defects. OCD lesions improved significantly following osteochondral transplantation. The limitations of this technique are the number and size of the plugs needed to repair the defect. Future research should focus on identifying the appropriate choice of operative treatment for well defined subtypes of articular cartilage lesions, rather than searching for one superior technique for all.

Keywords : knee ; osteochondritis dissecans ; osteochondral autograft ; mosaicplasty.

INTRODUCTION

Osteochondritis dissecans (OCD) is a localised injury or condition affecting the articular surface and subchondral bone, with separation of an osteochondral segment *(28)*. The knee is the joint most commonly affected. In adult OCD, focal osteochondral defects rarely heal without operative treatment, as cartilage defects over 2 mm in diameter have limited potential for self repair. Successful treatment of OCD in a weight bearing joint is an orthopaedic challenge.

There are four main principles of operative intervention : lavage and debridement, marrow-stimulating techniques, fixation of the loose body with (subchondral) bone, metallic or bio-absorbable pins, and resurfacing techniques. Lavage and debridement removing loose and instable cartilage

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No benefits or funds were received in support of this study

may offer temporary relief of pain for up to 4.5 years, but does not offer long-term protection against posttraumatic osteoarthritis A marrow-stimulating treatment in chondral lesions is the microfracture technique, in which the subchondral bone is perforated arthroscopically by angled awls. It is successful in young patients with traumatic chondral lesions, without subchondral bone loss. The disadvantage of this technique is that when the subchondral bone is involved as in case of an OCD lesion, restoration of the surface congruency by true hyaline cartilage is not expected from bone marrow stimulating techniques, although some regeneration of the bony defect will result. An alternative is offered by two resurfacing techniques : autologous chondrocyte implantation (ACI) and autologous osteochondral transplantation (AOT) or 'mosaicplasty'. For ACI an arthroscopic biopsy from the cartilage is taken and chondrocytes are isolated and cultured *in vitro.* The cultured chondrocytes can then be transplanted, three to five weeks later, to the defect (*7*), where they are expected to form hyaline cartilage. With the 'mosaicplasty' technique, autologous osteochondral plugs are retrieved from the trochlea of the ipsilateral knee and are transplanted to the defects in the weight bearing area of the knee. The osteochondral donor sites most frequently used are the lateral and medial trochlea. Osteochondral allografts are widely used in the United States. While this avoids donor site morbidity, it is still only recommended for treatment of large osteochondral defects were other repair techniques are not suitable. Controversy on indications and results persists (*5*). Issues such as chondrocyte viability, cryo-preservation and risk of disease transmission prevent this technique from yet being widely used in small focal lesions and raises need for further research (*16*).

Randomised and prospective studies comparing microfracture, ACI and AOT are scarce (*7,11,19,20*). The results of ACI are promising but the disadvantages are the difficulty to grow sufficient hyaline cartilage and the high cost. AOT provides a good rate of survival of the transplanted hyaline cartilage, and incorporation of bone has been demonstrated (*15,22*). On the contrary, the risk of donor site morbidity increases as more and larger plugs are harvested (*3,15*). In general, with a defect size not exceeding 4 cm^2, donor site morbidity consists of patellofemoral crepitus during the first 6 months. To prevent such donor site morbidity, direct filling of the defect with a biphasic resorbable matrix scaffold implant plug is possible. One such implant is the TruFit plug (Smith & Nephew). A prospective trial in which this plug is compared to microfracture is now ongoing.

The studies available in the literature compare clinical results of different operative techniques in different types of articular cartilage lesions. Rather inhomogeneous groups of patients have been studied, and superiority of any one approach cannot be claimed by these studies (*35*), as conclusions are conflicting.

We like to think that the indication for a specific treatment should be based on the defect characteristics. An OCD defect is mostly located on the lateral aspect of the medial condyle, it lacks an intact lining with the intercondylar notch and has a size of approximately 4 cm^2 with subchondral involvement (*2,23*). An advantage of the AOT technique is its inherent stability. The goal of this study was to evaluate the results of AOT in a well-defined homogenous subgroup of OCD articular cartilage defects on the lateral border of the medial femoral condyle.

PATIENTS AND METHODS

Between January 2005 and January 2007, 7 consecutive male patients with 8 symptomatic OCD lesions of the knee were treated by AOT at our institution. In this prospective level 2 case series cohort, patients were included with a symptomatic OCD lesion over 0.5 cm^2 and under 5 cm^2 with closed physis. Excluded were patients with previous mosaic plasty, additional intra-articular pathologies (ACL rupture, patellofemoral pathology), marked axis deviation or previous infection. The OCD lesions were confirmed preoperatively by conventional radiography and by MRI or arthroscopy. All lesions were classical osteochondral defects on the lateral border of the medial femoral condyle, with an open connection to the intercondylar notch. The left knee was affected in five out of eight cases. The mean age of the patients at the time of surgery was 33.4 years (range : 20 to 43).

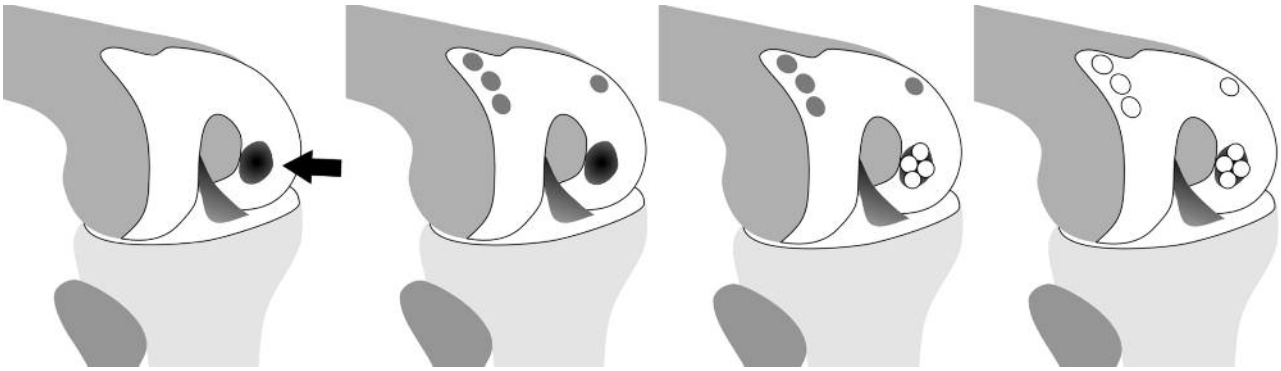

Fig. 1. — Schematic representation of osteochondral transplantation

Mean BMI was 23.9 (SD : 2.8). All patients had neutral or slight valgus limb alignment. There was a median duration of symptoms before surgery of 5 months (range : 1 to 59). Pre-operative level of activity was : fitness (n = 1), soccer (n = 2, of which 1 at professional level), cycling (n = 1), walking (n = 1) ; 2 patients did not participate in sports. All patients had persistent pain and reduction in activity ; three patients had a history of a minor trauma.

Surgical Technique

The osteochondral transplantations were performed by a single surgeon (JLCvS). A small medial arthrotomy was used. Debridement of the defect was first performed with excision of the rounded border of the defect and of the fibrous tissue on the bottom of the defect (fig 1). A fresh articular cartilage defect was thus created, with sharp edges of hyaline cartilage and a bottom of bleeding subchondral bone (fig 2). The Osteochondral Autologous Transfer System (OATS ; Arthrex, St Anthonis, Netherlands) was used for transplantation of the osteochondral plugs.

A stepwise reconstruction of the joint surface was meticulously planned. The length, width and containment of the defect with reference to the intercondylar notch were used to determine the amount and diameter of osteochondral plugs needed. Most frequently, plugs with a diameter of 8 or 6 mm were used (table I) ; from earlier series we experienced an increase in retropatellar crepitus if larger plugs were used. Typically an 8 mm (Ø) recipient hole was created, using the transfer system, with a depth of 15 mm. Subsequently a matching donor plug was harvested, preferably from the lateral trochlea and was transplanted to the recipient defect. In case of a big defect, donor plugs were also harvested from the medial flange of the trochlea. Prior to the press fit transfer of the osteochondral plug, the length of the donor plug was matched exactly with the depth of the recipient hole in order to have the plug resting on the bottom of the recipient hole ('bottoming'). From earlier biomechanical studies we know that 'bottoming' the plugs and a plug length of 15 mm are ideal to prevent subsidence of the transplant during weight bearing (*21*). These steps were repeated until restoration of the joint surface was established (fig 2B).

The donor site defects were then also addressed to improve chances of adequate resurfacing. The available subchondral bone plugs from the creation of the recipient holes were morselised and impacted into the donor site defects. The donor site defects were thus restored halfway up to the joint surface with an impacted cancellous bone graft. For the remaining donor site defect, a collagen type I haemostatic sponge was used to restore congruency of the joint. This collagen type I sponge may facilitate ingrowth of pluripotent stem cells from the synovium and thus potentially stimulate restoration of the donor site defect with fibrous cartilage (*33*). No lateral release was performed. The rehabilitation protocol consisted of six weeks 10 kg weight bearing with crutches. Since grafts were bottomed and thus stable, range of motion was unrestricted. From two months, progressive (athletic) activity was allowed as tolerated.

Clinical Assessment and MRI Evaluation

Patients were assessed preoperatively, and 6 and 12 months postoperatively using various clinical scores.

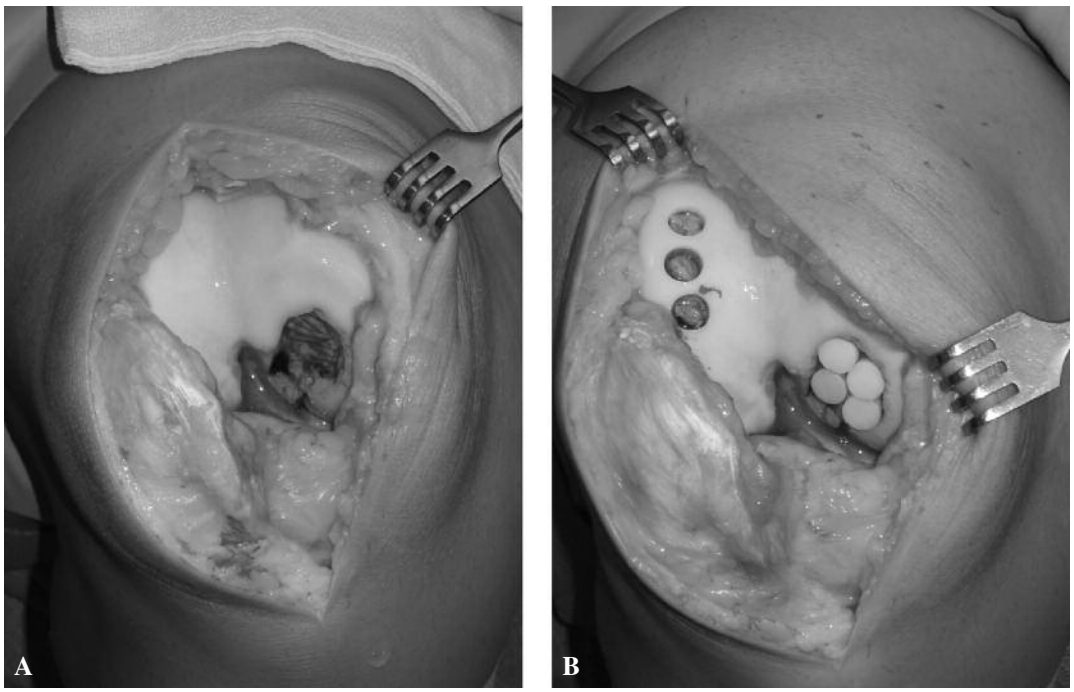

Fig. 2. — A) Macroscopic osteochondral defect on medial femoral condyle. B) Defect filled with osteochondral cylinder transplantation harvested from the lateral trochlea. Chips of subchondral bone from the recipient site are impacted into the donor site defects. Collagen type I haemostatic sponge, which is often used as a carrier of pluripotent stem cells, will be used to cover the defects.

Table I. — Lesion characteristics

Location of lesions (medial : lateral)		8 : 0	
Number of transplants		3.6 (1 - 6)	
Surface area of transplants		1.8 cm^2 (0.97)	
Surface size (cm^2)	Surface coverage	No. plugs	Plug diameter (no.)
0.50	100%	1	8 mm
1.01	100%	2	8 mm
1.01	100%	2	8 mm
1.51	100%	3	8 mm
1.70	100%	4	8 mm (3) / 5 mm (1)
2.07	80%	5	8 mm (3) / 6 mm (2)
3.02	90%	6	8 mm
3.20	80%	6	10 mm (3) / 6 mm (3)

The International Knee Documentation Committee (IKDC) scoring *(8)* was used to record both objective and subjective findings. The Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire *(30)* was used for additional information on symptoms, pain, sport/recreation, activities of daily living (ADL) and quality of life (QoL). Both questionnaires are scored on a scale from 0 to 100, in which 0 represents the worst outcome and 100 the best outcome.

Morphological evaluation after AOT was performed in seven cases by MRI (1.5 Tesla) one year postoperatively (fig 3). The modified Sanders grading system was used to evaluate surface congruency, protuberance of the cylinder, oedema, cartilage thickness and osseous

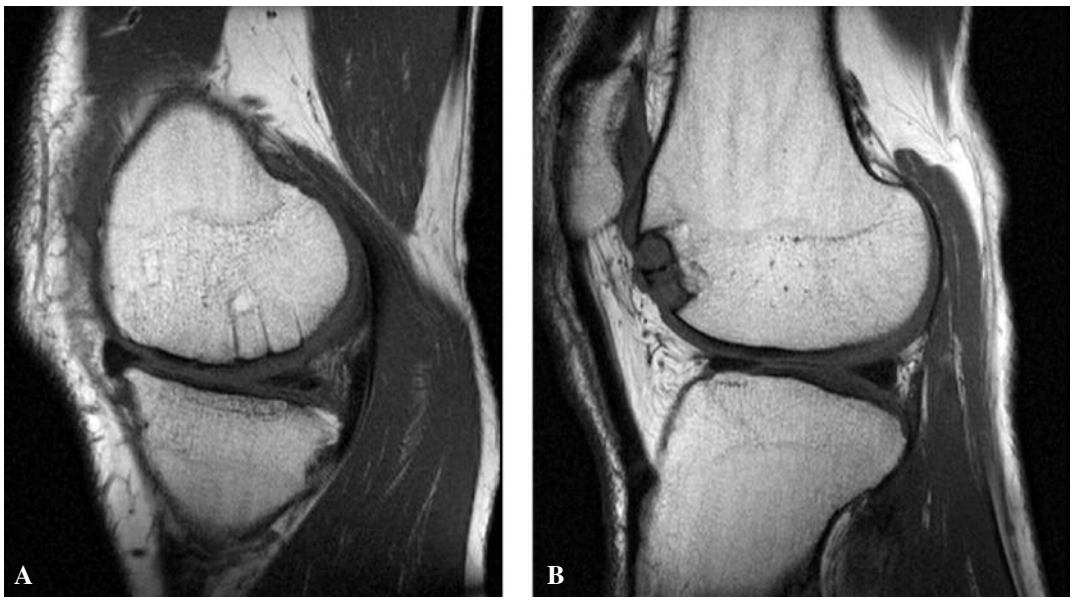

Fig. 3. — Postoperative MRI images, showing :
A) 2-plug mosaicplasty placed flush with perfect depth alignment. Note that the cartilage thickness of the graft matches with the recipient cartilage layer.
B) Donor site of the lateral femoral trochlea filled by impacted chips of subchondral bone and collagen type I haemostatic sponge.

integration (*31*). Two independent examiners reviewed the MRI images. Consensus on the scoring was reached in all cases.

Statistical Analysis

The variables tested were surface size, time to surgery, number of plugs, ICRS-score for current and subjective health, IKDC-score and KOOS score of symptoms, pain, sport/recreation, ADL and QoL. For all continuous variables the standard deviation was expressed in terms of mean ± standard deviation (SD) of the mean. The Repeated Measures ANOVA with Bonferroni correction was performed to determine significant differences at different follow-up times. Kendal rank correlation was performed to investigate relationships between the percentage of coverage and number of osteochondral plugs versus objective and subjective evaluation at 6-months and 12-months follow-ups postoperative. Alpha was set on 0.05.

RESULTS

Prospective follow-up revealed a highly significant improvement of the clinical IKDC score (fig 4) and of all subscales of the KOOS (fig 5) questionnaire. The results of pre-operative scoring and the 12-month post-operative outcome per subscale are summarised in table II.

The pre-operative clinical IKDC score and each subscale of KOOS is characterised by a relatively large standard deviation, indicating a wide range between individual patients (range : 20-80). Six months after surgery the IKDC subjective subscores revealed a significant improvement, as well as the KOOS subscales on Pain, Symptoms, ADL and QoL. The Current Health subscale remained unchanged (table II) and improvement on the subscale on Sport and Recreation was non-significant.

After one year all IKDC subjective scores and all KOOS subscales had improved significantly compared to the preoperative scoring (table II). In addition, the standard deviation on the outcome for each subscale had decreased dramatically with time. Postoperative adverse event was haemarthrosis lasting for a few weeks. No infection occurred. All patients experienced some kind of retropatellar irritation or crepitus initially. In most patients this disappeared within one month and in all patients within six months.

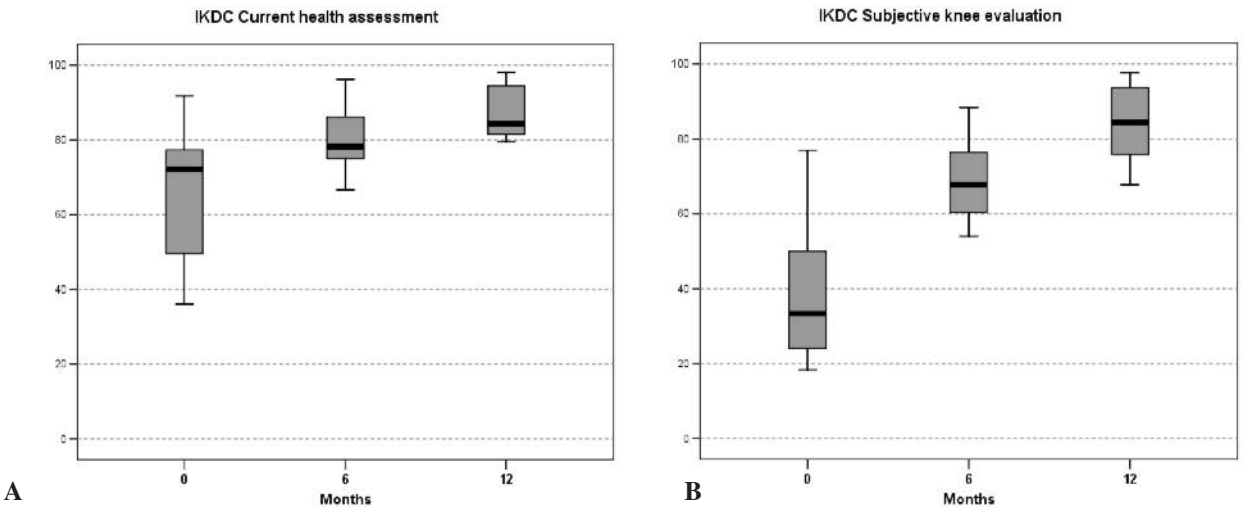

Fig. 4. — A) Boxplot IKDC Current health assessment. B) Boxplot IKDC Subjective knee evaluation

Table II. — Clinical assessment

	Pre-operative	Post-operative 6 months	Post-operative 12 months	p 0 m – 6 m	p 6 m – 12 m	P 0 m – 12 m
IKDC Current Health	66 (36-92)	80 (67-96)	87 (80-98)	0.180	0.007*	0.053
Subjective	39 (18-77)	69 (54-89)	84 (68-98)	0.004*	0.000*	0.001*
KOOS Pain	52 (17-83)	84 (58-100)	95 (86-100)	0.005*	0.102	0.002*
Symptoms	47 (21-79)	76 (57-100)	85 (79-93)	0.008*	0.303	0.003*
ADL	62 (20-96)	89 (79-100)	97 (93-100)	0.044*	0.070	0.019*
Sport/Recr	26 (15-80)	65 (15-95)	79 (45-95)	0.192	0.284	0.014*
QOL	25 (0-44)	54 (25-94)	70 (38-100)	0.011*	0.025*	0.000*

* Significant values.

MRI

The modified Sanders MRI grading scale was used to evaluate the postoperative result of the osteochondral transplantation (*24*). A one year follow-up MRI was available for seven knees (fig 3). For each MRI the AOT was evaluated with respect to surface congruency, cylinder protuberance, oedema, cartilage thickness and osseous integration (fig 6). Surface congruency could be graded as good in 5 cases and moderate in 2 cases. Protuberance of the cylinders was not found in 6 cases, protuberance of less than 2 mm was found in 1 case. Oedema was not present in any of the cases. The cartilage thickness of the graft was 100% similar to the adjacent cartilage in 5 cases and 2 cases revealed between 50 to 100% similarity of thickness. Osseous integration at one year was incomplete in all cases, showing a visible margin around the osteochondral cylinder, but fluid collection, cyst formation or loosening were not found.

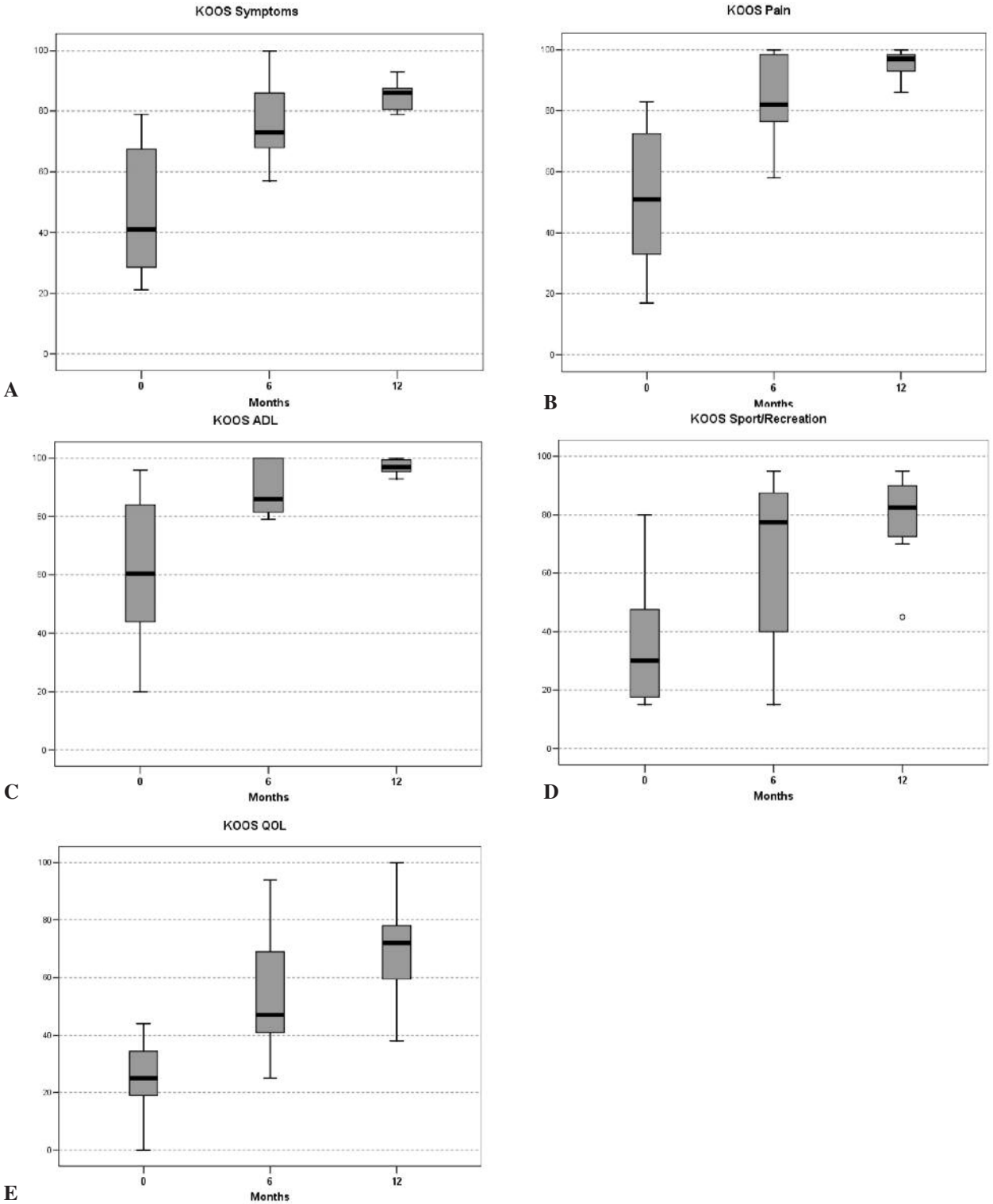

Fig. 5. — A) Boxplot KOOS Symptoms. B) Boxplot KOOS Pain. C) Boxplot KOOS ADL. D) Boxplot KOOS Sport/Recreation. E) Boxplot KOOS QOL.

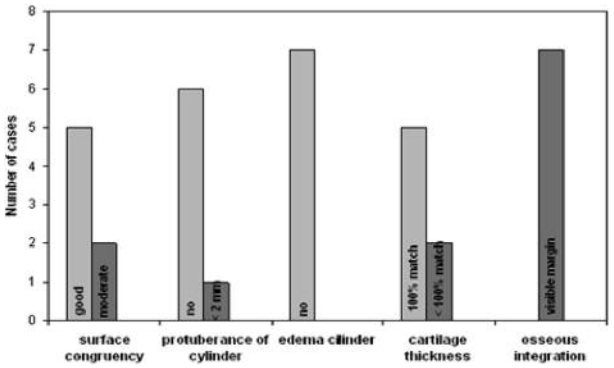

Fig. 6. — Graph showing results of the modified Sanders grading system for MRI. Every item could be scored with 0, 1 or 2 points from best to worst ; none of the MRI's scored 2 points on any of the items in this study.

As for the donor site defects a typical example is presented in figure 3B. Incorporation of the impacted morselised graft was observed at the bottom of the donor site defect, restoring the defect halfway up the joint surface. The remainding upper part of the defect, where a collagen scaffold was placed, appeared to be filled with regenerative tissue (fig 3B).

Statistical evaluation

The IKDC subjective score improved significantly ($p = 0.001$) from a preoperative value of 66 to 87 at one year follow-up. The KOOS evaluation also showed a significant improvement at one year follow-up for pain ($p = 0.002$), symptoms ($p = 0.003$), activities of daily living ($p = 0.019$), sport and recreation ($p = 0.014$) and quality of life ($p = 0.001$). On the subscales pain and activities of daily living, patients hardly had any disabilities after one year with scores of respectively 95 and 97 out of 100. No correlation was found between MRI findings, percentage of coverage, number of plugs used and patient satisfaction.

DISCUSSION

In this case series, good clinical and radiographic results were achieved with AOT for a highly homogeneous group of classic OCD lesions in the knee. Functional capacities and pain significantly improved. These results are in accordance with other studies claiming good-to-excellent clinical results with AOT in 76 to 92% of patients (*9,15,17, 18,24*). In one randomised controlled trial comparing AOT with ACT, Bentley *et al* considered AOT an obsolete technique for cartilage repair. In their study, however, a highly heterogeneous group of articular cartilage defects was evaluated, with defect sizes ranging from 1 to 12.2 cm^2.

Only AOT and to a lesser extent ACI can provide hyaline cartilage repair tissue (*7*). Chondrocyte implantation has two major disadvantages : its high costs and the need for two procedures. Superiority over OAT cannot be claimed from the data available (*35*). AOT, on the other hand, can provide good coverage of the defect with a sufficiently thick cap of good quality cartilage and satisfactory restoration of the curvature of the condyle (*18,22*). An additional advantage of the OAT procedure is that it can be used in non-contained defects, because the graft has inherent stability. It can be used in osteochondral defects which lack an intact lining with the intercondylar notch, like the defects treated in this study. There are, however, also clear disadvantages to this technique. Most importantly, there is the potential donor site morbidity, which remains an important limitation for the AOT technique. The osteochondral grafts are harvested in general from lesser weight bearing areas, usually the femoral trochlea. Several studies focus on pressure differences and surface morphology, whereby the (distal) medial trochlea is considered to be the best harvest location. In agreement with most authors, we used the (distal) lateral trochlea, because the surface area present is larger (*1,6,12*). Some studies assume spontaneous restoration and closure of the donor site defect with fibrocartilage (*15,17,25*). It is questionable if this restoration is not overestimated, as animal experiments on donor site defects show that the potential for spontaneous repair appears limited (*34*). Therefore, great care should be taken during the operation to minimize the chance of donor site morbidity and to stimulate recovery of the donor site defect. In the technique presented, all donor sites were carefully impacted

with "chips" of subchondral bone from the recipient site and covered with a type 1 collagen scaffold. Type 1 collagen is often used as a carrier of pluripotent stem cells. In a retrieval study we found a reasonable integration between the osseous plug and the adjacent cartilage and a fibrous layer covering the plug after three years (*22*). In our experience some patients may demonstrate a gradually decreasing patellofemoral crepitus during the first six months postoperatively. In this study no patient complained of retropatellar crepitus or pain at 12 months follow-up. Still, the donor site morbidity remains a problem, which restricts the defect size to be treated by OAT (*2,15,17*). In this study no correlation could be found between the number of plugs, and KOOS or IKDC outcome scores. This might be influenced by the great care taken to prevent donor site morbidity, the limited size of the defect (largest 3.2 cm^2) or the small number of patients. Marcacci *et al* reported a significant correlation at 2-year follow-up between the number of plugs implanted and worse IKDC objective score, which measures the donor site pain separately (*24*).

At one year follow-up a margin between the plug and its osseous surrounding remained visible on MRI in all patients, but no fluid surrounding the cylinder, cyst formation or graft loosening were present. Although the osseous integration was not complete at one year on MRI, this does not indicate that there was absence of osseous integration. Probably the MRI scan is very sensitive and simply reveals posttraumatic changes. This hypothesis is also supported by other study results (*31*). An earlier histological retrieval report on OAT has shown that after three years there is a full incorporation of the plug into the subchondral bone (*22*). Other studies reported complete osseous integration measured by MRI at 3 months (*27*), 6 months (*26*) and 7 years follow-up (*24*). Rose *et al* found that incongruence of the cartilage surface and higher protuberance between donor and host cartilage did not lead to a decrease in knee function in the mid-term follow-up (*31*). This also seems to apply to our patient group, as 2 cases showed only moderate surface congruency and 1-2 mm protuberance of the cylinder while the results on the IKDC and KOOS questionnaire are good to excellent, and no correlation could be found.

Obviously, there are limitations to our study, which had a very limited number of patients, with a short MRI follow-up of 12 months. The modified Sanders MRI score is subjective on some points : especially when evaluating surface congruency, oedema of cylinder and cartilage thickness. It is a semi-quantitative score as these items cannot be measured objectively. Other scores, like the MOCART and modified MOCART score are also in use. Further validation of these scoring systems is mandatory (*10*). Correlations between defect size, clinical outcome and MRI appearance could not be established. On the other hand, the study involved a highly homogeneous group of patients, who, at least on the short term, clearly benefited from a controversial cartilage repair technique.

For the classic OCD lesion with a diameter up to 4 cm^2, AOT remains a valuable treatment option. Care should be taken to avoid harvesting more than 4 osteochondral plugs as well as plugs with a diameter larger than 8 mm, as this would lead to more retropatellar crepitus. Further improvement in the repair of the donor site defects may allow extending the indication of AOT to larger defects. As already mentioned in our introduction a possible solution to this limitation is filling up these donor site defects with implants such as the TruFit plug or other bone substitutes (*29*). Results seem promising with good bone restoration and even hyaline cartilage formation ; further long term research is however needed.

Clinical relevance

AOT appears as a valid treatment option for selected articular cartilage defects. This study shows that a subgroup of OCD lesions with a limited size on the lateral border of the medial femoral condyle appears to do very well on the short term. Future research on surgical techniques for cartilage repair should probably focus on defining the appropriate surgical technique for different types of lesions, instead of stimulating competition between techniques in larger trials with inhomogeneous cartilage defects.

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