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ORIGINAL STUDY

Is there any correlation between short-term MRI and mid-term clinical results in patients undergoing an Osteochondral Autograft in the knee?

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Thirthy three patients (mean age 32 years) undergoing OA were retrospectively evaluated. All patients had MRI at mean 6.6 months. Lysholm, International Knee Documentation Committee (IKDC), and Tegner scores. The aim is to evaluate Magnetic Resonance Imaging (MRI) in patients who underwent an Osteochondal Autograft (OA) and correlate them with their clinical results-evaluated at mean follow-up of 28 months (12-88).

Tegner Pre-operatively: 6.6, Post-operative: 7.4 ($p<0.001$). Mean Lysholm: 87, mean IKDC: 86. MRI: complete filling of the lesion in 25 (75.7%) patients, complete integration of the graft in 5 (15.1%) and intact repair tissue in 22 (66.6%.

Positive correlation between the degree of repair and filling of the defect and higher Lysholm and IKDC ($p<0.05$).

There is a minor association between short-term MRI and mid-term clinical results after an OA being the degree of repair and filling of the chondral defect the only parameters correlated with patient´s evolution.

Keywords: OATS, MRI, cartilage repair, osteochondral autograft transfer system, magnetic resonance imaging, MOCART score.

INTRODUCTION

Over the past few years, the number of options available to repair the articular cartilage of the knee has increased, revolutionizing surgical treatment. Different techniques include microfracture, mosaicplasty, osteochondral autograft (OA) and autologous chondrocyte implantation among others *(2,11,28)*. The only surgical technique that is known for filling the osteochondral lesion with hyaline cartilage is the OA; that feature makes it one of the most promising techniques *(31)*. Animal studies and subsequent clinical trials have demonstrated the survival of transplanted hyaline cartilage. However, long-term data is limited and it is unclear whether OA transplantation can prevent further deterioration in the affected articular cartilage, despite promising outcomes reported in the literature *(9,10,14,15,18,19)*.

Ideally, the best way to assess outcomes and compare the efficacy of these techniques is an arthroscopic view of the lesion. As that option is rarely possible or suitable, there is an increasing interest in noninvasive methods to evaluate the quality of the tissue postoperatively. Magnetic resonance imaging (MRI) is a useful method to evaluate the morphology of the articular cartilage and repair tissue *(4,13,25)*, besides, it lacks of ionizing radiation, has multiplanar capabilities, and

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more accuracy in evaluating articular cartilage and subchondral bone tissue than other imaging studies *(10)*.

Normally a lot of orthopaedic surgeons ask for an MRI in patients with OA transplantation to check the status of the graft before allowing them to return to their previous sports activity. Nevertheless there´s no clarity if that MRI can predict future outcomes in this group of patients.

That's why the purpose of this study is to evaluate short-term MRI findings in patients who underwent an OA procedure, and correlate them with their mid-term clinical results. We hypothesized that patients with higher scores in short-term MRI evaluation will have higher scores in mid-term clinical evaluation.

METHODS

Study Design

Retrospective case series.

Patients

Institutional Ethics Board approved this study, and all patients gave their informed consent. 33 patients: mean age 32 years old. (12-56) 87% male, 13% females, undergoing open (mini incision arthrotomy) OATS (Osteochondral autograft transfer system) procedure in our Institution between 2006 and 2012 by one surgical team (2 surgeons, 25 years experience each) were retrospective enrolled in the study and evaluated clinically and with MRI.

Inclusion criteria were : Patients with knee pain attributable to a single osteochondral lesion, patients with single grade IV International Cartilage Repair Society (ICRS) chondral lesions of femoral condyles or patellar defects were included. Patients with inflammatory or infectious disease were excluded. Patients with multiple chondral lesions or osteoarthritis were excluded. Associated procedures and prior procedures on the knee were registered.

Surgery

The surgery was performed in an open manner, with a lateral or medial parapatellar mini arthrotomy depending on the location of the lesion except in patellar lesions where a classic medial parapatellar approach was used to turn the patella and expose the defect. Arthrex™ (Naples Fl) OATS system was used in all patients. The size of the chondral defect was estimated using the appropriate sizer available (6, 8 or 10 mm). The most used sizer width was 10 mm. Mean chondral defect size was 0.9 cm^2 (0.64-1.2). The lesion was extracted down to the subchondral bone, making a cylinder of 15 mm depth in femoral condyles, and 10 mm depth in the patella. After harvesting the chondral lesion, the graft donor site was harvested. We used in all cases the medial or lateral paratrochlear groove as donor site depending on the location of the lesion. Once the grafts were in place (Fig 1.), the range of motion was tested, checking the stability and fitting of the graft. Surgical data are displayed in Table 1.

Table I. — Surgical data

	Number (%)
Lesion site	
Medial condyle	11 (33.3)
Lateral condyle	15 (45.4)
Patellar	7 (21.2)
Defect size (mm^2)	90.9 (64-120)
Number of plugs	1 (100)
Previous surgery	6 (18.1)
Meniscectomy	4 (12.1)
ACL reconstruction	4 (12.1)
Associated procedures	20 (60.6)
Ipsilateral meniscectomy	11 (33.3)
Contralateral meniscectomy	1 (3)
Anterior Cruciate Ligament reconstruction	7 (21.2)
High Tibial Osteotomy	1 (3)
Medial patello femoral ligament reconstruction	2 (6)
Microfracture	3 (9)

Rehabilitation

After the surgery patients used a continuous passive motion machine until discharge (24 to 48 hours). No restrictions in range of motion were made. Weight bearing was initiated in the first postoperatory day with 2 crutches and 10% of the body weight progressing to 50% weight bearing at 2 weeks and full weight bearing at 6 weeks.

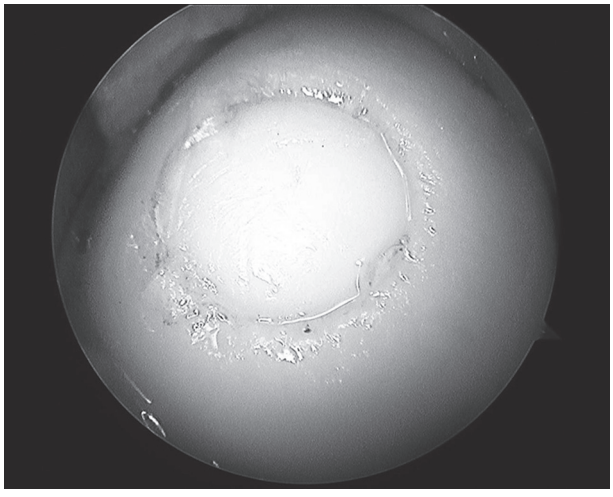

Fig. 1. **—** Arthroscopic view of the knee showing a press fit OATS in the lateral femoral condyle.

MRI evaluation

All patients had preoperative MRIs. Postoperative MRI was taken at a mean time of 6.6 months (3-12). We used 1.5 Tesla MRI. The sequences were:

(a) Axial proton density with fat saturation (FRFSE-XL; time echo (TE): 24 ms; time repetition (TR) 2500 ms; echo train (ETR) 7; Field of view (FOV): 15x15; slice thickness 4.0 mm; slice gap 1.5; matrix 288x224; number of excitation (NEX): 2).

(b) Coronal proton density with fat saturation (fast spin echo-XL; TE 28 ms; TR 2065 ms; ETR 6; FOV 14x14; slice thickness 3.5; slice gap 1.0; matrix 288x224; NEX 2).

(c) Coronal T1 (Cor FSE-XL; TE 15 ms; TR 640 ms; ETR 2, FOV 14x14; slice thickness 3.5; slice gap 1.0; matrix 384x224; NEX 2).

(d) Sagital T2 (Sag FSE-XL; TE 90 ms; TR 5165 ms; ETR 16; FOV 15x15; slice thickness 2.5; slice gap 1.2; matrix 416x256; NEX 2).

(e) Sagital DP (Sag FRFSE-XL; TE 21 ms; TR 1709 ms; ETR 4; FOV 15x15; slice thickness 2.5; slice gap 1.2; matrix 416x256; NEX 2).

One experienced musculoskeletal staff radiologist assessed and reviewed the images. The Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) *(20,29)* scoring system was applied to all the MRIs. (Table 2)

Clinical evaluation

Patients were followed every week for 1 month, monthly until 6 months and then they had 1 final visit at 1 year prior to yearly controls depending of their clinical status. Clinical evaluation for this research was done at an average of 28 months (12-88). Functional evaluation was performed with Lysholm Score *(17)* and subjective International Knee Documentation Committee (IKDC) Score *(12)*. Activity level was evaluated with Tegner Score *(26)* preoperative and postoperative. Return to sports was also assessed.

Statistical analysis

For comparing data we used contingency tables. To assess the association between variables we used Fischer´s exact test. In case of paired variables Exact Wilcoxon Mann-Whitney Rank Sum was used. The linear association between data was tested using Spearman´s coefficient. We decided to use p values < 0.05 as significancy. For analysis we used R 3.0.2 The R Foundation for Statistical Computing Software.

RESULTS

Clinical evaluation

Postoperative Tegner Score was significantly lower ($p < 0.001$) than pre-injury Tegner Score (6.6 v/s 7.4). Even though 69.6% *(23)* of patients were able to return to sports activity, only 16 patients (48%) were able to practice sports at the same level or higher level than the pre-injury state. The mean time to return to sports was 6.4 months (5-8). Mean Lysholm Score was 87 points, and mean IKDC Score was 86 points, both results graded as good (Table 3).

MRI evaluation

At MRI evaluation of the graft (Table 4), a complete filling of the cartilage was shown in 75.7% (Fig 2) of the patients whereas < 50% of underfilling of the adjacent cartilage was seen in 24.2%. There were no cases of complete graft reabsorption. Complete integration of the graft was detected in 15.1% of cases. Most of the images had

Table II. — The Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) Score System

Variable	Classes
Degree of defect repair and defect filling	Complete (on a level with adjacent cartilage)
	Hypertrophy (over the level of the adjacent cartilage)
	Incomplete (under the level of the adjacent cartilage; underfilling)
	>50% of the adjacent cartilage
	<50% of the adjacent cartilage
	Subchondral bone exposed (complete delamination or dislocation and/or loose body)
Integration to border zone	Complete (complete integration with adjacent cartilage
	Incomplete (incomplete integration with adjacent cartilage)
	Demarcating border visible x
	Defect visible <50% of the length of the repair tissue
Surface of the repair tissue	Surface intact (lamina splendens intact)
	Surface damaged (fibrillations, fissures and ulcerations)
	<50% of repair tissue depth
	>50% of repair tissue depth or total degeneration
Structure of the repair tissue	Homogeneous
	Inhomogeneous or cleft formation
Signal intensity of the repair tissue	Dual T2-FSE
	Isointense
	Moderately hyperintense
	Markedly hyperintense
	3D GE-FS
	Isointense
	Moderately hypointense
	Markedly hypointense
Subchondral lamina	Intact
	Not intact
Subchondral bone	Intact
	Edema, granulation tissue, cysts, sclerosis
Adhesions	No
	Yes
Effusion	No effusion
	Effusion

a "split line" appearance (84.8%) (Fig 3) The repair tissue surface was intact in 66.6% (Fig 4), whereas in 33.3% < 50% was damaged. The structure of the repair tissue was homogeneous in most of cases (60.6%). The graft signal intensity score in the T2 sequence was predominantly isointense (87.8%) with the adjacent native cartilage. The subchondral lamina was intact in the majority of the cases (72.7%) but subchondral bone changes (edema, granulation tissue, cysts and sclerosis) were observed in 72.7%. There were no cases with adhesions, and 57.5% of the cases showed some synovitis.

At MRI evaluation of the donor site (Table 5), a complete filling of the defect was shown in only 9% of the patients whereas 90.9% had partial filling of the donor site. There were no cases of complete graft reabsorption. Complete integration of the graft was detected in 27.2% of cases. Most of the images (72.7%) had incomplete integration to the border zone. The repair tissue surface was damaged in all cases. The structure of the repair tissue was not homogeneous in most of cases (81.8%). The graft signal intensity score in the T2 sequence was isointense in half of the cases, and moderately

Table III. — Clinical Results

Preop Tegner Score	7.4 (5-9)
Postop Tegner Score	6.6 (5-9)
Return to Sports	69.6%
Lysholm Score	87 (57-100)
IKDC Score	86 (60-100)

Table IV. — MRI evaluation of the Graft

	Scores	N (%)
(1) Degree of defect repair and filling of the defect	20	25 (75.7)
	15	0
	10	0
	5	8 (24.2)
	0	0
(2) Integration to border zone	15	5 (15.1)
	10	0
	10	28 (84.8%)
	5	0
	0	0
(3) Surface of the repair tissue	10	22 (66.6)
	5	11 (33.3)
	0	
(4) Structure of the repair tissue	5	20 (60.6)
	0	13 (39.3)
(5) Signal intensity of the repair tissue (T2 FSE)	15	29 (87.8)
	5	4 (12.1)
	0	0
(6) Subchondral lamina	5	24 (72.7)
	0	9 (27.2)
(7) Subchondral bone	5	9 (27.2)
	0	24 (72.7)
(8) Adhesions	5	33 (100)
	0	0
(9) Synovitis	5	14 (42.4)
	0	19 (57.5)

hiperintense in the other half. The subchondral lamina was not intact in the majority of the cases (81.8%), and subchondral bone changes (edema, granulation tissue, cysts and sclerosis) were observed in 90.9% of the cases. (Fig 5.) Most of the cases had some adhesions (87.8%), and 57.5% of the cases showed synovitis.

MRI – Clinical correlation

There was no correlation between the zone of the chondral lesion and Lysholm (p = 0.3), IKDC (p = 0.79) and Tegner (p = 1) postoperative Score. There was also no correlation between the area of the chondral lesion and Lysholm (p = 0.1), IKDC (p = 0.78) and Tegner postoperative Score (p = 0.34). There was no correlation between any parameter

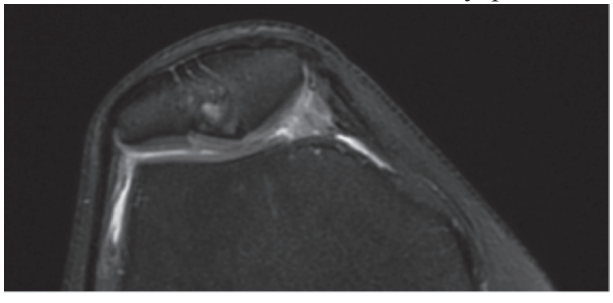

Fig. 2. — Axial MRI view T2 sequence showing a complete filling of a patellar lesion with the graft in situ.

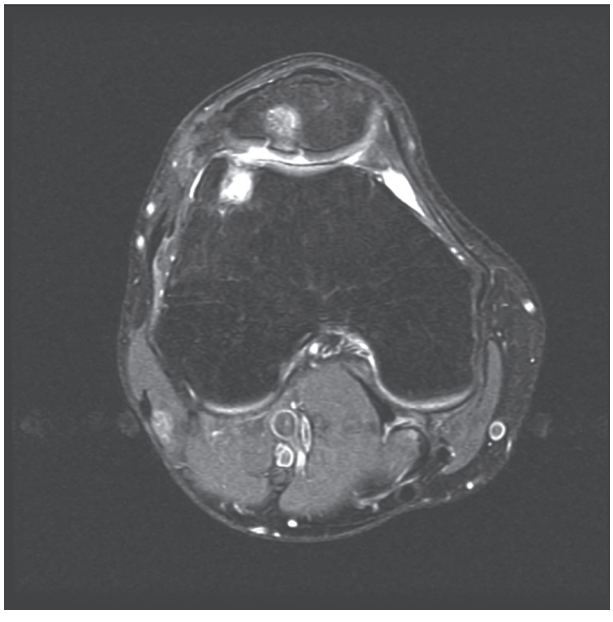

Fig. 3. — Axial T2 MRI view of a patellar OATS showing split – like image of the graft and the donor site in the paratrochlear groove.

of the MOCART score and the area of the lesion, nor with the MOCART score and the localization of the lesion. When analyzing the MOCART variables with the clinical scores; we found a statistical difference between the degree of repair and filling of the defect and the Lysholm and the IKDC scores. The cases with complete repair had higher clinical scores than the ones with incomplete repair (Lysholm 90.4 versus 83.3, IKDC 87.9 versus 80.1, $p < 0.05$). When evaluating the other parameters of the MOCART scores with the clinical scores, we did not find any statistically correlation.

DISCUSSION

Nowadays, the use of articular cartilage repair procedures has become a real therapeutic option for the treatment of chondral lesions. As surgery improves techniques for assessment of repaired articular cartilage have become increasingly important *(22)*. Arthroscopy is unsuitable for routine follow up due to its invasive nature and associated risks and high cost. Conventional radiographs and Computed Tomography are not sensitive studies to assess cartilage *(32)*. In that scenario MRI has become the method of choice for non-invasive follow up of patients undergoing cartilage repair *(30)*.

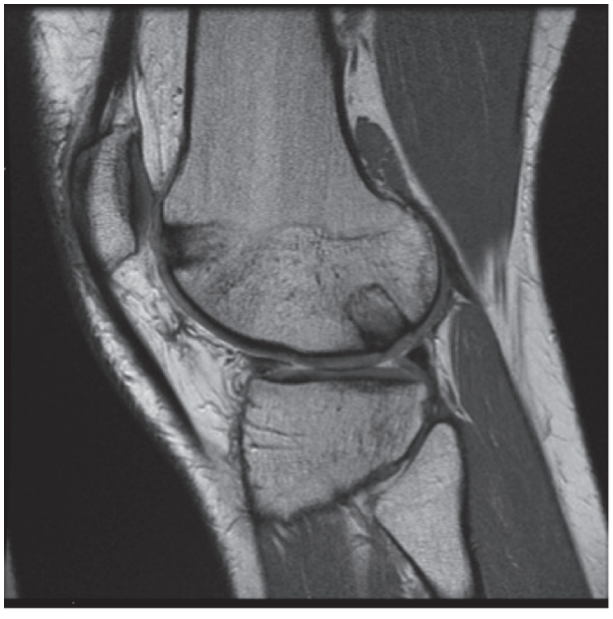

Fig. 4. — Sagital T1 MRI view of a lateral femoral condyle OATS showing intact repair tissue surface and the donor site in the paratrochlear groove.

Table V. — MRI evaluation of the donor site

	Scores	N (%)
(1) Degree of defect repair and filling of the defect	20	3 (9)
	15	0
	10	14 (42.4)
	5	16 (48.4)
	0	0
(2) Integration to border zone	15	9 (27.2)
	10	0
	10	5 (15.1)
	5	9 (27.2)
	0	10 (30.2)
(3) Surface of the repair tissue	10	0
	5	12 (36.3)
	0	21 (63.6)
(4) Structure of the repair tissue	5	6 (18.1)
	0	27 (81.8)
(5) Signal intensity of the repair tissue (T2 FSE)	15	16 (48.4)
	5	17 (51.5)
	0	0
(6) Subchondral lamina	5	6 (18.1)
	0	27 (81.8)
(7) Subchondral bone	5	3 (9)
	0	30 (90.9)
(8) Adhesions	5	29 (87.8)
	0	4 (12.1)
(9) Synovitis	5	14 (42.4)
	0	19 (57.5)

Numerous studies have been published regarding MRI and cartilage repair surgery *(1,3,5-7,21)*. Despite measuring different surgical techniques many of them show some grade of correlation between MRI parameters and clinical results. Regarding to OA

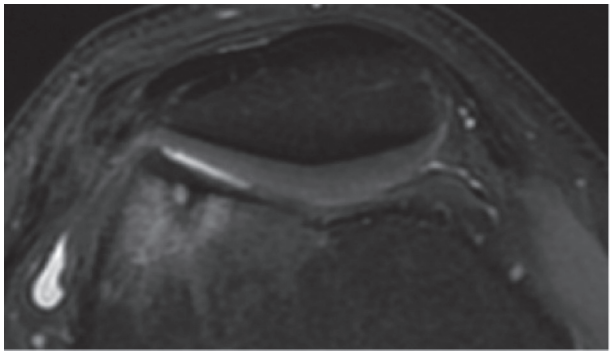

Fig. 5. — Axial MRI view T2 sequence showing subchondral edema surrounding the graft donor site in the paratrochlear groove.

there are four studies in the literature all case series (level of evidence type IV) *(16,19,24,27)*. Two of them found positive correlation between the MOCART score and/or many of its parameters and multiple clinical outcome scores, while the other two found no significant correlation.

Our study shows little association between imaging parameters and clinical results only finding correlation between the degree of repair and filling of the chondral defect in MRI with better clinical scores. Regarding to the factors that have positive association with clinical results in this study it is important to note that a complete filling of the previous lesion was shown in 75.7% of the patients in follow up MRI, higher than the other studies that evaluate MRI and clinical correlations in patients with OA, but they have longer follow up MRI which can explain their results *(16,27)*. On the other hand complete integration of the graft was detected in only 15.1% of cases while the other studies show percentages around 70% *(16,27)*, that can also can be explained by the shorter follow-up of the MRI in our study so we need a longer one to certify this findings. Considering that a 6-month MRI showed only 15.1% of cases with complete integration of the graft and 69.6% of the patients returned to sports in a mean time of 6.4 months meaning that MRI didn't had an impact in the permission to return to sports, this study puts into question the need to perform a short-term control MRI in OA patients as a method of follow-up. Probably a longer follow-up MRI is a better method for assessing integration of the graft and the status of the articular cartilage.

Interesting is the fact that subchondral bone changes were observed in a high number of patients. Although it seems to have no clinical relevance, it shows that the repair process is still active. We need future MRIs to know if healing has been finished or the process remains to be ongoing but other studies with long term follow up (9.2 and 7.9 years) *(16,27,24)* showed that these changes were maintained over time and with no clinical influence in these studies too.

Our clinical results showed excellent and good Lysholm and IKDC scores in most of our patients, with a high percentage of them returning to sports, but only half returning to the same or better level as the pre-injury state. This is consistent with the literature that in most of the cartilage procedures studies shows that when a patient has a symptomatic cartilage lesion he has high probability of not returning to their pre-injury sports level *(8)*. There are some studies that shows percentages of nearly 90% of sports returning for OATS patients *(23)*, our lower percentage (69.6%) it´s probably related to the demographic characteristics of the people included in our study because we only have few professional athletes in our daily practice, most of our patients are normal people who do sports as a hobby and not for living so they are not required to come back to sports or to a high level of sport if they have pain.

Limitations

Our study shows various limitations: The small number of patients limits the strength of the study. However, sample size was calculated to get a statistical power of 80% so the statistical significance is not affected. We have a shorter follow-up than other studies, so we need longer follow-up of our patients to see their evolution in the clinical aspect and also in MRIs. Because of causes cited before, we had not arthroscopic second look that is the Gold Standard to evaluate articular cartilage, so we also don´t have histological tissue to compare with our clinical and imaging results.

We can conclude that there is a minor association between imaging parameters in a short-term follow-up MRI and mid-term clinical results after an OA procedure being the degree of repair and filling of the chondral defect the only parameter correlated

with the patient´s evolution. This questions the importance of a short-term MRI in the follow-up of OA patients making necessary more studies and longer follow-up to ensure its usefulness.

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