Biomedical
Research & Therapy

ISSN: 2198-4093
www.bmrat.org

Original Research

Autologous osteochondral transplantation for treatment of cartilage defects in osteoarthritic knee: preliminary results

Bui Hong Thien Khanh[1,*], Nguyen Duc Thanh[2], Le Tuong Vien[2], Duong Dinh Triet[2], Tran Nguyen Phuong[2], Nguyen Thanh Nhan[1], Mai Thanh Viet[2], Nguyen Phuc Thinh[2], Ho Ngoc Tu[3]

[1]Department of Orthopaedics and Rehabilitation, University of Medicine and Pharmacy, Ho Chi Minh City, Viet Nam
[2]Department of Orthopaedic Surgery, University Medical Center Ho Chi Minh City, Viet Nam
[3]Department of Radiology, University Medical Center, Ho Chi Minh City, Viet Nam

***For correspondence:**

khanhbui1969@yahoo.com

Competing interests: The authors declare that no competing interests exist.

Received: 02 June 2016
Accepted: 14 November 2016
Published: 21 November 2016

Abstract

Introduction: Osteoarthritis is a contributing factor for pain and loss of function of the knee. Osteoarthritis results in many damages to the knee; one of the most common damages that is difficult to recover is cartilage injury. This study aims to apply autologous osteochondral transplantation (OAT) under knee arthroscopy for the treatment of knee cartilage defects. **Methods**: This was a prospective, descriptive and non-controlled study. Patients were diagnosed as having osteoarthritis, as confirmed by 1cm^2 – 3cm^2 cartilage defects. Arthroscopic OAT was performed on each patient. Treatment efficacy and safety were evaluated based on Lysholm, Oxford Knee Scores (OKS) and pain scales (VAS) after 3, 6, 12 and 18 months. **Results**: From 3/2014 - 8/2016, 61 cases (54 women and 7 men) participated in the study. The average age was 55 ± 8 years old. Most cases had cartilage defects in the medial condyle. Results showed that Lysholm, OKS scores and VAS scales improved after 12 months of treatment. Of the cases, 33 of 61 were followed out to 18 months; these patients showed improvement in knee function and pain scores. There was 1 case with incomplete matching between the plug and receiving site and 1 case with a broken plug. At the final stage of monitoring, there were no patients who experienced complications, such as broken instruments or fracture of condyle, nor who experienced early postoperative complications, such as infection and bleeding. **Conclusion**: Autologous osteochondral transplantation via arthroscopy is a safe and promising method for the treatment of knee cartilage defects in patients with average osteoarthritis.

Biomedical
Research & Therapy

ISSN: 2198-4093
www.bmrat.org

Keywords

Autologous osteochondral transplantation, cartilage defect , osteoarthritis, cartilage injury, mosaic plasty, OATS, OAT, osteochondral autograft transfer system

Introduction

Articular cartilage lesions cause pain and decreased mobility, affecting the working capacity and quality of life. To date, cartilage defects have been treated by different strategies, including debridement and lavage, microfracture, osteochondral autograft transplantation, osteochondral allograft transplantation, autologous chondrocyte implantation, and stem cell transplantation. Debridement and lavage are procedures of the oldest technique and typically reserved for low- demand older patients with small lesions (<2 to 3 cm^2) (Bert and Maschka, 1989; Federico and Reider, 1997; Freedman et al., 2004; Owens et al., 2002). Current research has suggested that the best candidates for debridement and lavage are those who suffer from mechanical symptoms (Moseley et al., 2002). Meanwhile, for patients with small to moderate sized lesions (1 to 5 cm^2), microfracture is a suitable treatment. The microfracture process helps stimulate fibrocartilage in-growth into the chondral defect to cover the underlying bone (Freedman et al., 2004; Gill and Macgillivray, 2001; Steadman et al., 2003). The procedure is performed by creating tiny fractures in the subchondral bone plate.

Moreover, osteochondral autograft plugs have been investigated as a means to restore cartilage defects. Osteochondral autograft transplantation has been most commonly applied to treat symptomatic lesions (Freedman et al., 2004; Hangody et al., 2001). The greatest advantage of osteochondral autografts is the use of live hyaline cartilage. This technique results in cartilage that is most similar to the injured cartilage. However, this technique also has disadvantages, namely donor site morbidity (pain and new cartilage defect), technical difficulty and risk of cartilage or bone collapse.

Fresh osteochondral allograft transplantation entails the implantation of a cadaveric osteochondral graft into the cartilage defect (Aubin et al., 2001; Bugbee, 2000; Garrett, 1994). This technique can be used for large articular cartilage defects (from 3 cm^2 up to an entire hemicondyle). The major advantage of osteochondral allografts is the ability to replace large osteochondral defects in a single-stage procedure.

Currently, autologous cultured chondrocyte implantation has also been explored for the treatment of cartilage defects. In this technique, a small piece of cartilage

ISSN: 2198-4093
www.bmrat.org

is harvested arthroscopically. Chondrocytes from the sample are isolated and grown expanded in culture over several weeks. In the next step, millions of autologous cultured cartilage cells are suspended in a solution of fibrin glue and later implanted into cartilage defects (Peterson et al., 2000). This technique is usually considered for intermediate to high-demand patients who have failed arthroscopic debridement or microfracture (Brittberg et al., 1994; Chu et al., 1999; Gillogly et al., 1998).

Stem cell transplantation is currently another promising therapy for osteoarthritis and cartilage defects. Some recent studies have shown that autologous adipose stem cell transplantation can improve osteoarthritis (Bui et al., 2014). Combination of stem cell transplantation and microfracture have also proven to be better than microfracture alone (Nguyen et al., 2016). However, similar to osteochondral allograft transplantation and autologous chondrocyte implantation, stem cell transplantation is expensive but yields promising results in clinical trials.

In this study, we aim to investigate the application of osteochondral transplantation to treat cartilage defects of osteoarthritic knee.

Methods

Inclusion criteria

From March 2014 to August 2016, 61 patients (54 women and 7 men) were enrolled in our study; all had degenerative knee of grades III or IV (classified by Outerbridge), with cartilage lesions with an area of 1- 3 cm^2 on the weight–bearing surface of the femoral condylar. All patients who participated in our study underwent arthroscopic osteochondral autologous transplantation. The mean age of the patients was 55 ± 8 years old.

Exclusion criteria

All patients with any of the following characteristics were excluded from our study: joint space ≤ 2mm, varus/valgus alignment > 5^0, knee stiffness, other joint diseases (e.g. rheumatoid arthritis, inflammation and neoplasm), and joint damage (e.g. caused by systemic diseases). Most patients had 1 or 2 plugs of osteochondral graft and 1 patient had 3 plugs. Moreover, 60 patients had lesions on the medial femoral condyle and 1 had lesions on the lateral femoral condyle (LFC). The mean size of cartilage defects was 1.54 cm^2. Patients were given clinical and functional evaluations pre-operatively and at 3, 6, and 12 months post-operation using the Lysholm, OKS and VAS scales.

Surgical procedure

Surgery was performed under arthroscopy. The location of the defect was determined. Remnants of residual cartilage were removed from the defect. The

ISSN: 2198-4093
www.bmrat.org

size of the defect was measured. The osteochondral grafts were later removed from the donor site on the superior-lateral aspect of the LFC or trochlea and transferred into the cartilage defect. The length of plug was at least 15 mm and similar to the recipient site depth (**Fig. 1, Fig. 2**).

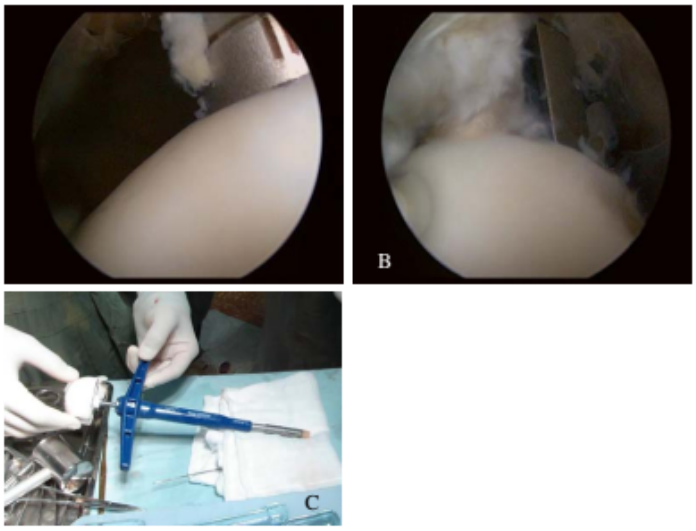

Figure 1. Havesting donor plug from lateral condyle. A, B : Graft is removed from superior-lateral aspect of the lateral femoral condyle; C : Graft is taken out.

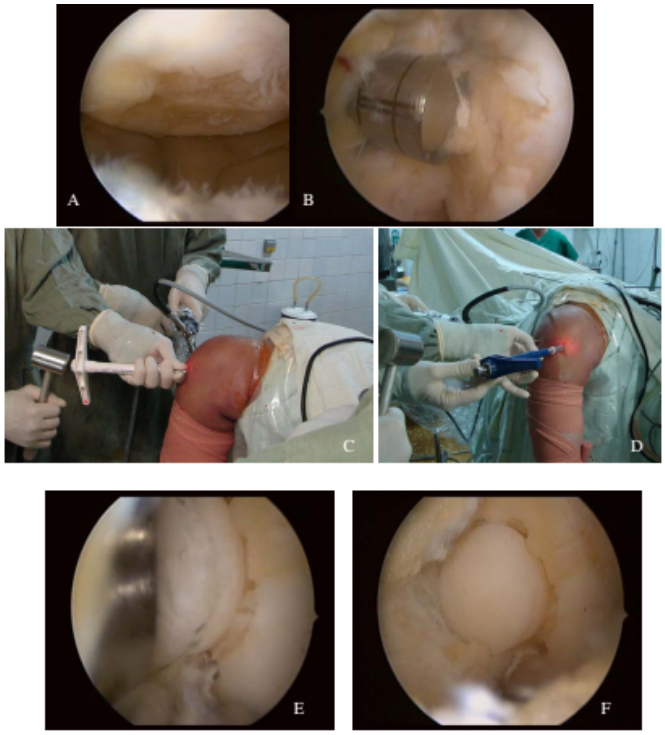

Figure 2. Donor plug is placed into the cartilage defect in the knee. A: Cartilage defect of femoral condyle; B : Measuring the size of defect; C: Havesting graft; D,E : Graft was transferred to recipient site; F : Recipient site after transfer

ISSN: 2198-4093
www.bmrat.org

Post-operative rehabilitation

The knee was passively mobilized on the second post-operative day. Touch-down weight bearing with crutches was allowed after 6 weeks, and the patient could then move gradually toward full weight bearing (at about 8 weeks).

Statistical Analysis

All continuous data were calculated as mean values and standard deviation of the mean. The Kolmogorov Smirnov test was performed to assess the normal distribution of the continuous variables. The normal distribution values were compared using t-tests. Non-normal distribution values or small numbers were compared using the Wilcoxon signed-rank-test and Mann-Whitney U test. Pearson correlation coefficients were used to determine the correlation between MOCART score and cartilage defect size, and between MOCART score and clinical outcomes. Confidence level for all analyses was set at $p < 0.05$. The statistical data was processed using the SPSS 16.0 software (IBM Corp., Armonk, NY, USA).

Results

Changes in Lysholm, OKS and VAS scores

The results showed an improvement in Lysholm, OKS and VAS scores at 3, 6, and 12 months after surgery. Specifically, the OKS score increased significantly from 24.9 ± 8.9 to 40.5 ± 5.5 after 12 months (paired t-test, $p<0.001$). Moreover, the VAS score decreased significantly from 6.2 ± 1.3 to 1.5 ± 1.3 after 12 months (paired t-test, $p<0.001$) (**Table 1**). In 33 patients who were followed out to 18 months, the same trend was observed. In fact, there was no significant difference when comparing the 12-month-follow up results with the 18-month results (paired t-test, $p>0.05$), thus demonstrating that improved outcomes were maintained out to 18 months post-operation (**Table 2**). The window in which patients felt improvement of symptoms was at about 3.7 months (1 to 7 months) after surgery.

The percentage of patients with normal or mild knee arthritis, based on the OKS scores, increased from 31.2% (pre-operation) to 95.1% (at 12 months post-operation) (**Table 4**). We also found that the percentage patients with no or mild pain, based on the VAS scores, went from 0% (pre-operation) to 93.4% (at 12 months post-operation) (**Table 5**). The percentage of patients with pre-operative good knee function, based on the Lysholm scores, was 3.3% (pre-operation) and 32.8% (at 12 months post-operation) and there was no patient with poor

ISSN: 2198-4093
www.bmrat.org

function (63.9% preoperative) (**Table 3**). Similar results was found in the 18-month follow-up group (**Table 2**).

There are 35 cases with one-plug OAT and 25 cases with double-plug OAT. Both groups showed improvement in function and VAS scores at 12 months post operation (paired t-test, $p<0.001$; Wilcoxon signed-rank test, $p>0.05$). Moreover there was no significant difference between those two groups at any follow-up time (Mann-Whitney U, $p>0.05$) (**Table 7**).

Table 1. Pre-operative and post-operative functional and pain outcomes

Unit (Point)	Preoperative	3 months	6 months	12 months
Lysholm	60.3 ± 12	72.8 ± 11.8	80.8 ± 9.6	83.3 ± 7.4
	(95% CI : 57.2–63.4)	(95%CI : 69.8-75.9)	(95%CI : 78.3-83.2)	(95%CI : 81.4-85.2)
OKS	24.9 ± 8.9	31.9 ± 7.5	38 ± 7	40.5 ± 5.5
	(95% CI: 22.7-27.2)	(95% CI: 30.0-33.8)	(95% CI: 36.2-9.8)	(95% CI: 39.1-41.9)
VAS	6.2 ± 1.3	3.1 ± 1.8	2.0 ± 1.6	1.5 ± 1.3
	(95% CI: 5.9-6.6)	(95% CI: 2.7-3.6)	(95% CI : 1.6-2.5)	(95% CI : 1.2-1.9)

Table 2. Pre-operative and post-operative outcomes out to 18-months of follow-up

Unit (Point)	Pre-operative	6 months	12 months	18 months
Lysholm	58.9 ± 12.3	79.3 ± 11.4	83.3 ± 8.5	83.9 ± 8.2
OKS	25.5 ± 9.1	37.3 ± 7.2	39.8 ± 6	40 ± 6.2
VAS	6.3 ± 1.4	2.2 ± 1.7	1.8 ± 1.5	1.5 ±1.7

When divided into two groups according to the size of lesion, (2 – 3 cm^2 group and <2 cm^2 group), we found that there was no significant difference in any of the scales at all follow-up times (Mann-Whitney U, $p>0.05$) (**Table 6**). Moreover, the size of defect had no correlation with clinical outcomes ($p > 0.05$). In the 18-month follow-up group, there were also no significant difference when comparing outcomes of single-plug group and double-plug group (Mann-

ISSN: 2198-4093
www.bmrat.org

Whitney U, $p > 0.05$) between the 2-3 cm^2 and < 2 cm^2 groups (Mann-Whitney U, $p > 0.05$) (**Tables 6 and 7**). There was no plug migration into the joint space, as assessed by clinical evaluation and knee X-ray after surgery.

MRI was performed for 39 patients at 6 months post-operation and for 25 patients at 12 months post-operation. For all cases, the MOCART scores were calculated, as well as assessment of integration of grafts into the receiving site, and intact cartilage surface. The mean MOCART was 61.8 ± 18 (95% CI: 55.9 – 67.7) at 6 months post-operation, and 62.4 ± 16 (95% CI: 55.5 – 69.3) at 12 months post-operation (**Table 8**).

Table 3. Results/grading of Lysholm scores (%)

	Poor (<65)	Fare (65-83)	Good (84-90)	Excellent (>90)
Pre-operative	63.9	32.8	3.3	0
3 months	24.5	52.5	16.4	6.6
6 months	6.6	47.5	31.1	14.8
12 months	0	49.2	32.8	18
18 months (33 cases)	0	42.4	30.3	27.3

Table 4. Results/grading of OKS scores (%)

	Severe (0-19)	Moderate (20-29)	Mild (30-39)	Normal (40-48)
Pre-operative	26.2	42.6	24.6	6.6
3 months	3.3	37.7	41	18
6 months	0	16.4	34.4	49.2
12 months	0	4.9	31.2	63.9
18 months (33 cases)	0	9.1	33.3	57.6

The rate of complete defect fill (100 – 125%) was 13% after 6 months and 8% after 12 months; the rate of partial cartilage defect fill (50 – 100%) was 69% after 6 months and 80% after 12 months (**Table 8**). At 6 months after surgery, the rate of complete integration of plug into subchondral bone was 56%, and 72% after 12 months. Eighteen patients had MRI performed at both 6 and 12 months post-

ISSN: 2198-4093
www.bmrat.org

operation; there was an observed increase of 3D MOCART, from 61.7 ± 18 to 64.4 ± 14.7, though the difference was not significant (Wilcoxon, p = 0.341).

Table 5. Results grading of VAS scores (%)

	None	Mild	Moderate	Severe
	0	(1-3)	(4-6)	(7-10)
Preoperative	0	0	57.4	42.6
3 months	8.2	52.5	37.7	1.6
6 months	18	60.7	21.3	0
12 months	19.7	73.7	6.6	0
18 months (33 cases)	30.3	60.6	6.1	3

Table 6. Outcomes of groups with defect size of < 2 cm^2 and 2-3 cm^2

Size	Time	Lysholm	OKS	VAS
< 2cm^2	**Pre-operative**	61.2	25.3	6.2
	3 months	73.8	32.5	3.2
	6 months	81.1	38.4	2.1
	12 months	83.2	40	1.6
	18 months (33 cases)	84.3	40.2	1.7
2-3cm^2	**Pre-operative**	57	23.1	6.3
	3 months	71.5	31.3	3.0
	6 months	80.4	37.4	2
	12 months	82.2	40.5	1.5
	18 months (33 cases)	85.5	41.3	0.8

Imaging results

There was no correlation between the size of lesion and MOCART score at 6 and 12 months post-operation (p=0.15 and p=0.263, respectively) (**Fig. 3**). We also found no correlation between MOCART score (or its variables) and clinical outcome scores (Lysholm, OKS and VAS) (p> 0.05 for all).

ISSN: 2198-4093
www.bmrat.org

Table 7. Outcomes of single-plug group and double-plug group

	Time	Lysholm	OKS	VAS
1 plug	Pre-operative	61.8	24.8	5.9
	3 months	73.2	32.5	3.1
	6 months	82	38.3	2
	12 months	84.7	41	1.3
	18 months (17 cases)	84.2	41.3	1.7
2 plugs	Pre-operative	58.8	25	6.6
	3 months	72.7	30.9	3.2
	6 months	79.2	37.5	2.1
	12 months	81.3	39.7	1.8
	18 months (15 cases)	83.5	39.5	1.4

Twenty single-plug cases and eighteen double-plug cases received an MRI evaluation at 6 months post-operation. The mean MOCART score for the single-plug group was 66.7 ± 17.9 and for the double-plug group was 56.4 ± 17.7; however, the difference was not significant (Mann-Whitney U, p=0.112). Similarly, the MRI results after 12 months for the 12 single-plug cases and 12 double-plug cases revealed no significant difference in MOCART score between the groups (Mann-Whitney U, p = 0.630).

Complications

We did not observe any complications during the operation, such as breakage of instrument, fracture of femoral condyle, and anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) attachment injury. There was one case of incomplete matching between plug and receiving site and one case of broken plug. Both instances entailed replacement of a new plug. None of the 61 experienced any early post-operative complications, such as infection, hemorrhaging or migration of plug.

ISSN: 2198-4093
www.bmrat.org

Table 8. 3D MOCART scores

	Point	6 months		12 months	
		Number	%	Number	%
1. Defect fill (degree of defect repair and filling if the defect in relation to the adjacent cartilage)					
0-25%	0	2	5	1	4
25-<50%	5	5	13	2	8
50-<100%	10	27	69	20	80
100- <125%	15	5	13	2	8
125- <150%	5	0	0	0	0
>150	0	0	0	0	0
2. Cartilage interface (integration with adjacent cartilage to border zone in two planes)					
Complete	15	4	10	3	12
Demarcating borders	10	24	61	11	44
Defect visible < 50%	5	10	26	9	36
Defect visible > 50%	0	1	3	2	8
3. Bone interface (Integration of the transplant to the subchondral bone, integration of a possible periosteal flap)					
Complete	5	22	56	18	72
Incomplete	0	17	44	7	28
4. Surface (constitution of the surface of the repair tissue)					
Surface intact	10	10	26	7	28
Surface damaged < 50% of depth	5	27	69	15	60
Surface damaged > 50% of depth or adhesions	0	2	5	3	12
5. Structure (constitution of the repair tissue)					
Homogeneous	5	19	49	16	64
Inhomogeneous or Cleft formation	0	20	51	9	36
6. Signal intensity (Intensity of MR signal of the repair tissue in comparison to the adjacent cartilage)					
Normal (identical to adjacent cartilage)	15	4	10	2	8
Nearly normal (slight areas of signal alteration)	10	32	82	21	84

ISSN: 2198-4093
www.bmrat.org

Abnormal (large areas of signal alteration)	0	3	8	2	8
7. Subchondral lamina (constitution of the subchondral lamina)					
Intact	5	24	62	16	64
Non-intact	0	15	38	9	36
8. Chondral osteophytes (Osteophytes within the cartilage repair area)					
Absent or Osteophyte with < 50% of the thickness of the cartilage transplant	5	39	100	25	100
Osteophyte with > 50% of the thickness of the cartilage transplant	0	0	0	0	0
9. Bone marrow edema (maximun size and location in relation to the cartilage repair tissue and other alternations)					
Absent	5	13	33	8	32
Edema	0	26	67	17	68
10. Subchrondral bone (constitution of the subchondral bone)					
Intact	5	15	38	8	32
Non-intact	0	24	62	17	68
11. Effusion (approx. size of joint effusion visualized in all planes)					
Absent	15	5	13	6	24
Small or medium	10	34	87	19	76
Large	0	0	0	0	0

Discussion

Hangody et al. recommended the use of OAT only for patients <40 years of age; there have been relative contraindications in patients ranging from 40-50 years of age, and contraindications in those >50 years of age (Hangody et al., 2001). Kish et al. (Kish et al., 1999) as well as Marcacci et al. (Marcacci et al., 2005) have also reported better results in younger patients. However, Chow et al. have found that age is not a factor which limits the procedure; old people with chondral defects and a stable knee joint can achieve good results (Chow et al., 2004). In our study, we also found in patients with a mean age of 55 ± 8 years old, clinical results as well as pain scores improved at 12 and 18 months post-operation. In a recent study, mosaicplasty for treatment of cartilage defects demonstrated promising results. In a multi-center study, Hangody et al. showed that mosaicplasty was better than other cartilage repair methods, including debridement, subchondral penetration and abrasion arthroplasty (Hangody et al., 2001). Similarly, Krych et al. saw better activity levels after osteochondral autograft transfer mosaicplasty than after microfracture (Krych et al., 2012).

ISSN: 2198-4093
www.bmrat.org

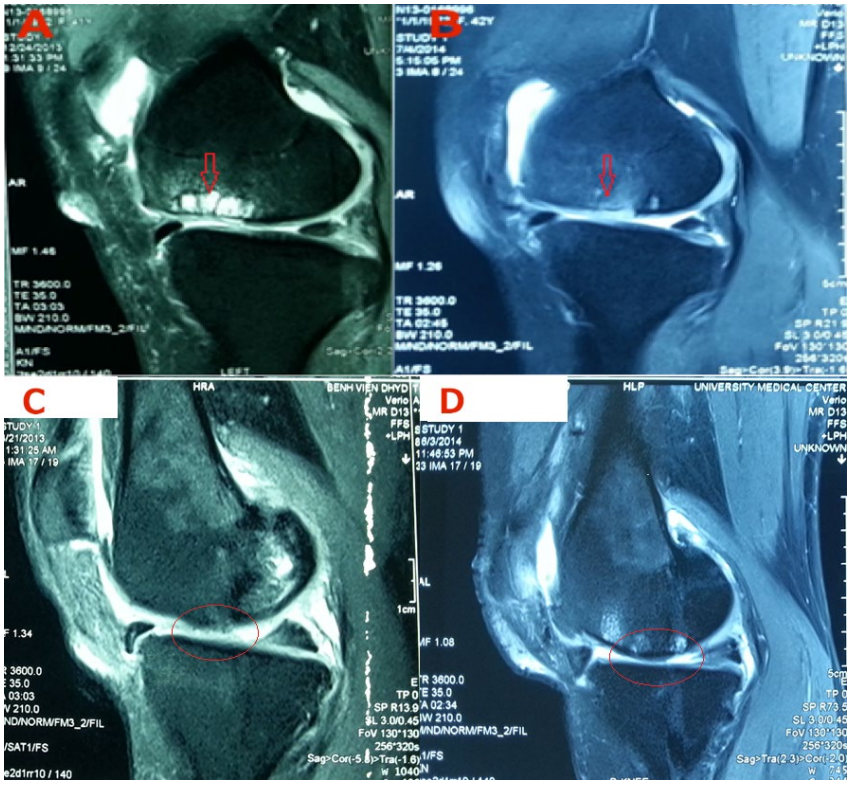

Figure 3. Pre-operative and 6-month post-operative MRI. Restoration of articular cartilage and subchondral bone could be observed (**C, D**) compared to pre-operation (**A, B**). A and B: Case 1, C and D: case 2

Several other studies have also demonstrated improved results after mid-term and long-term follow-up. Randomized studies with a control group have been performed. Horas et al. (Horas et al., 2003) and Dozin et al. (Dozin et al., 2005) concluded that the clinical outcome of mosaicplasty was equivalent to autologous chondrocyte implantation, with a high rate of hyaline cartilage. However, after early- stage promising results, Solheim et al. (Solheim et al., 2010) showed that there is a gradual reduction of efficacy after 10 to 14 years of follow-up; 40% of the 73 cases had poor outcome, and good outcome was often seen in younger patients with defect size <3 cm^2. In a study of 52 patients at 37 months follow-up, Jakob et al. found that the method was limited by the defect size and the number of plugs taken at the donor site (Jakob et al., 2002). Marcacci et al. studied 30 patients and confirmed better outcome was associated with small defect size and with only 1-3 plugs (Marcacci et al., 2005).

In our study, after the 12 month follow-up period, the percentage with good and excellent Lysholm score was 50.8%. The percentage having knee with normal or mild inflammation on the OKS scale was 95.1%, and the rate of mild pain or no pain on the VAS scale was 93%. Although the Lysholm scale results was lower than previous studies, the results of the VAS scores and OKS scores were

ISSN: 2198-4093
www.bmrat.org

equivalent to what other authors, such as Marcacci et al. (Marcacci et al., 2005) and Jakob et al. (Jakob et al., 2002) have published. The reason for the lower Lysholm scale scores in this study may be due to the fact that the patients in our study included those with knee osteoarthritis.

Osteochondral autograft transplantation for isolated cartilage defects with < 2-3 cm^2 lesion area in young people requiring high activity is nothing controversial. In our study, osteochondral autograft transplantation for grade III/IV cartilage defects with 1-3 cm^2 lesion area on the weight-bearing surfaces of femoral condylar in older adults with osteoarthritis is an expanded indication to delay knee replacement surgery. Initial results showed good results with lesion area of ≤ 3 cm^2 at 12 months post-operation and similar results in the 18 months post-operative group. In studies by Hangody et al., the authors only performed OAT for cartilage defect sizes from 1-4 cm^2, although it can be applied as a temporary method for 8 cm^2 cartilage defects (Hangody et al., 2001).

In this study, we compared the results in two groups of lesion defects: <2 cm^2 and 2-3 cm^2. We saw good results in both groups; there was no correlation between lesion size and clinical results. Marcacci et al. observed better results with smaller-sized lesions (Marcacci et al., 2005), but other authors have found (Jakob et al., 2002), as we did too, that there are no statistically significant correlation between clinical outcome and lesion size.

With the development of diagnostic imaging devices, MRI provides not only a non-invasive means to diagnose cartilage lesions but also a reliable tool for monitoring and evaluating results of articular cartilage lesion treatment. In particular, 3D MOCART is a good scale and most often used for evaluating results of OAT by MRI (Marlovits et al., 2006; Marlovits et al., 2004). 3D MOCART scale assesses many variables, including: degree of repair filling, integration of the cartilage repair tissue to the border zone, structure of the surface, structure of the whole repair tissue, and signal intensity. Thus, the scale can be used to evaluate the effectiveness, success or failure of treatment.

Rate of complete defect fill after 1 year according to research by Zak et al. is 50% (Zak et al., 2014). In our study, this rate was only 8%; most cases (80%) had defect fill from 50% to <100%. We found intact surface rate of cartilage after 1 year to be 28%; Zak group's found it to be 70% (Zak et al., 2014). This difference may be due to parameters in other studies which are not seen in osteoarthritis patients. The majority of patients in our study are older and osteoarthritic thus MRI results after 1 year were worse. However, the rate of complete bone interface was 72% and we did not have any complete delamination case, meaning that all plugs were stable and in place.

The average MOCART score after 12 months in our study was 62.4 points, not too much lower than 75 points in Zak et al.'s study (Zak et al., 2014) and Krusche-Mandl et al.'s study (Krusche-Mandl et al., 2012). We also did not find a correlation between MOCART score and function scores or VAS scores.

ISSN: 2198-4093
www.bmrat.org

Concerning the correlation between MOCART score and clinical outcome, Krusche-Mandl et al. did not find any correlation between MOCART score and Lysholm, IKDC or VAS scores (Krusche-Mandl et al., 2012). Tetta et al. also found that there is only a correlation with the IKDC scale but not with the Tegner scale (Tetta et al., 2010). A recent meta-analysis study also found that there is not enough evidence to confirm a correlation between morphological results of MRI and clinical outcome (Wakitani et al., 2002).

Ensuring the matching between plugs and the receiving site to create a smooth cartilage surface is a challenge in the OAT technique. Chow et al. showed that harvesting and transplanting of osteochondral plugs should be perpendicular to cartilage surface; in fact, wrong angle placement will reduce efficacy (Chow et al., 2004). Marcacci et al. also agreed with this assessment after 3 of their cases failed and were related to the surface matching problem (Marcacci et al., 2005). Hangody and Fules also emphasized the importance of matching between plugs and the receiving location (Hangody et al., 2001). Therefore, in our study, we carefully performed the OAT procedure, and only 1 case without matching after transplantation had to be replaced with another plug.

Conclusion

OAT procedure under arthroscopy was investigated as a treatment for osteoarthritis patients with grade III/IV cartilage defects (1-3 cm^2 lesion area) and showed promising initial results. OAT is an accepted and trusted method in the treatment of 1-3 cm^2 cartilage defects, helping to delay knee replacement surgery. There is no correlation between 3D MOCART and functional outcome, or to post-operative pain score. OAT under arthroscopy may be a promising procedure for the treatment of knee articular cartilage defects since it is a minimally invasive, low-priced, and one-stage procedure which yields some efficacy and few complications.

List of Abbreviations

OAT : autologous osteochondral transplantation; OKS : Oxford Knee Score; LFC : Lateral femoral condyle; MOCART :Magnetic resonance observation of cartilage repair tissue

Acknowledgment

This study was granted by Department of Science and Technology, Ho Chi Minh city, Viet Nam, under project: "Autologous osteochondral transplantation for the treatment of cartilage defects in knee: Applied research"; code: YT-2013-37.

Biomedical
Research & Therapy

ISSN: 2198-4093
www.bmrat.org

Ethical approval and informed consent

All patients gave informed consent and the studies were approved by the Committee of Department of Science and Technology, Ho Chi Minh city, Viet Nam.

Author Contribution

BHTK: collected, analyzed, data and wrote the manuscript; MTV, NDT, LTV, NPT: collected data, write the draft of manuscript; HNT: diagnosis, evaluated clinical scores; performed MRI evaluation. All authors approved this manuscript

ISSN: 2198-4093
www.bmrat.org

References

Aubin, P., Cheah, H., Davis, A., and Gross, A. (2001). Long-term followup of fresh femoral osteochondral allografts for posttraumatic knee defects. *Clinical orthopaedics and related research* 391, S318-S327.

Bert, J.M., and Maschka, K. (1989). The arthroscopic treatment of unicompartmental gonarthrosis: a five-year follow-up study of abrasion arthroplasty plus arthroscopic debridement and arthroscopic debridement alone. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 5, 25-32.

Brittberg, M., Lindahl, A., Nilsson, A., Ohlsson, C., Isaksson, O., and Peterson, L. (1994). Treatment of deep cartilage defects in the knee with autologous chondrocyte transplantation. *New england journal of medicine* 331, 889-895.

Bugbee, W.D. (2000). Fresh osteochondral allografting. *Operative Techniques in Sports Medicine* 8, 158-162.

Bui, K.H.-T., Duong, T.D., Nguyen, N.T., Nguyen, T.D., Le, V.T., Mai, V.T., Phan, N.L.-C., Le, D.M., Phan, N.K., and Van Pham, P. (2014). Symptomatic knee osteoarthritis treatment using autologous adipose derived stem cells and platelet-rich plasma: a clinical study. *Biomedical Research and Therapy* 1, 2-8.

Chow, J.C., Hantes, M.E., Houle, J.B., and Zalavras, C.G. (2004). Arthroscopic autogenous osteochondral transplantation for treating knee cartilage defects: a 2-to 5-year follow-up study. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 20, 681-690.

Chu, C.R., Convery, F.R., Akeson, W.H., Meyers, M., and Amiel, D. (1999). Articular Cartilage Transplantation: Clinical Results in the Knee. *Clinical orthopaedics and related research* 360, 159-168.

Dozin, B., Malpeli, M., Cancedda, R., Bruzzi, P., Calcagno, S., Molfetta, L., Priano, F., Kon, E., and Marcacci, M. (2005). Comparative evaluation of autologous chondrocyte implantation and mosaicplasty: a multicentered randomized clinical trial. *Clinical Journal of Sport Medicine* 15, 220-226.

Federico, D.J., and Reider, B. (1997). Results of isolated patellar debridement for patellofemoral pain in patients with normal patellar alignment. *The American journal of sports medicine* 25, 663-669.

Freedman, K.B., Fox, J.A., and Cole, B.J. (2004). Knee cartilage: Diagnosis and decision making. *Textbook of arthroscopy*, 555-567.

Garrett, J.C. (1994). Fresh osteochondral allografts for treatment of articular defects in osteochondritis dissecans of the lateral femoral condyle in adults. *Clinical orthopaedics and related research* 303, 33-37.

Gill, T.J., and Macgillivray, J.D. (2001). The technique of microfracture for the treatment of articular cartilage defects in the knee. *Operative Techniques in Orthopaedics* 11, 105-107.

Gillogly, S.D., Voight, M., and Blackburn, T. (1998). Treatment of articular cartilage defects of the knee with autologous chondrocyte implantation. *Journal of Orthopaedic & Sports Physical Therapy* 28, 241-251.

Hangody, L., Feczkó, P., Bartha, L., Bodó, G., and Kish, G. (2001). Mosaicplasty for the treatment of articular defects of the knee and ankle. *Clinical orthopaedics and related research* 391, S328-S336.

ISSN: 2198-4093
www.bmrat.org

Horas, U., Pelinkovic, D., Herr, G., Aigner, T., and Schnettler, R. (2003). Autologous chondrocyte implantation and osteochondral cylinder transplantation in cartilage repair of the knee joint. *J Bone Joint Surg Am* 85, 185-192.

Jakob, R.P., Franz, T., Gautier, E., and Mainil-Varlet, P. (2002). Autologous osteochondral grafting in the knee: indication, results, and reflections. *Clinical orthopaedics and related research* 401, 170-184.

Kish, G., Módis, L., and Hangody, L. (1999). Osteochondral mosaicplasty for the treatment of focal chondral and osteochondral lesions of the knee and talus in the athlete: rationale, indications, techniques, and results. *Clinics in sports medicine* 18, 45-66.

Krusche-Mandl, I., Schmitt, B., Zak, L., Apprich, S., Aldrian, S., Juras, V., Friedrich, K., Marlovits, S., Weber, M., and Trattnig, S. (2012). Long-term results 8 years after autologous osteochondral transplantation: 7 T gagCEST and sodium magnetic resonance imaging with morphological and clinical correlation. *Osteoarthritis and Cartilage* 20, 357-363.

Krych, A.J., Harnly, H.W., Rodeo, S.A., and Williams, R.J. (2012). Activity levels are higher after osteochondral autograft transfer mosaicplasty than after microfracture for articular cartilage defects of the knee. *J Bone Joint Surg Am* 94, 971-978.

Marcacci, M., Kon, E., Zaffagnini, S., Iacono, F., Neri, M.P., Vascellari, A., Visani, A., and Russo, A. (2005). Multiple osteochondral arthroscopic grafting (mosaicplasty) for cartilage defects of the knee: prospective study results at 2-year follow-up. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 21, 462-470.

Marlovits, S., Singer, P., Zeller, P., Mandl, I., Haller, J., and Trattnig, S. (2006). Magnetic resonance observation of cartilage repair tissue (MOCART) for the evaluation of autologous chondrocyte transplantation: determination of interobserver variability and correlation to clinical outcome after 2 years. *European journal of radiology* 57, 16-23.

Marlovits, S., Striessnig, G., Resinger, C.T., Aldrian, S.M., Vecsei, V., Imhof, H., and Trattnig, S. (2004). Definition of pertinent parameters for the evaluation of articular cartilage repair tissue with high-resolution magnetic resonance imaging. *European journal of radiology* 52, 310-319.

Nguyen, P.D., Tran, T.D.-X., Nguyen, H.T.-N., Vu, H.T., Le, P.T.-B., Phan, N.L.-C., Vu, N.B., Phan, N.K., and Van Pham, P. (2016). Comparative Clinical Observation of Arthroscopic Microfracture in the Presence and Absence of a Stromal Vascular Fraction Injection for Osteoarthritis. *Stem Cells Translational Medicine*, sctm. 2016-0023.

Owens, B.D., Stickles, B.J., Balikian, P., and Busconi, B.D. (2002). Prospective analysis of radiofrequency versus mechanical debridement of isolated patellar chondral lesions. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 18, 151-155.

Peterson, L., Minas, T., Brittberg, M., Nilsson, A., Sjögren-Jansson, E., and Lindahl, A. (2000). Two-to 9-year outcome after autologous chondrocyte transplantation of the knee. *Clinical orthopaedics and related research* 374, 212-234.

Solheim, E., Hegna, J., Øyen, J., Austgulen, O.K., Harlem, T., and Strand, T. (2010). Osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee: results at 5 to 9 years. *The Knee* 17, 84-87.

Steadman, J.R., Briggs, K.K., Rodrigo, J.J., Kocher, M.S., Gill, T.J., and Rodkey, W.G. (2003). Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 19, 477-484.

ISSN: 2198-4093
www.bmrat.org

Tetta, C., Busacca, M., Moio, A., Rinaldi, R., Delcogliano, M., Kon, E., Filardo, G., Marcacci, M., and Albisinni, U. (2010). Knee osteochondral autologous transplantation: long-term MR findings and clinical correlations. *European journal of radiology* 76, 117-123.

Wakitani, S., Imoto, K., Yamamoto, T., Saito, M., Murata, N., and Yoneda, M. (2002). Human autologous culture expanded bone marrow mesenchymal cell transplantation for repair of cartilage defects in osteoarthritic knees. *Osteoarthritis and Cartilage* 10, 199-206.

Zak, L., Krusche-Mandl, I., Aldrian, S., Trattnig, S., and Marlovits, S. (2014). Clinical and MRI evaluation of medium-to long-term results after autologous osteochondral transplantation (OCT) in the knee joint. *Knee Surgery, Sports Traumatology, Arthroscopy* 22, 1288-1297.