The Knee 21 (2014) 1145–1150

Contents lists available at ScienceDirect

The Knee

Osteochondral grafting for failed knee osteochondritis dissecans repairs

Kevin R. Stone [a,b,*], Jonathan R. Pelsis [b], John V. Crues III [c], Ann W. Walgenbach [a,b], Thomas J. Turek [b]

[a] The Stone Clinic, San Francisco, CA, USA
[b] Stone Research Foundation, San Francisco, CA, USA
[c] Radnet, Los Angeles, CA, USA

ARTICLE INFO

Article history:
Received 10 October 2013
Received in revised form 1 April 2014
Accepted 9 September 2014

Keywords:
Osteoarthritis
Osteochondritis dissecans
Osteochondral paste grafting
Failed repair
Arthroscopy

ABSTRACT

Background: Revision of failed surgical treatments of osteochondritis dissecans (OCD) lesions remains a challenge without an obvious solution. The aim of this study was to evaluate seven consecutive patients undergoing osteochondral grafting of a failed OCD repair.

Methods: The mean time from surgery to the latest evaluation was 7.0 years. IKDC, WOMAC, Tegner, and MRI studies were collected both preoperatively and during follow-up. Evaluation of the graft was assessed using the magnetic resonance observation of cartilage repair tissue (MOCART) grading system.

Results: Over the course of the study period, five patients required additional surgery with a study median of one additional surgery (range, zero to 3). At most recent follow-up, there was significant improvement from preoperative values in median IKDC ($p = 0.004$), WOMAC ($p = 0.030$), and Tegner ($p = 0.012$). Complete cartilage fill and adjacent tissue integration of the paste graft were observed by MRI evaluation in five of the seven (71.4%) patients. Definitive correlation between clinical outcomes and MRI scores was not observed.

Conclusions: This study shows promising results of osteochondral grafting as a viable option for the revision of failed OCD lesion repairs; however, more patients are needed to fully support its efficacy in these challenging failed revision cases.

1. Introduction

Osteochondritis dissecans (OCD) of the knee is a debilitating disorder primarily affecting adolescents and young adults at a rate between 15 and 30 per 100,000 [1,2]. OCD is characterized by the separation of an osteochondral fragment from its surrounding bone and cartilage tissues. Fixation of the dislocated fragment is often seen as an ideal surgical solution, with the potential to recreate the natural joint surface and biomechanical properties. However, human histological studies have shown fibrous repair tissue in the subchondral cleft [3–7]. Furthermore, substantial damage to articular cartilage can occur through the use of surgical instrumentation and fixation devices. For OCD lesions that have failed to respond to previous surgical interventions, the goal should be to: i) re-establish the compromised subchondral bone; ii) restore marrow access in an injured or ischemic area; and iii) restore a protective cartilaginous cover with good integration at the border zone. Studies of the osteochondral grafting technique in rabbits have demonstrated the technique's ability to create a synergistic interaction between pluripotential cells, cartilage matrix, and viable chondrocytes [8] yielding well-integrated cartilage tissue with near-complete rebuilding of the subchondral bone [9]. Previous clinical studies by Stone et al. have shown the efficacy of articular cartilage paste grafting to accomplish these goals in Outerbridge Grades III and IV articular cartilage lesions of varying sizes and aetiologies [10,11]. To our knowledge, there has been no report specifically on the treatment of failed surgical repairs of OCD lesions using this osteochondral grafting technique. This report documents the first group of patients treated in order to expose surgeons to a new treatment option for these difficult conditions. The purpose of this study was to evaluate the effect of osteochondral grafting on previously failed surgical repair of OCD lesions with a hypothesis of resultant satisfactory healing and clinical outcomes.

2. Patients and methods

A total of seven patients, six males and one female, diagnosed with failed OCD repairs of the knee were treated by the senior author using the osteochondral graft technique between December 1997 and September 2006. Prior to surgery, patients were consented to a follow-up protocol approved by an independent Institutional Review Board. Study evaluations included the International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC) [12], Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [13], and Tegner activity index [14]. The primary study inclusion criteria included: previous diagnosis of a femoral condyle OCD lesion confirmed by independent musculoskeletal radiologist and previous failed surgical treatment of the OCD lesion. Failure was clinically defined as: clinical presentation of palpable pain and moderate to

* Corresponding author at: The Stone Clinic, San Francisco, CA, USA. Tel.: +1 415 563 3110.

http://dx.doi.org/10.1016/j.knee.2014.09.003
0968-0160/

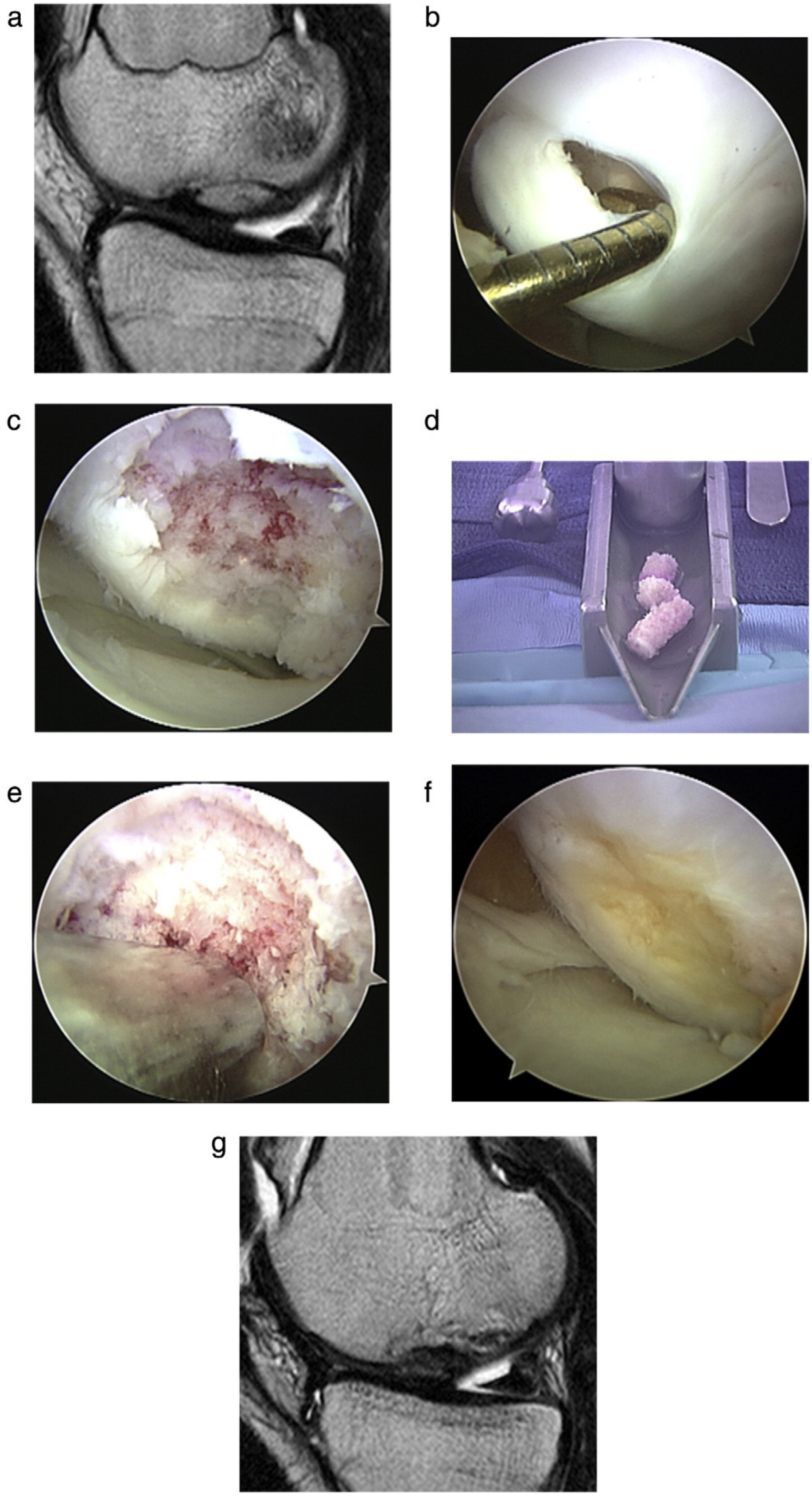

Fig. 1. a: Patient 7 was a 16-year-old student at the time of initial osteochondral grafting who had failed to respond to a fixation of an unstable OCD lesion on the MFC. Preoperative sagittal MRI image showing an unstable fragment. b: Arthroscopic image of the unstable fibrous fragment. c: Debridement of defect. d: Harvested osteochondral plugs in graft impactor. e: Paste graft impacted into morselized defect. f: Defect healing 1 year post-operatively. g: 4 year postoperative sagittal MRI image showing defect healing.

Table 1a
Patient demographics.

Patient ID	Age	Sex	Compartment	Previous procedure	Lesion size ($l \times w \times d$) (mm)	
					Preoperative	Latest MRI follow-up
1	17	M	LFC	OATS	20 × 20 × 3	0 × 0 × 0
2	20	M	MFC	Refixation	17 × 15 × 7	12 × 5 × 4
3	25	M	MFC	Refixation	24 × 18 × 17	35 × 24 × 0
4	39	M	MFC	OATS	25 × 23 × 5	13 × 13 × 1
5	34	M	MFC	Drilling	13 × 11 × 4	9 × 6 × 3
6	15	F	LFC	Drilling	15 × 14 × 6	12 × 12 × 5
7	16	M	MFC	Refixation	24 × 11 × 5	21 × 18 × 5

l = AP dimension, w = transverse dimension, and d = defect depth

severe swelling of the affected joint; difficulty ascending and/or descending stairs; and severe pain with activities reported on the IKDC and WOMAC questionnaires. Exclusion criteria included multi-compartmental or bilateral cartilage degradation.

2.1. Surgical technique and operative procedure

Osteochondral grafting was performed on all subjects using an arthroscopic technique as previously reported [23]. Any previously installed hardware was identified and removed. Unstable, degenerative failed repair tissue was removed and the defect bed was debrided back to a stable subchondral base. The exposed bone was morselized with an arthroscopic pick until bleeding occurred, creating a healing bed for the graft. An 8-mm trephine was then used to harvest 8-mm × 15-mm plugs of articular cartilage and cancellous bone from the intercondylar notch. Three to four plugs, depending on the size of the lesion, were reduced to a morselized mixture of cancellous bone and articular cartilage in a graft impactor (DePuy/Mitek, Raynam, MA) generating between 2.2 and 3.0 ml of osteochondral graft material to be impacted into the prepared defect. No effort was made to completely fill the defect as our experience has shown that the repair tissue will often hypertrophy and fill the defect. Fig. 1 shows an example of a patient treated for a failed fixation of a loose fragment.

2.2. Rehabilitation

All patients were discharged from the outpatient surgery center on the day of surgery. Patients were non-weight bearing for four weeks postoperatively and used a passive motion machine for six h daily. A hinged neoprene brace was used for support and knee protection. Deep-water workouts and stationary bike exercises were initiated immediately for the non-involved side. After two weeks, use of both legs was encouraged. Gradual return to non-impact sports was initiated after three months; however, return to impact exercises was discouraged during the initial 12 months [15].

2.3. Clinical evaluations

Subjective clinical outcomes were determined from the analysis of IKDC and WOMAC scores. IKDC scores were calculated using Anderson's method to control for over- and under-estimation of missing values [16]. Return to pre-injury sports and activities was measured using the Tegner activity index.

2.4. Magnetic resonance imaging and evaluations

The paste graft's regenerative capability was assessed objectively using magnetic resonance imaging (MRI) evaluation. Pre- and post-surgery MRIs were collected using a 1.0 Tesla magnet (ONI Medical Systems, Wilmington, MA). The following sequences were applied: i) Sagittal fast-spin-echo (FSE) proton density weighted; ii) Coronal FSE T_1 weighted; iii) Sagittal FSE T_2 weighted; iv) Sagittal FSE IR; and v) Coronal FSE IR.

MRI assessment and evaluation were performed by a single independent musculoskeletal radiologist blinded to preoperative or postoperative status of each MRI. Lesion surface area was estimated from MRI as the product of anteroposterior and transverse dimensions providing an estimate of gross lesion size. Evaluation of the graft was assessed using the MOCART MRI grading system [17] (Table 2) adapted to match the MRI studies that were collected.

2.5. Statistical analysis

Continuous variables are presented as mean ± standard deviation, categorical variables as number and percentage, and non-normally distributed variables as median and inter-quartile [IQR] range. Group-wise changes between preoperative and latest follow-up subjective test scores were compared by the Mann–Whitney test for non-parametric data samples. Correlation coefficient was calculated using least squares regression. SPSS 16.0 (SPSS, Chicago, IL) was used for calculation and significance level was set at $p = 0.05$ for all tests.

3. Results

All seven patients had initial onset of symptoms and primary diagnosis of OCD between the ages of 13 and 18 (average age: 14 years old) (Table 2). Subjects had undergone a median of three surgeries (range, one to three) to treat the OCD lesions, with failed surgical interventions lasting an average of 2.1 years (range, 4 months–7.3 years) before the osteochondral graft procedure was performed. The mean age of the patients at the time of osteochondral grafting was 24 years (range, 15 to 39 years). The lesions were in the medial femoral condyle in five cases and lateral femoral condyle in two cases (Tables 1a, 1b). The mean follow-up time was 7.0 ± 3.6 years (range, 2.0 to 13.0 years) post-surgery.

The average preoperative lesion size was estimated at 326 ± 150 mm^2 (range, 143–575 mm^2). Average lesion depth was estimated at seven ± five mm (range, 3–17 mm). Average lesion size estimate from most recent MRI was 235 ± 294 mm^2 (range, 0–840 mm^2) and the average depth was three ± two mm (range, 0–5 mm). Over the course of the study period, five patients required additional surgery with a study median of one additional surgery (range, zero to three) (Table 3). Two patients experienced traumatic

Table 1b
MOCART, IKDC, WOMAC, and Tegner scores at most recent follow-up[a].

Patient ID	Age	Years post-op	MOCART										IKDC	WOMAC	Tegner
			1	2	3	4	5	6	7	8	9	TOTAL			
1	17	3.1	20	15	10	5	15	5	0	5	5	80	83.9	0	6
2	20	6.5	20	15	10	5	15	0	0	5	5	75	41.4	30	10
3	25	10.3	5	10	0	0	15	0	0	5	0	35	100.0	0	10
4	39	13.0	15	10	5	5	15	5	0	5	5	65	56.3	0	5
5	34	4.7	20	15	10	0	15	5	0	5	5	75	54.0	25	4
6	15	8.1	20	15	5	0	15	5	0	5	5	70	60.9	11	4
7	16	3.8	20	15	5	5	15	5	0	5	5	75	98.9	0	7

IKDC, International Knee Documentation Committee Subjective Knee Form.
WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a] MOCART, Magnetic resonance observation of cartilage repaired tissue.

events and were regrafted. The donor site in the intercondylar notch was observed to fill with normal repair tissue and no donor site morbidity was observed.

3.1. Clinical outcomes

There was a significant improvement from median preoperative IKDC score of 39.0 points (IQR, 33.0–39.9) to a median score of 60.9 points (IQR, 55.2–91.4, $p = 0.004$) at most recent follow-up (Fig. 2a). Median WOMAC score improved significantly from a median preoperative value of 32.1 points (IQR, 17.1–51.8) to a median score of 0.0 points (IQR, 0.0–18.0, $p = 0.030$) at most recent follow-up (Fig. 2b). Raw Tegner score improved as well from a preoperative median score of 2.0 (IQR, 2.0–2.8) to 6.0 (IQR, 4.8–8.5, $p = 0.012$) at most recent follow-up (Fig. 2c).

3.2. MRI assessments

Examination of preoperative MRI consistently revealed basal bone marrow oedema and highly irregular cartilage surface. At the latest MRI evaluation (Tables 1a, 1b), complete cartilage fill was seen in five/seven (71.4%) of patients. In the same five patients, there was complete integration of the osteochondral graft with the adjacent tissue. The remaining two patients showed incomplete integration. An intact surface of the graft was observed in three/seven patients (42.9%), while an additional 42.9% showed damage to the surface of <50% of the repair depth. Damage to the surface of the repair tissue >50% was observed in only one patient. The structure of the repair tissue was homogenous in four/seven patients (57.1%). The signal intensity of the repair tissue was iso-intense with the adjacent cartilage in all patients. The subchondral lamina was intact in 71.4% of the patients: however, subchondral bone changes, including increased thickness, density, and irregularity, were noted in all patients. There were no signs of adhesions in any of the patients and only one patient was notable for occasional synovitis. Correlation coefficients of MOCART score with IKDC, WOMAC, and Tegner scores of 0.43, 0.35, and 0.47 respectively.

Table 2
Magnetic resonance observation of cartilage repaired tissue (MOCART).

Variables	Point scale
(1) Degree of repair and filling of the defect	
Complete (on a level with adjacent cartilage)	20
Hypertrophy (over the level of the adjacent cartilage)	15
Incomplete (under the level of the adjacent cartilage; underfilling)	
>50% of the adjacent cartilage	10
<50% of the adjacent cartilage	5
Subchondral bone exposed	0
(Complete delamination/dislocation and/or loose body)	
(2) Integration to border zone	
Complete (complete integration with adjacent cartilage)	15
Incomplete (incomplete integration with adjacent cartilage)	10
Demarcating border visible (split-like)	10
Defect visible	
<50% of the length of the repaired tissue	5
>50% of the length of the repaired tissue	0
(3) Surface of the repair tissue	
Surface intact (lamina splendens intact)	10
Surface damaged (fibrillations, fissures and ulcerations)	
<50% of repair tissue depth	5
>50% of repair tissue depth or total degeneration	0
(4) Structure of the repair tissue	
Homogeneous	5
Inhomogeneous or cleft formation	0
*(5) Signal intensity of the repair tissue**	
T2 FSE	
Isointense	15
Moderately hyperintense	5
Markedly hyperintense	0
(6) Subchondral lamina	
Intact	5
Not intact	0
(7) Subchondral bone	
Intact	5
Edema, granulation tissue, cysts, sclerosis	0
(8) Adhesions	
No	5
Yes	0
(9) Synovitis	
No	5
Yes	0

*This parameter was altered to reflect the studies that were collected.

4. Discussion

In this initial group of patients, osteochondral grafting is a reasonable option for the revision of failed OCD repairs of the femoral condyle, with 100% follow-up at an average of 7.0 years (range 2.0 years to 13.0 years). All subjective outcome scores, showed significant improvement at a mean follow-up of 7.0 years as compared to baseline.

Studies have suggested that large osteochondral lesions including osteochondritis dissecans may be a form of subchondral bone disease

Table 3
Full list of osteochondral repair procedures performed.

Patient ID	Age (years)	Procedure performed*	Indication for surgery**
1	13.9	Chondral drilling	
	14.8	Chondral drilling	
	16.0	OATS	
	16.6	Loose body removal	
	16.8	**Primary osteochondral grafting**	
	17.0	Chondroplasty & debridement	Hypertrophy
	19.2	Chondroplasty & debridement	Hypertrophy
2	15.6	Chondral drilling	
	17.0	Fixation (resorbable screws)	
	17.9	Fixation (cannulated screws)	
	18.1	Cannulated screw removal	
	20.6	**Primary osteochondral grafting**	
	22.0	Loose body removal	Loose body
3	18.2	Fixation (Herbert screws)	
	20.7	Tightening of Herbert screws	
	25.4	Herbert screw removal	
	25.5	**Primary osteochondral grafting**	
	26.1	Partial revision paste graft	Incomplete healing
	33.3	Microfracture & debridement	Incomplete healing
4	19.4	Loose body removal	
	26.4	Loose body removal	
	39.2	OATS with fixation using polylactide screws	
	39.8	**Primary osteochondral grafting**	
	41.0	Chondroplasty & debridement	Incomplete healing, trauma
	48.7	Revision paste graft	Repeat trauma
	53.0	Chondroplasty & debridement, removal of loose bodies	Loose body
5	18.9	Chondral drilling	
	21.9	Microfracture to OCD lesion	
	32.9	Microfracture to OCD lesion	
	34.6	**Primary osteochondral grafting**	
6	14.9	Lateral menisectomy, chondral drilling to OCD lesion	
	15.9	**Primary osteochondral grafting**, lateral meniscus allograft	
	16.9	Chondroplasty & debridement, lateral meniscal repair	Trauma
	19.2	Revision paste graft, revision lateral meniscus allograft	Repeat trauma
	19.4	Revision paste graft, revision lateral meniscus allograft	Repeat trauma
7	16.5	Fixation with chondral darts	
	16.9	**Primary articular cartilage paste graft**	

*Procedures in which the OCD lesion was addressed are listed.
**Surgical indication is listed for any surgical procedure occurring after primary osteochondral grafting.

originating from bone necrosis or subchondral fracture [3,18]. The articular cartilage paste grafting technique creates a fracture through the subchondral bone and the lesion is then filled with a matrix of cartilage and bone cells [11]. During the healing process of these large lesions, hypertrophy (n = one) or incomplete healing (n = seven) of the repair tissue required further surgical intervention. Independent of the number of surgeries required to fully treat the lesion, subjective outcome measures showed significant improvements. It has been hypothesized that morselization allows mesenchymal stem cells and growth factors from the bone marrow to migrate to the repair site [19]. This hypothesis has been supported by Xing et al. in a rabbit study showing greater DNA, glycosaminoglycan (GAG), and DNA-normalized GAG content in repair tissue generated from paste graft as compared to microfracture [8].

MRI has been shown to be an effective, noninvasive diagnostic and follow-up tool in patients with large osteochondral defects [20–22]. Evaluation of both preoperative and postoperative MRI images using the MOCART scoring system evaluates the lesion in terms of surface area, volumetric size, integration, and pathological changes. Sequential imaging allows for analysis for both articular cartilage repair and the remodeling of the underlying bone. In this study, MRI scores and subjective outcomes scores were fairly discordant. The lack of correlation between MRI evaluation and clinical findings has been reported in other published studies [23,24]. With the small sample size and statistical power of this case series, this outcome is not unexpected. An MRI unit with higher field strength may allow for more precise visualization of the repair tissue. Independent of the MOCART score at most recent follow-up, patients consistently reported decreased pain, with improvements in function and activity level as compared to preoperative levels. In a report on five different surgical techniques to treat osteochondritis dissecans, Kon et al. reported positive results on 10 patients undergoing this osteochondral grafting technique with an average of 3.8 years of follow-up [25]. Our results are comparable and extend further into the postoperative period, suggesting that the positive early to mid-term results are sustained through the medium-term postoperative period.

The major limitations of this report are the small sample size and evaluation of a single treatment without control groups. Due to the rare nature of this disorder and inclusion limited to previously failed surgical treatment, it is difficult to create a large study population in a single center and this report is meant to stimulate a larger study amongst other centers. While there are reports of cartilage repair procedures in primary OCD lesions, we are unaware of any reports on a viable surgical option for the treatment of failed OCD lesions. In primary repair cases, instrumented fixation of stable fragments has shown to be problematic, with fixation metal screws requiring healthy and stable underlying bone and secondary surgery for removal [26,27]. Bioabsorbable screws and pins having the same primary fixation limitations have been noted to fail [28,29]. Furthermore, excision of the bony fragment has shown poor long-term results, leaving large volume defects without cartilage cover [30]. Alternately, the paste graft was effective as a revision technique of failed hardware fixation in large volume defects cases.

Osteochondral grafting, unlike autologous cartilage implantation, mosaicplasty, and osteochondral grafting techniques, can be performed without laboratory cell culture, customized instrumentation, fixation, or hardware. The long-term efficacy of the osteochondral grafting

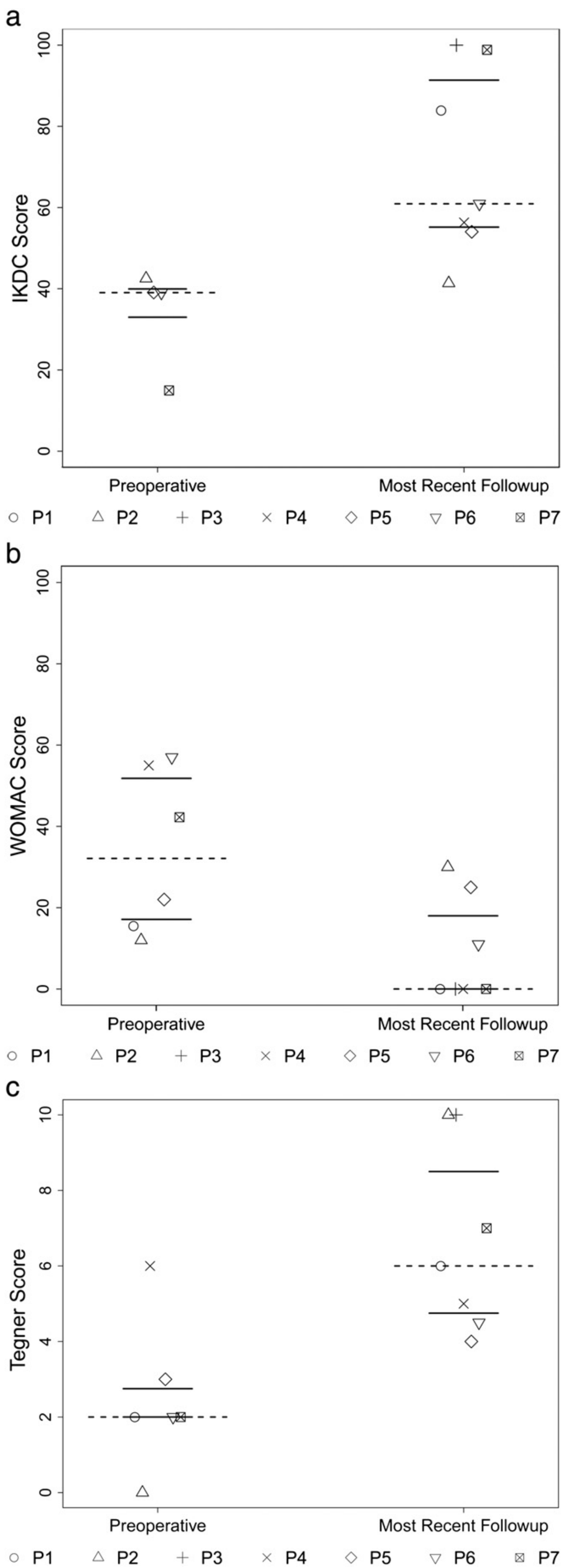

Fig. 2. a: This chart shows preoperative and most recent follow-up values for IKDC scores. Patients are represented individually as symbols. Median values are noted as a dashed horizontal line and interquartile values as solid horizontal lines. The change in median score from preoperative to most recent follow-up was significant for IKDC (39.0 to 60.9, $p = 0.004$) scores. b: This chart shows preoperative and most recent follow-up values for WOMAC scores. Patients are represented individually as symbols. Median values are noted as a dashed horizontal line and interquartile values as solid horizontal lines. The change in median score from preoperative to most recent follow-up was significant for WOMAC (32.1 to 0.0, $p = 0.030$) scores. c: This chart shows preoperative and most recent follow-up values for Tegner scores. Patients are represented individually as symbols. Median values are noted as a dashed horizontal line and interquartile values as solid horizontal lines. The change in median score from preoperative to most recent follow-up was significant for Tegner (2.0 to 6.0, $p = 0.012$) scores.

technique has previously been demonstrated in arthritic knees [11] and expanded utility for cartilage revision cases is considered in this report. At an average of seven years following osteochondral grafting, patient median pain, activity, and function levels showed significant improvement as compared to preoperative levels. This study shows promising results of osteochondral grafting for the revision of failed OCD lesion repairs; however, more patients are needed to fully support its efficacy in these challenging failed revision cases.

Conflict of interest statement

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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