

The use of articular cartilage paste graft in massive articular cartilage defects of the femoral condyle

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Objectives

Large osteochondral lesions can be extremely debilitating because of the body's inability to repair this tissue. Treatment of such defects can be challenging and various surgical techniques have been reported in the literature including drilling; marrow stimulation; internal fixation; fragment or loose body removal; and chondral resurfacing techniques. No consensus has been reached as to the best treatment option. The goal of both primary and salvage repair should be to re-establish the compromised subchondral bone, restore access to marrow in an injured or ischemic area, and to restore a protective cover of fibrocartilage and/or hyaline cartilage with good integration at the border zone. Should the primary effort at repair fail, an ideal salvage treatment would be minimally destructive thereby allowing for further efforts at repair. Articular cartilage paste grafting has been previously reported by the senior author for primary treatment of large Outerbridge Grade III and IV articular cartilage lesions^{1,2}. We report the outcomes in nine patients undergoing articular cartilage paste grafting for primary and salvage treatment of massive articular cartilage defects with a mean preoperative defect size of 352-mm² and mean defect depth of 7-mm.

Methods

Nine patients diagnosed with large, full-thickness articular cartilage lesions of the knee were treated by the senior author (KRS) using the articular cartilage paste graft technique. Prior to surgery, patients underwent an informed consent process as approved by an independent Institutional Review Board. Patients who had undergone articular cartilage paste grafting to a large (>100-mm² surface area), full-thickness osteochondral lesion of the femoral condyle were included. Mean follow-up was 7.5 ± 2.4 years (range 3.5 to 10.5 years). Patients were evaluated using MRI and validated subjective assessments of pain, activity, and function preoperatively and over the course of follow-up. Lesion surface area and volume were estimated from MRI measurements. Lesion surface area was estimated from the product of anteroposterior and transverse dimensions. Lesion volume was estimated from the product of anteroposterior, transverse, and depth dimensions.

The subjective clinical outcome was 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 values³. Patients' return to pre-injury sports and activities was measured using the Tegner score. A patient's Tegner Index was calculated based on their pre-injury Tegner level at each follow-up⁴.

MRI assessment and evaluation was performed by an independent musculoskeletal radiologist. Evaluation of the graft was assessed MRI grading scales proposed by Mintz⁵, Nho⁶, Peterson⁷, and the ICRS⁸.

Continuous variables are presented as mean ± standard deviation and discrete variables as median and interquartile [IQR] range. Preoperative and latest follow-up subjective test scores were compared by the Mann-Whitney test for non-parametric data. Significance level was set at $p = 0.05$.

Results

Average age at time of surgery was 29.7 (range 17 – 50 yrs). Six patients were male, 3 were female. Six of nine patients underwent previous surgical intervention for treatment of massive osteochondral defects on their femoral condyle (Table I). Average number of previous surgeries for these six patients was 3 (range 1 – 4). Previous surgical attempts lasted an average of 56 months (range 7 – 188 months) before articular cartilage paste grafting was performed. Seven patients had been previously diagnosed with OCD and reported

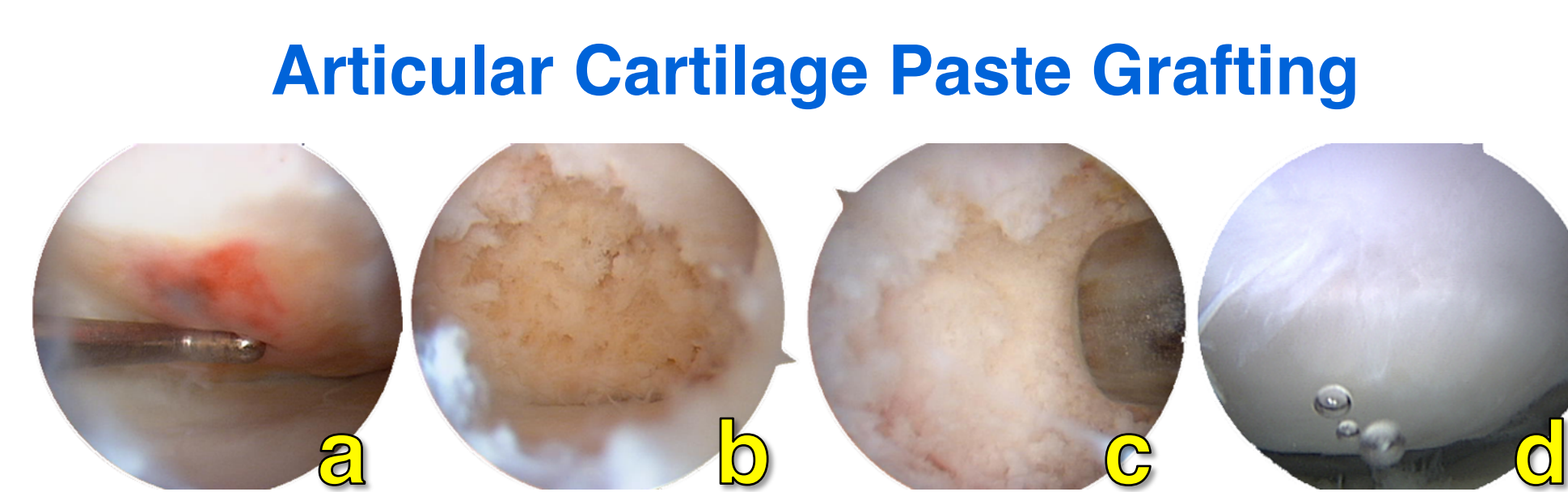


Figure 1. (a) Femoral condyle showing an osteochondral defect with a red fibrous covering. (b) The area is debrided and extensive microfracture of the base is carried out. (c) The paste graft is packed into the defect. (d) 28 months after articular cartilage paste grafting.

knee pain and symptoms beginning between the ages of 13 and 18. The remaining two patients suffered an acute injury while playing sports causing a focal osteochondral lesion. Average lesion surface area was estimated at 352 ± 16-mm² (range 143 – 600-mm²). Mean surface area MRI measurement improved from baseline of 352-mm² to 71-mm² ($p = 0.001$) at most recent follow-up. Average lesion volume was estimated at an average of 2559 ± 2178-mm³ (range 572 – 7344 mm³). There was a significant improvement in mean lesion volume from baseline MRI measurement of 2559-mm³ to 200-mm³ ($p = 0.015$) at most recent follow-up. Figure 1 shows the treatment and healing response representative of the aggregate patient population. The filled lesion will often hypertrophy, and unfortunately sometimes requires further surgical intervention. Six of the nine (66.7%) cases in this study required an average of 1.8 (range 1 – 3) additional surgeries to treat hypertrophy of repair tissue.

Patient Summary Data (N = 9)

Lesion Site	N	Mean (SD)
Medial Condyle	7	
Lateral Condyle	2	
Previous Surgeries		
OATS	2	
Refixation	2	
Microfracture	1	
Drilling	1	
None	3	
Defect Surface Area (mm²)		
Pre-Op		352 (162)
Most Recent Follow-Up		71 (81)
Defect Volume (mm³)		
Pre-Op		2559 (2178)
Most Recent Follow-Up		200 (279)

Table I. Patient Summary Data. Continuous variables are presented as mean ± standard deviation; discrete variables are presented as number and percentage. Abbreviations – OATS: Osteoarticular Transfer System

Evaluations of most recent MRI images are summarized in Table II. Of particular note, surface area and volumetric cartilage fill were each rated *Good* in seven of the nine cases. ICRS volumetric and surface area repair grade was II in all cases. This corresponds to a “nearly normal” cartilage appearance.

Multiple Score Evaluation at most recent follow-up

Nho et al.	N (%)	ICRS - Area	N (%)	Median (IQR)
Defect Appearance		Degree of Defect Repair Area Score		
Defect	5 (55.6)	4	3 (33.3)	
Flush	3 (33.3)	3	3 (33.3)	
Proud	1 (11.1)	2	1 (11.1)	
Subchondral Edema		1	2 (22.2)	
None	0 (0.0)	0	0 (0.0)	
Mild	5 (55.6)	Integration to Border Zone		
Moderate	3 (33.3)	4	7 (77.8)	
Severe	1 (11.1)	3	1 (11.1)	
Signal Intensity of Repaired Cartilage		2	0 (0.0)	
Hypointense	0 (0.0)	1	0 (0.0)	
Isointense	4 (44.4)	0	1 (11.1)	
Hyperintense	5 (55.6)	Surface Appearance		
Interface		4	0 (0.0)	
Smooth	7 (77.8)	3	4 (44.4)	
Fissure <2mm	0 (0.0)	2	2 (22.2)	
Fissure >2mm	2 (22.2)	1	2 (22.2)	
Interface Signal		0	1 (11.1)	
Hypointense	0 (0.0)	Total Repair Score	9 (IQR: 8 - 11)	
Isointense	7 (77.8)	Overall Repair Grade	2 (IQR: 2 - 2)	
Hyperintense	2 (22.2)	I	0 (0.0)	
Cartilage Fill (Area)		II	7 (77.8)	
Good	7 (77.8)	III	1 (11.1)	
Moderate	1 (11.1)	IV	1 (11.1)	
Poor	1 (11.1)	ICRS - Volume		
Cartilage Fill (Volume)		Degree of Defect Repair Volume Score		
Good	7 (77.8)	4	3 (33.3)	
Moderate	2 (22.2)	3	4 (44.4)	
Poor	0 (0.0)	2	1 (11.1)	
ICRS Adjacent Cartilage		1	1 (11.1)	
Normal	5 (55.6)	0	0 (0.0)	
Grade 1	3 (33.3)	Integration to Border Zone		
Grade 2	1 (11.1)	4	7 (77.8)	
Grade 3	0 (0.0)	3	1 (11.1)	
Grade 4	0 (0.0)	2	0 (0.0)	
ICRS Opposite Cartilage		1	1 (11.1)	
Normal	9 (100.0)	0	0 (0.0)	
Grade 1	0 (0.0)	Surface Appearance		
Grade 2	0 (0.0)	4	0 (0.0)	
Grade 3	0 (0.0)	3	4 (44.4)	
Grade 4	0 (0.0)	2	2 (22.2)	
		1	2 (22.2)	
		0	1 (11.1)	
Peterson et al.		Total Repair Score	9 (IQR: 8 - 11)	
Bony Overgrowth		Overall Repair Grade	2 (IQR: 2 - 2)	
No	9 (100.0)	I	0 (0.0)	
Yes	0 (0.0)	II	7 (77.8)	
Subchondral Edema		III	1 (11.1)	
No	5 (55.6)	IV	1 (11.1)	
Yes	4 (44.4)	Cartilage-like Repair Tissue		
		No	0 (0.0)	
		Yes	9 (100.0)	
Mintz et al.				
Normal	0 (0.0)			
Grade 1	1 (11.1)			
Grade 2	4 (44.4)			
Grade 3	3 (33.3)			
Grade 4	0 (0.0)			
Grade 5	1 (11.1)			

Table II. Evaluation of most recent MRI images using cartilage evaluation methods proposed by Nho, Peterson, Mintz, and ICERS. Continuous variables are presented as mean ± standard deviation; discrete variables are presented as number and percentage.

There was a significant improvement from median preoperative IKDC score of 39.1 points (IQR 28.5 – 52.3) to 83.9 points (IQR 57.5 – 96.0, $p = 0.009$) at most recent follow-up (Figure 2). Median WOMAC score improved significantly from a preoperative value of 22.0 points (IQR 12.0 – 57.0) to 1.0 points (IQR 0.0 – 18.0, $p = 0.012$) at most recent follow-up. Raw Tegner score improved as well from a preoperative median score of 2.0 (IQR: 0.3 – 5.3) to 6.0 (IQR: 4.8 – 9.0, $p = 0.016$) at most recent follow-up. Tegner Index Ratio improved significantly from a median preoperative value of 0.300 (IQR 0.031 – 0.857) to 0.857 (IQR 0.691 – 1.000, $p = 0.033$) at most recent follow-up. Figure 2 shows comparison of median subjective outcome measure scores and their corresponding IQRs at baseline and most recent follow-up.

Subjective Outcome Measures

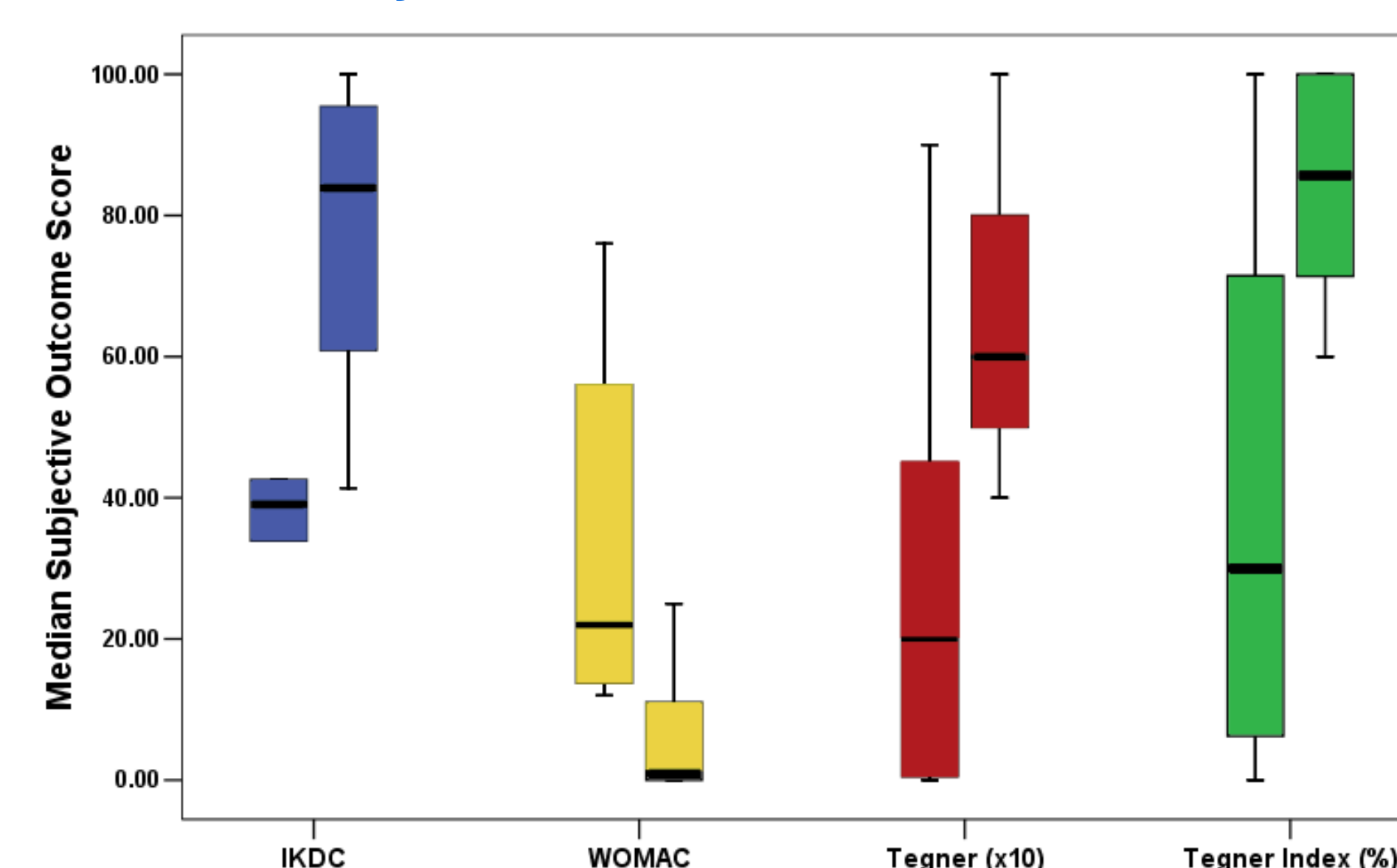


Figure 2. Patients showed significant improvements in IKDC (blue, $p = 0.009$), WOMAC (yellow, $p = 0.012$), Tegner (red, $p = 0.016$), and Tegner Index ($p = 0.033$) at most recent follow-up as compared to baseline. Boxes represent IQRs and bars represent ranges.

Conclusions

Left untreated, large osteochondral lesions can lead to massive defects and present a formidable challenge to manage surgically. Furthermore, if primary repair fails, few options exist for salvage of the articular surface. This study shows that articular cartilage paste grafting is a promising technique for the treatment of 9 massive osteochondral defects of the femoral condyle, with 100% follow-up at an average of 7.5 years (range 3.5 years to 10.5 years). Widely adopted grading scales for large osteochondral lesions, such as the one developed by the ICERS, are suited primarily for use during arthroscopy and are based primarily on the condition of the overlying articular cartilage. MRI has been shown to be an effective, noninvasive diagnostic and follow-up tool in patients with large combined cartilage-bone defects^{9,10,11}. Evaluation of both preoperative and postoperative MRI images using a selection of grading scales collectively evaluates the lesion in terms of surface area, volumetric size, integration and pathological changes. During the postoperative healing phase, this method of MRI grading accounts for both the repair of the articular cartilage and the remodeling of the underlying bone. This study supports the use of articular cartilage paste grafting for primary and salvage treatment of massive femoral condyle lesions resulting in regenerate articular cartilage surface and subchondral bone.

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