Short-Term Patient-Reported Outcomes After Osteochondral Allograft Combined With Concomitant Knee Procedures Predict Mid- and Long-Term Outcomes

Andrew S. Bi, M.D., Chloe H. Franzia, B.S., Yusuf N. Mufti, B.S., Jared P. Sachs, M.S., and Brian J. Cole, M.D., M.B.A.

Purpose: To determine whether short-term patient-reported outcomes (PROs) after primary osteochondral allograft (OCA) of the knee correlate with mid- and long-term PROs at a minimum 5-year follow-up. **Methods:** A retrospective review of a prospectively maintained database of patients who underwent single or multifocal plug OCA in 2001-2019 was performed. Inclusion criteria included patients with preoperative, 2-year, and minimum 5-year postoperative PROs. Exclusion criteria included cases of revision OCA and a pre-existing diagnosis of inflammatory arthritis. PROs assessed included International Knee Documentation Committee (IKDC) score, all subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS), and Lysholm score. Mid-term PROs were defined as 5-10 years, and long-term PROs as ≥10 years. **Results:** A total of 77 patients (mean age 31.1 ± 9.2 years, 55.8% female) met inclusion criteria. Mean follow-up was 8.9 ± 3.4 years (range, 4.8—17.2). Sixty-six (85.7%) patients underwent a concomitant procedure. Two-year PROs significantly correlated with midterm (5-10 years) improvements: IKDC (P = .0050), KOOS Pain (P = .0132), KOOS Symptoms (P = .0001), KOOS ADL (P = .0058), KOOS Sport (P = .0037), KOOS QOL (P = .0024), and Lysholm (P = .0233). In addition, 2-year PROs were significantly correlated with long-term (≥10 years) improvements: IKDC ($P \leq$ .0001), KOOS Pain (P = .0046), KOOS Symptoms P = .0025), KOOS ADL ($P \leq$. 0001), KOOS Sport (P = .0052), KOOS QOL P = .0039), and Lysholm (P = .0145). MCID achievement ranged from 57.4% to 85.9% at short-term follow-up, 42.9% to 77.4% at midterm follow-up, and 45.0% to 89.5% at long-term follow-up. In total, 13 patients (16.8%) had any subsequent reoperation on the same knee, none of which included revision OCA or arthroplasty. **Conclusions:** Two-year improvements in PROs following primary OCA are predictive of sustained mid- and long-term improvements, with significant correlations between 2-year outcomes and those at 5-10 years and ≥10 years. **Level of Evidence:** Level IV, retrospective case series.

Osteochondral allograft (OCA) transplantation provides both a structural and biologic solution to large focal chondral or osteochondral defects in the knee.[1] In the absence of diffuse osteoarthritic changes and coronal mechanical malalignment, OCAs provide long-term pain relief, improvement in patient-reported outcomes (PROs), graft survivorship, and relatively predictable return to sport.[2,3] Multiple studies have reported sustained clinical improvements and graft survivorship upwards of 15 to 20 years.[2,4,5] As increasing numbers of OCAs are being performed, it is important to identify which patients will be more likely to have successful outcomes.

Several demographic factors have been investigated as outcome predictors after OCA. Age older than 40 years serves as a negative predictive factor for the success of OCA, with studies reporting lower rates of achievement in older patients of statistically and clinically significant PROs and survivorship.[5-7] Increased body mass index (BMI) is also a predictive factor for poor outcomes.[5,8] Graft and intraoperative factors also affect OCA outcomes; clinical and preclinical translational studies show that grafts stored longer than 28 days have greater failure rates.[8,9] Donor-recipient

From Rush University Medical Center, Chicago, Illinois, U.S.A.
Received December 13, 2024; accepted March 24, 2025.
Address correspondence to Brian J. Cole, M.D., M.B.A., Midwest Orthopaedics at Rush University Medical Center, 1611 W. Harrison St., Suite 300, Chicago, IL 60612, U.S.A. E-mail: brian.cole@rushortho.com

0749-8063/242088
https://doi.org/10.1016/j.arthro.2025.03.063

sex and size graft mismatch is suggested to lead to increased failure rates, although size matched opposing condyles can be used safely.[10-15]

In addition to the ability to predict postoperative outcomes for OCAs on the basis of preoperative or intraoperative/donor graft parameters, the ability to predict whether patients will maintain improved clinical outcomes on the basis of short-term follow-up PROs is an important prognosticator. The ability to counsel patients postoperatively at short-term follow-up on their long-term prognosis provides valuable information for patient care, as well as the treating surgeon to identify patients who may require more frequent or longer follow-up on the basis of poor short-term improvements. Several studies in the hip arthroscopy literature report that patients who achieved greater improvements in PROs at short-term follow-up (6 months to 2 years) were predictive of maintaining improved PROs, achieving clinically significant improvements and survivorship at longer-term follow-up (2-10 years).[16-18] Currently, there is a lack of such studies in the OCA literature. The purpose of our study was to determine whether short-term PROs after primary OCA of the knee correlate with mid- and long-term PROs at a minimum 5-year follow-up. We hypothesized that there would be a significant relationship between PROs at or before 2 years and greater than 5 year PROs, and achievement of clinical significance as measured by minimal clinically important difference (MCID).

Methods

Study Design and Patient Inclusion

We conducted a retrospective review of a prospectively maintained database of all patients who underwent single or multifocal plug OCA of the knee performed by the senior author (B.J.C.) for the treatment of focal chondral or osteochondral defects in the medial femoral condyle (MFC), lateral femoral condyle (LFC), patella, or trochlea, between the years of 2001 and 2019. Of note, patients in this database have been reported on in other investigations.[6,19-23] This study met ethical standards and underwent institutional review board approval (ORA #24070703-IRB01; FWA #00000482). Inclusion criteria were all patients who underwent OCA with availability of PROs at preoperative baseline, short-term postoperative 2-year follow-up or less, and a minimum of 5-year follow-up, with or without concomitant procedures. Exclusion criteria were revision OCA (for primary analysis, no patients who underwent primary OCA with preoperative, 2-year, and at least 5-year follow-up that eventually underwent revision OCA were excluded from this study) and a pre-existing diagnosis of inflammatory arthritis.

Patient Demographics and Surgical Characteristics

Demographic variables including age, sex, race/ethnicity, and BMI were recorded. Intraoperative variables of interest, such as laterality, number of plugs, and the compartment of OCA (MFC, LFC, patella, or trochlea) also were recorded. In addition, concomitant procedures such as meniscal allograft transplant (medial or lateral), osteotomy (distal femoral, high tibial, or tibial tuberosity), microfracture, articular cartilage debridement, hardware removal, anterior cruciate ligament reconstruction, autologous chondrocyte implantation, or meniscectomy were recorded. Subsequent knee surgeries were also recorded.

Patient-Reported Outcomes

PROs of interest included the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Score, Lysholm score, and all Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales: pain, symptoms, activities of daily living, sport, and quality of life (QOL). Patients were separated into cohorts on the basis of the date of their follow-up; midterm follow-up defined as 5 to less than 10 years, and long-term follow-up defined as greater than or equal to 10 years. Outcome improvement, defined as improvement from preoperative baseline scores, was evaluated at each time point.

Statistical Analysis

Continuous variables are presented as means and standard deviation, and categorical variables are presented as frequencies and percentages. In addition, the MCID for all PROs of interest was determined at each postoperative time point using a distribution-based method. The MCID was calculated as half the standard deviation of the mean change in outcome scores from baseline, following established guidelines in the literature.[24] The MCID thresholds at 2-year follow-up were 10.1 for IKDC, 9.9 for KOOS pain, 9.9 for KOOS symptoms, 9.4 for KOOS activities of daily living, 16.4 for KOOS Sport, 12.6 for KOOS QOL, and 9.8 for Lysholm. Achievement of MCID at 2-year, 5-10 year, and $\geq$10 years was recorded. Linear regression was used to correlate continuous demographic and intraoperative variables with short-term improvements in IKDC. Logistic regression was used to correlate any categorical demographic and intraoperative variables with short-term improvements in IKDC. The χ^2 and 2-tailed Student paired *t* test were used to compare differences in demographic and intraoperative variables between the 5-10 and $\geq$10 year follow-up groups. The Student paired *t* test used to compare differences in all PROs preoperatively, at 2 years, 5-10 years, and $\geq$10 years follow-up. Linear regression was used to assess for correlations between improvement at 2 years to improvement at either 5-10 years or $\geq$10-year follow-

ARTICLE IN PRESS

up. For linear regression, we interpreted correlation coefficients of 0.00-0.19 as very weak, 0.20-0.39 as weak, 0.40-0.59 as moderate, 0.60-0.79 as strong, and 0.80-1.00 as a very strong correlation.[25,26] Statistical analysis was performed using RStudio, version 2024.04.2 Build 764 (RStudio, Boston, MA) and Microsoft Excel Version 2308 (Microsoft Corp, Redmond, WA). We performed post-hoc power analysis in G*Power (Version 3.1.9.7, University of Düsseldorf, Düsseldorf, Germany).

Results

Patient Demographics and Concomitant Procedures

Our study cohort included 192 patients who had both preoperative and 2-year postoperative PROs. Of this cohort, 77 patients had PROs at a minimum of 5 years. 43 (56%) patients had PROs available at 5-10 years, and 34 (44%) patients had PROs available at 10 years or beyond. There were no patients who had PROs at both 5-10 years and ≥10 years (Fig 1).

There were 77 patients who met all inclusion criteria. Forty-three (55.8%) patients were female, and 34 (44.2%) patients were male with an average BMI of 26.3 ± 3.8 (range, 18.46 − 36.15) and an average age of 31.1 ± 9.2 (range, 15-49.1) years. In total, 71 (92.2%) patients were White, 3 (3.90%) patients were Hispanic, 1 (1.30%) patient was Black/African American, 1 (1.30%) patient was Asian, and 1 patient had no race/ethnicity data reported. The average time to most recent follow-up in the entire cohort was 8.9 ± 3.4 years. The average time to most recent follow-up in the midterm follow-up cohort was 6.6 ± 1.7 years and 12.1 ± 2.6 years in the long-term follow-up cohort.34 patients (44.2%) had grafts in the MFC alone, 35 (45.5%) in the LFC, and 2 (2.6%) in the trochlea. Five (6.5%) patients received grafts in separate compartments during their procedure. The average area of the treated cartilage defect was 318 ± 146 mm^2.

There was no significant association between short term increase in IKDC with any demographic variables (Table 1). We found a significant positive correlation between cartilage defect size and short-term increase in IKDC. Repeating this analysis for the other PROs, we found a similar relationship with defect size and short-term increase in Lysholm (P = .020), but we did not find any relationship with any of the KOOS subscores (P > .05). A total of 66 (85.7%) patients underwent a concomitant procedure at time of surgery, including 45 (58.4%) meniscal allograft transplants (medial or lateral), 15 (19.5%) osteotomies (distal femoral, high tibial, or tibial tuberosity), 11 (14.3%) microfractures, 6 (7.8%) articular cartilage debridements, 4 (5.2%) hardware removals, 2 (2.6%) ACL reconstructions, 1 (1.3%) trochlear autologous chondrocyte implantation, and 1 (1.3%) lateral meniscectomy. There was no significant association between short-term increase in IKDC with the presence of any concomitant procedure (Table 1).

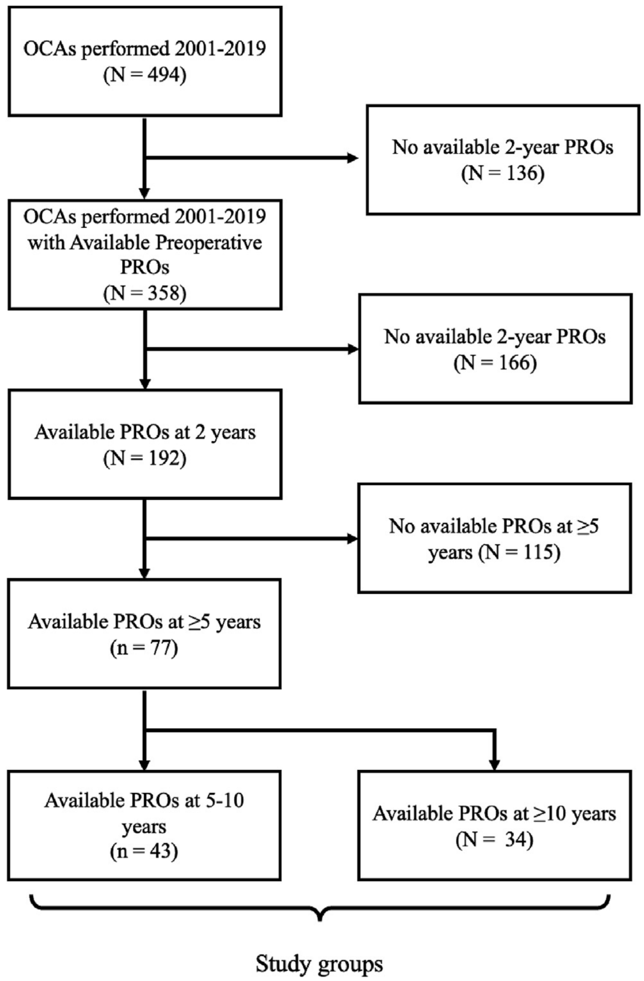

Fig 1. Flow diagram for study population. During the study period, 494 osteochondral allograft transplantations (OCAs) were performed. In total, 358 patients had available preoperative patient-reported outcomes (PROs), and 192 of these patients had 2-year postoperative PROs. Of the 192 patients who had both preoperative and 2-year postoperative PROs, 77 had PROs at a minimum of 5 years (follow-up). A total of 43 patients had PROs available at 5-10 years and 34 patients had PROs available at 10 years or beyond. There were no patients who were included in both groups.

Patient-Reported Outcomes

For all PROs, there was a significant increase in scores from baseline to 2-year follow-up. The percentage of patients who achieved MCID at short-term follow-up ranged from 57.4% for IKDC to 85.9% for KOOS Pain (Table 2). MCID was calculated to be 10.1 for IKDC, 9.8 for Lysholm, and 9.4-

Table 1. Baseline Demographic and Intraoperative Characteristics of Cohort and Correlation With Short-Term Improvements in International Knee Documentation Committee (IKDC) Scores

Characteristic	Total (N = 77)	*P* Value	5-10 yr (N = 43)	≥10 yr (N = 34)	*P* Value
Age	31.1 ± 9.2	0.860*	30.3 ± 8.9	32.1 ± 9.5	0.385‡
BMI	26.3 ± 3.8	0.133*	26.4 ± 3.9	26.2 ± 3.7	0.821‡
Sex		0.239†			0.640§
Female	34 (44.2%)		20 (46.5%)	14 (41.2%)	
Male	43 (55.8%)		23 (53.5%)	20 (58.8%)	
Race/Ethnicity‖		0.568†			0.764§
White	71 (92.2%)		40 (93.0%)	31 (91.2%)	
Hispanic	3 (3.90%)		2 (4.7%)	1 (2.9%)	
Black/African American	1 (1.30%)		1 (2.3%)	0 (0%)	
Asian	1 (1.30%)		0 (0%)	1 (2.9%)	
Unknown	1 (1.30%)		0 (0%)	1 (2.9%)	
Time to follow-up (Years)					
Total Cohort	8.9 ± 3.4		6.6 ± 1.7	12.1 ± 2.6	
Laterality		0.665†			0.321§
Left	32 (41.6%)		20 (46.5%)	12 (35.3%)	
Right	45 (58.4%)		23 (53.5%)	22 (64.7%)	
Compartment					0.543§
Medial Femoral Condyle	34 (44.2%)	0.202†	19 (44.2%)	15 (44.1%)	
Lateral Femoral Condyle	35 (45.5%)	0.585†	18 (41.9%)	17 (50.0%)	
Trochlea	2 (2.6%)		1 (2.3%)	1 (2.9%)	
Bicompartmental	6 (7.8%)	0.721†	5 (11.6%)	1 (2.9%)	
Treated Defect Area (mm^2)	318 ± 146	**0.024***	301 ± 112	338 ± 178	0.278§
Concomitant Procedure	66 (85.7%)	0.329†	34 (79.1%)	32 (94.1%)	0.061§
MMAT/LMAT	45 (58.4%)	0.585†	24 (55.8%)	21 (61.8%)	0.599§
HTO/DFO/TTO	15 (19.5%)	0.578†	12 (27.9%)	3 (8.8%)	**0.036**§
Microfracture	11 (14.3%)	0.721†	6 (14.0%)	5 (14.7%)	0.925§
ACD	6 (7.8%)		5 (11.6%)	1 (2.9%)	0.158§
Hardware Removal	4 (5.2%)		3 (7.0%)	2 (2.9%)	0.847§
ACL Reconstruction	2 (2.6%)		1 (2.3%)	3 (2.9%)	0.202§
Trochlear ACI	1 (1.3%)		0 (0%)	4 (2.9%)	
Lateral Meniscectomy	1 (1.3%)		1 (2.3%)	0 (0%)	

NOTE. Bold represents statistically significant values ($P < .05$).

ACD, articular cartilage debridement; ACI, autologous chondrocyte implantation; ACL, anterior cruciate ligament; BMI, body mass index; DFO, distal femoral osteotomy; HTO, high tibial osteotomy; LMAT, lateral meniscal allograft transplantation; MMAT, medial meniscal allograft transplantation; TTO, tibial tuberosity osteotomy.

*Linear Regression comparing variable of interest with increase in IKDC from baseline to two years.

†Logistic regression comparing variable of interest with increase in IKDC from baseline to two years.

‡Independent two samples t-test comparing 5-10 years and >10 years groups.

§Chi-squared tests comparing 5-10 years and >10 years groups.

‖For race/ethnicity p-values represent comparison between white vs nonwhite individuals.

16.4 for KOOS subscales at 2-year follow-up. There were 43 patients who completed PROs at preoperative baseline and at midterm 5- to 10-year follow-up. The percentage of patients who achieved MCID at midterm follow-up ranged from 42.9% for IKDC to 77.4% for KOOS Pain (Table 2). MCID was calculated to be 9.4 for IKDC, 11.9 for Lysholm, and 10.2 to 16.9 for KOOS subscales at this follow-up period. Within this cohort, there was a statistically significant increase in all PROs, with the exception of IKDC. There were 34 patients who completed PROs at preoperative baseline and at long-term follow-up 10 years and beyond. The percentage of patients who achieved MCID at long-term follow-up ranged from 45.0% for KOOS Symptoms to 89.5% for KOOS QOL (Table 2). MCID was calculated to be 12.7 for IKDC, 10.7 for Lysholm, and 8.9-15.6 for KOOS subscales at this follow-up period. Within this cohort, there was a statistically significant increase in all patient-reported outcomes, with the exception of IKDC.

Failure and Reoperation

No patients in this cohort underwent revision OCA or arthroplasty at final follow-up. One patient (1.2%) was found to have graft delamination on second-look arthroscopy, which responded favorably to debridement. Thirteen patients (16.8%) had any subsequent operation on the same knee, most commonly articular cartilage debridement (7 patients, 9.1%) at a mean time of 3.9 ± 3.5 years. We found no significant differences in short-term increases in patient reported outcomes

Table 2. Baseline and 2-Year PROs for the Entire Cohort (N = 77), Baseline and 5- to 10-Year PROs for the Midterm Cohort (n = 43), and Baseline and ≥10-Year PROs for the Long-Term Follow-Up Cohort (n = 34)

Outcome	Preoperative	PROs	MCID	% Achieved MCID	*P* Value*
2-yr					
IKDC	60.1 ± 15.6	73.4 ± 17.2	10.1	57.41%	**.0001**
KOOS Pain	56.7 ± 15.9	83.2 ± 15.5	9.9	85.92%	**<.0001**
KOOS Symptoms	60.1 ± 15.6	77.2 ± 15.8	9.9	62.26%	**<.0001**
KOOS ADL	70.2 ± 18.2	91.6 ± 12.8	9.4	69.23%	**<.0001**
KOOS Sport	32.0 ± 23.4	64.8 ± 23.9	16.4	66.67%	**<.0001**
KOOS QOL	25.7 ± 16.7	61.8 ± 21.9	12.6	81.25%	**<.0001**
Lysholm	50.4 ± 18.0	80.2 ± 16.2	9.8	83.78%	**<.0001**
5-10 yr					*P* Value* (vs Baseline)
IKDC	60.4 ± 15.7	63.4 ± 15.9	9.4	42.86%	.1610
KOOS Pain	52.9 ± 15.7	80.7 ± 17.3	11.5	77.42%	**<.0001**
KOOS Symptoms	60.4 ± 15.7	70.8 ± 17.8	10.2	51.85%	**.0051**
KOOS ADL	69.0 ± 18.8	88.6 ± 14.9	11.3	57.69%	**.0001**
KOOS Sport	34.8 ± 24.1	62.0 ± 23.9	16.9	69.23%	**.0001**
KOOS QOL	28.0 ± 19.6	57.0 ± 24.1	14.2	68.00%	**<.0001**
Lysholm	50.5 ± 17.4	32.0 ± 20.0	11.9	58.33%	**.0045**
≥10 yr					*P* Value* (vs Baseline)
IKDC	59.8 ± 15.8	70.1 ± 20.4	12.7	50.00%	.1872
KOOS Pain	61.3 ± 15.0	83.8 ± 14.4	10.8	76.67%	**<.0001**
KOOS Symptoms	59.8 ± 15.8	72.4 ± 18.3	12.1	45.00%	**.0375**
KOOS ADL	72.0 ± 17.5	92.0 ± 10.7	8.9	68.42%	**.0001**
KOOS Sport	27.9 ± 22.3	63.7 ± 21.1	15.6	77.78%	**.0003**
KOOS QOL	22.5 ± 11.0	62.5 ± 22.5	11.9	89.47%	**<.0001**
Lysholm	50.3 ± 19.3	80.2 ± 11.8	10.7	66.67%	**.0008**

NOTE. Bold represents statistically significant values ($P < .05$).

ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; MCID, minimally clinically important difference; PRO, patient-reported outcome; QOL, Quality of Life.

*Student paired *t* test comparing outcomes at baseline and at time point of interest.

when comparing patients who did and did not have a subsequent operation (Table 3).

Correlation Between Improvements in Short-Term PROs and Sustained Improvements in Long-Term PROs

Within patients with midterm follow-up between 5 and 10 years (n = 33), we found significant correlations between short-term improvements in PROs and midterm improvements in PROs for all PROs of interest (Table 4). Performing a post-hoc power analysis for the correlation between short- and midterm IKDC yielded a power of 97.2%. The correlation coefficients ranged from 0.479 for KOOS Pain (indicating moderate correlation) to 0.726 for IKDC (indicating a strong correlation). Within patients with long-term follow-up ≥10 years (n = 28), we found significant correlations between short-term improvements in PROs and long-term improvements in PROs for all PROs of interest. The correlation coefficients ranged from 0.620

Table 3. Comparison of Short-Term Improvement in Patients With and Without Subsequent Reoperation

Outcome	Mean Increase in Outcome From Baseline to 2 Years: No Reoperation, n = 64	Mean Increase in Outcome From Baseline to 2 Years: Reoperation, n = 13	OR	95% CI	*P* Value*
IKDC	4.1 ± 22.5	22.5 ± 14.2	0.974	0.937-1.006	.131
KOOS Pain	24.3 ± 24.0	24.0 ± 27.6	0.992	0.962-1.022	.584
KOOS Symptoms	14.1 ± 22.0	22.0 ± 17.1	0.992	0.960-1.026	.647
KOOS ADL	19.2 ± 21.7	21.7 ± 22.2	0.990	0.956-1.024	.550
KOOS Sport	27.6 ± 29.9	29.9 ± 34.8	0.982	0.959-1.007	.153
KOOS QOL	26.4 ± 21.2	21.2 ± 36.1	0.992	0.966-1.019	.545
Lysholm	31.9 ± 23.7	23.7 ± 28.8	1.008	0.968-1.050	.694

ADL, Activities of Daily Living; CI, confidence interval; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; OR, odds ratio; QOL, Quality of Life.

*Logistic regression.

Table 4. Correlation Between Short Term (Baseline, 2 Years), Midterm (Baseline to 5-10 Year Follow-up) (n = 43), and Long-Term (Baseline to ≥10-Year Follow-Up) Increases in PROs (n = 34)

PRO	R	Adjusted R^2	Slope	95% CI	*P* Value*
5-10 yr					
IKDC	0.726	0.484	1.123	0.416-1.829	**.0050**
KOOS Pain	0.479	0.198	0.555	0.127-0.983	**.0132**
KOOS Symptoms	0.667	0.436	0.658	0.357-0.950	**.0001**
KOOS ADL	0.526	0.247	0.570	0.182-0.958	**.0058**
KOOS Sport	0.548	0.271	0.885	0.316-1.454	**.0037**
KOOS QOL	0.578	0.305	0.818	0.320-1.316	**.0024**
Lysholm	0.646	0.359	0.642	0.107-1.178	**.0233**
≥10 yr					
IKDC	0.955	0.901	1.049	0.784-1.314	**<.0001**
KOOS Pain	0.620	0.348	0.599	0.211-0.986	**.0046**
KOOS Symptoms	0.637	0.372	0.730	0.292-1.168	**.0025**
KOOS ADL	0.847	0.700	0.761	0.516-1.006	**<.0001**
KOOS Sport	0.734	0.510	1.128	0.575-1.682	**.0052**
KOOS QOL	0.644	0.378	0.752	0.279-1.226	**.0039**
Lysholm	0.682	0.412	0.715	0.175-1.255	**.0145**

NOTE. Bold represents statistically significant values ($P < .05$).

ADL, Activities of Daily Living; CI, confidence interval; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; PRO, patient-reported outcomes; QOL, Quality of Life.

*Linear regression.

(moderate correlation) for KOOS pain to 0.955 (strong correlation) for IKDC.

Discussion

The main finding of this study for cartilage surgeons to takeaway is that statistically and clinically significant improvements in short-term PROs, including IKDC, Lysholm, and all KOOS subscales, predict sustained improvements in those same PROs at mid- and long-term follow-up after OCAs with or without concomitant procedures, providing important prognostic information used to manage both physician and patient expectations. This was accompanied by statistically and clinically significant improvements in IKDC, Lysholm, and all KOOS subscales at short-, mid-, and long-term follow-up after OCA. Too often, surgeons determine procedural success on the basis of short-term studies that report success in the literature, whereas long-term results may significantly drop off. To this end, it is essential to not only publish cohorts with ≥10-year follow-up but also correlate whether short-term postoperative improvements correlate with long-term postoperative improvements, or if there is a precipitous drop-off or late improvements in PROs. This provides surgeons the ability to counsel patients postoperatively at short-term follow-up on their long-term prognosis, as well as provide the treating surgeon the ability to identify patients who may require more frequent or longer follow-up on the basis of poor short-term improvements.

Currently, there are a lack of studies in OCA literature regarding the correlation between short-term and long-term improvements in PROs. The most relatable orthopaedic studies involve hip arthroscopy for the treatment of femoroacetabular impingement syndrome. Lin et al.[18] investigated short-term follow-up PROs of 173 patients and found patients who achieved MCID in modified Harris Hip Score at 6 months were significantly more likely to achieve MCID at 2 years postoperatively. At midterm follow-up, Akpinar et al.[16] reported in 89 patients with a mean age of 43.3 years that patients who had "high increase" in 1-year postoperative improvements in modified Harris Hip Score and Non-Arthritic Hip Score were corelated with greater 5-year improvements in the same PROs. In a slightly younger retrospective cohort, Alvero et al.[17] showed in 60 patients with a mean age of 36.0 years who underwent hip arthroscopy that their early 6-month postoperative improvements in Hip Outcome Score subscales, modified Hip Harris Score, and VAS score were correlated with 2-year, 5-year, and 10-year improvements in the same PROs. These studies show in the hip arthroscopy literature that early statistically and clinically significant improvements in PROs are typically correlated with sustained improvements at short- to long-term follow-up, which our study showed for OCAs.

There were no cases of conversion to unicompartmental or total knee arthroplasty in this cohort, a 16.8% reoperation rate (all of which were knee arthroscopy and chondroplasty), and statistically significant improvements in Lysholm and all KOOS subscales at 2-year, 5-10 year, and ≥10 year follow-up, with IKDC only showing statistically significant improvement at 2-year follow-up. There have been several recent publications of mid- to long-term outcomes for OCAs in the literature. Frank et al.[6] reported on 170 patients at a mean 5.0-year follow-up with statistically significant improvements in Lysholm, IKDC, and KOOS. Gilat et al.,[20] in 160 patients with a mean follow-up of 7.7 years, reported statistically significant improvements in all PROs, with 75.0% of patients achieving MCID for IKDC at final follow-up. Contrary to the current study, they found a reoperation rate of 39.4% that was significantly associated with a lower likelihood of achieving MCID. Levy et al.[27] in 122 patients with median follow-up 13.5 years reported significant improvements in IKDC and Merle d'Aubigné-Postel scores, with 24% failure at a mean of 7.2 years. In a systematic review of 5 studies with 291 patients, Assenmacher et al.[4] reported significant improvements in the Knee Society Knee Score, Hospital for Special Surgery Score, and Lysholm scores at final follow-up of 12.3 years with a reoperation rate of 36%.

There was no correlation between demographic factors on short-term improvements in PROs in our cohort. The correlation between these factors and outcomes after OCA is mixed in the literature. Nuelle et al.,[8] using VAS score as a primary outcome, found BMI <35 to a significant predictor of successful outcome after OCA, whereas age had no correlation, a finding corroborated by the aforementioned study by Frank et al.[6] This is in contrast to a meta-analysis by Kunze et al.[5] of 16 studies with 1,401 patients, in which the authors reported increasing age was a significant risk factor for graft failure, in addition to greater BMI and male sex. Multiple studies have suggested that patellofemoral OCAs do worse compared with femoral condyle OCAs,[3,4,28] which was not corroborated by our study, although our cohort had a minority of patellofemoral lesions (7.3%) and was not our primary outcome. We found a significant correlation between increased treated defect size and short-term increase in IKDC. Tírico et al.[29] investigated the impact of lesion size on outcomes after OCA and found similar postoperative outcomes between small (<5 cm^2), medium (5-8 cm^2), and large (>8 cm^2), with the greatest improvements observed in patients with the largest grafts.

In addition, our study had a high proportion of concomitant procedures, primarily meniscal allograft transplants, osteotomies, and microfractures. However, OCAs often are performed with one or more concomitant procedures to optimize the mechanical and biologic environment of the graft, and we believe this increases the external validity of our findings. In addition, our analysis revealed no significant correlation between the presence of concomitant procedures and short-term improvements in IKDC. Multiple studies have reported that when performed in a single stage, major concomitant procedures to address malalignment, meniscal deficiency, or ligamentous insufficiency lead to significant improvements in postoperative outcomes. Haunschild et al.[30] and Liu et al.[31] reported significant improvements in PROs and a high return to sport rate in OCAs performed with distal femoral osteotomy and high tibial osteotomy, respectively, at midterm follow-up. Tírico et al.[32] and Wang et al.[33] reported no differences between OCAs performed concomitantly with ACL reconstruction compared to isolated OCAs. Lastly, Richards et al.[34] in a prospective cohort study and Husen et al.[35] in a retrospective comparative study showed high success rates at midterm follow-up in OCAs with concomitant meniscal allograft transplantation, with no difference between isolated OCA and OCA with meniscal allograft transplantation, respectively. Our study adds support to this growing body of literature that coronal malalignment, ligamentous insufficiency, and meniscal deficiency may be addressed concomitantly with OCA without significant negative effects on postoperative PROs or graft failure rates.

Limitations

There are several limitations of our study. This was a relatively small cohort of 77 patients, given our strict inclusion criteria of OCAs with the presence of preoperative baseline, 2-year, and midterm or long-term PROs. There may be potential selection and transfer bias in our study due to loss to follow-up, because no patients had PROs recorded at all 4 time points. We also did not calculate patient acceptable symptom state for PROs, given the focus of the study was primarily on the correlation between short-term statistically significant increases in PROs and mid- to long-term follow-up. Our cohort also had a high rate of concomitant procedures, primarily alignment osteotomies, meniscal transplant, or ligamentous procedures, which makes applying these results to isolated OCAs difficult. Within our samples, 2 of 34 (5.9%) of patients in the greater than 10-year group and 9 of 44 patients (20.5%) in the 5- to 10-year group had isolated OCAs. These numbers are too small to draw any adequate conclusions. Because this was an entirely retrospective study, we did not perform an a priori power analysis. We performed a post-hoc power analysis for the correlation between short- and midterm increases in IKDC, yielding an acceptable level of power. However, because our results were already statistically significant, there is not much utility in a post-hoc power analysis. Moreover, given the small sample size of this cohort, we could not further analyze the data by disaggregating it by sex because of concerns about statistical power. Lastly, future authors using this study for potential systematic reviews should remain cognizant that this database, and a large number of this cohort of patients, have been reported in several other investigations.[6,19-23]

Conclusions

Two-year improvements in PROs after primary OCA are predictive of sustained mid- and long-term improvements, with significant correlations between 2-year outcomes and those at 5-10 years and ≥10 years.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: A.S.B. reports board membership with *Arthroscopy*. B.J.C. reports financial support was provided by OSSIO; funding grants from Aesculap AG; board membership with the *American Journal of Sports Medicine* and *Journal of the American Academy of Orthopedic Surgeons*; consulting or advisory with and funding grants from Arthrex and Elsevier; equity or stocks from Bandgrip and OSSIO; and funding grants from JRF Ortho and National Institutes of Health. B.J.C. has patents with royalties paid to Arthrex and Elsevier Publishing. All other authors (C.H.F., Y.N.M., J.P.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Cavendish PA, Everhart JS, Peters NJ, Sommerfeldt MF, Flanigan DC. Osteochondral allograft transplantation for knee cartilage and osteochondral defects: A review of indications, technique, rehabilitation, and outcomes. *JBJS Rev* 2019;7:e7.
2. Crawford ZT, Schumaier AP, Glogovac G, Grawe BM. Return to sport and sports-specific outcomes after osteochondral allograft transplantation in the knee: A systematic review of studies with at least 2 years' mean follow-up. *Arthroscopy* 2019;35:1880-1889.
3. Familiari F, Cinque ME, Chahla J, et al. Clinical outcomes and failure rates of osteochondral allograft transplantation in the knee: A systematic review. *Am J Sports Med* 2018;46:3541-3549.
4. Assenmacher AT, Pareek A, Reardon PJ, Macalena JA, Stuart MJ, Krych AJ. Long-term outcomes after osteochondral allograft: A systematic review at long-term follow-up of 12.3 years. *Arthroscopy* 2016;32:2160-2168.
5. Kunze KN, Ramkumar PN, Manzi JE, Wright-Chisem J, Nwachukwu BU, Williams RJ. Risk factors for failure after osteochondral allograft transplantation of the knee: A systematic review and exploratory meta-analysis. *Am J Sports Med* 2023;51:1356-1367.
6. Frank RM, Cotter EJ, Lee S, Poland S, Cole BJ. Do outcomes of osteochondral allograft transplantation differ based on age and sex? A comparative matched group analysis. *Am J Sports Med* 2018;46:181-191.
7. Wang D, Kalia V, Eliasberg CD, et al. Osteochondral allograft transplantation of the knee in patients aged 40 years and older. *Am J Sports Med* 2018;46:581-589.
8. Nuelle CW, Nuelle JAV, Cook JL, Stannard JP. Patient factors, donor age, and graft storage duration affect osteochondral allograft outcomes in knees with or without comorbidities. *J Knee Surg* 2017;30:179-184.
9. Williams JM, Virdi AS, Pylawka TK, Edwards RB, Markel MD, Cole BJ. Prolonged-fresh preservation of intact whole canine femoral condyles for the potential use as osteochondral allografts. *J Orthop Res* 2005;23:831-837.
10. Bernstein DT, O'Neill CA, Kim RS, et al. Osteochondral allograft donor-host matching by the femoral condyle radius of curvature. *Am J Sports Med* 2017;45:403-409.
11. Merkely G, Farina EM, Leite CBG, et al. Association of sex mismatch between donor and recipient with graft survivorship at 5 years after osteochondral allograft transplantation. *Am J Sports Med* 2022;50:681-688.
12. Mologne TS, Bugbee WD, Kaushal S, et al. Osteochondral allografts for large oval defects of the medial femoral condyle: A comparison of single lateral versus medial femoral condyle oval grafts versus 2 overlapping circular grafts. *Am J Sports Med* 2023;51:379-388.
13. Mologne TS, Cory E, Hansen BC, et al. Osteochondral allograft transplant to the medial femoral condyle using a medial or lateral femoral condyle allograft: Is there a difference in graft sources? *Am J Sports Med* 2014;42:2205-2213.
14. Urita A, Cvetanovich GL, Madden BT, et al. Topographic matching of osteochondral allograft transplantation using lateral femoral condyle for the treatment of medial femoral condyle lesions: A computer-simulated model study. *Arthroscopy* 2018;34:3033-3042.
15. Wang D, Coxe FR, Balazs GC, et al. Graft-recipient anteroposterior mismatch does not affect the midterm clinical outcomes of osteochondral allograft transplantation of the femoral condyle. *Am J Sports Med* 2018;46:2441-2448.
16. Akpinar B, Lin LJ, Bloom DA, Youm T. Hip arthroscopy for femoroacetabular impingement: 1-year outcomes predict 5-year outcomes. *Am J Sports Med* 2021;49:104-111.
17. Alvero AB, Chan JJ, Vogel MJ, Larson JH, Nho SJ. Six-month outcomes correlate with 10-year outcomes after hip arthroscopy for femoroacetabular impingement syndrome. *Arthroscopy* 2025;41:660-666.
18. Lin CC, Colasanti CA, Bloom DA, Youm T. Six-month outcome scores predicts short-term outcomes after hip arthroscopy. *Arthroscopy* 2021;37:3081-3087.
19. Frank RM, Lee S, Levy D, et al. Osteochondral allograft transplantation of the knee: Analysis of failures at 5 years. *Am J Sports Med* 2017;45:864-874.
20. Gilat R, Haunschild ED, Huddleston HP, et al. Osteochondral allograft transplant for focal cartilage defects of the femoral condyles: Clinically significant outcomes, failures, and survival at a minimum 5-year follow-up. *Am J Sports Med* 2021;49:467-475.
21. Hevesi M, Wagner KR, Quigley RA, et al. No association between donor variables and clinically significant outcomes, reoperations, and failure after osteochondral allograft transplantation. *Am J Sports Med* 2025;53:385-395.
22. Meeker ZD, Knapik DM, Wagner KR, et al. Comparison of revision and primary osteochondral allograft transplantation at midterm follow-up: Patient reported outcomes, survivorship, and reoperation rates. *Am J Sports Med* 2025;53:863-870.
23. Yazdi AA, Weissman AC, Wagner KR, et al. Men and women demonstrate comparable rates of failures and

reoperations following primary osteochondral allograft transplantation of the knee, but women undergo reoperation sooner. *Knee Surg Sports Traumatol Arthrosc* 2024;32:2622-2634.

24. Copay AG, Eyberg B, Chung AS, Zurcher KS, Chutkan N, Spangehl MJ. Minimum clinically important difference: current trends in the orthopaedic literature, part II: Lower extremity: A systematic review. *JBJS Rev* 2018;6:e2.
25. Griffin D, Audige L. Common statistical methods in orthopaedic clinical studies. *Clin Orthop Relat Res* 2003;413:70-79.
26. Hamilton DF, Ghert M, Simpson AHRW. Interpreting regression models in clinical outcome studies. *Bone Joint Res* 2015;4:152.
27. Levy YD, Görtz S, Pulido PA, McCauley JC, Bugbee WD. Do fresh osteochondral allografts successfully treat femoral condyle lesions? *Clin Orthop Relat Res* 2013;471:231-237.
28. Matthews JR, Brutico JM, Abraham DT, et al. Differences in clinical and functional outcomes between osteochondral allograft transplantation and autologous chondrocyte implantation for the treatment of focal articular cartilage defects. *Orthop J Sports Med* 2022;10:23259671211058425.
29. Tírico LEP, McCauley JC, Pulido PA, Bugbee WD. Lesion size does not predict outcomes in fresh osteochondral allograft transplantation. *Am J Sports Med* 2018;46:900-907.
30. Haunschild ED, Gilat R, Aghogho E, et al. Functional outcomes and survivorship of distal femoral osteotomy with cartilage restoration of the knee. *J Cartilage Joint Preserv* 2021;1:100004.
31. Liu JN, Agarwalla A, Christian DR, et al. Return to sport following high tibial osteotomy with concomitant osteochondral allograft transplantation. *Am J Sports Med* 2020;48:1945-1952.
32. Tírico LEP, McCauley JC, Pulido PA, Bugbee WD. Osteochondral allograft transplantation of the femoral condyle utilizing a thin plug graft technique. *Am J Sports Med* 2019;47:1613-1620.
33. Wang D, Eliasberg CD, Wang T, et al. Similar outcomes after osteochondral allograft transplantation in anterior cruciate ligament-intact and -reconstructed knees: A comparative matched-group analysis with minimum 2-year follow-up. *Arthroscopy* 2017;33:2198-2207.
34. Husen M, Wang AS, Levy BA, Saris DBF, Stuart MJ, Krych AJ. Influence of concomitant meniscal allograft transplantation on midterm outcomes after osteochondral allograft transplantation: A comparative matched-pair analysis. *Am J Sports Med* 2024;52:1238-1249.
35. Richards JA, Rucinski K, Stannard JP, Nuelle CW, Cook JL. Prospective assessment of outcomes after femoral condyle osteochondral allograft transplantation with concurrent meniscus allograft transplantation. *Orthop J Sports Med* 2024;12:23259671241256619.