Comparison of Revision and Primary Osteochondral Allograft Transplantation at Midterm Follow-up

Patient Reported Outcomes, Survivorship, and Reoperation Rates

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Background: Previous studies have observed promising short-term outcomes after revision osteochondral allograft (OCA) transplantation. However, few studies have examined midterm outcomes after revision OCA transplantation.

Purpose: To examine midterm outcomes after revision OCA transplantation of the femoral condyle and evaluate reoperation and survivorship compared with a matched cohort of patients who underwent primary OCA transplantation.

Study Design: Cohort study; Level of evidence, 3.

Methods: A retrospective review of prospectively collected data identified patients undergoing revision OCA transplantation to the femoral condyle between 1999 and 2018 (minimum 5-year follow-up). A 1:2 cohort of patients who underwent revision OCA transplantation to patients who underwent primary OCA transplantation, matched by defect size, age, sex, and body mass index, was created. Patient-reported outcome measures and the incidence of reoperations or graft failures were collected. Failure was defined as subchondral collapse of the OCA transplantation as confirmed via second-look arthroscopy, revision OCA transplantation, or conversion to knee arthroplasty.

Results: Fifteen patients who underwent revision OCA transplantation were matched to 30 patients who underwent primary OCA transplantation. The mean follow-up in the revision OCA transplantation group was 9.3 ± 3.0 years (range, 5.1-14.7 years), with a mean age of 31.4 ± 10.0 years (range, 19.9-52.7 years) and a mean body mass index of 25.9 ± 3.4 (range, 20.8-30.4). Revision OCA transplantation was performed to the lateral condyle in 53% of cases (8/15). A concomitant procedure was performed in 73% of patients (11/15), most commonly involving meniscal allograft transplantation (73% [8/11]), followed by realignment osteotomy (27% [3/11]). The Patient Acceptable Symptom State was achieved by a majority of patients who underwent revision OCA transplantation for all patient-reported outcome measures examined (International Knee Documentation Committee, 70%; Lysholm, 83%; Knee injury and Osteoarthritis Outcome Score [KOOS] Pain, 100%; KOOS Symptoms, 70%, KOOS Sport, 90%; KOOS Activities of Daily Living, 80%; KOOS Quality of Life, 80%), and there was no difference in the proportion of patients the Patient Acceptable Symptom State when compared with those undergoing primary OCA transplantation ($P \geq .070$) (see Table 3). Eight patients (53%) underwent revision OCA transplantation reoperation at a mean time of 3.9 ± 3.7 years (range, 0.6-11.2 years). Failures were observed in 20% (3/15) of patients who underwent revision OCA transplantation at a mean of 4.3 ± 1.9 years (range, 1.7-6.4 years). Graft survivorship free from reoperation ($P = .905$; revision 53% [8/15], primary 43% [13/30]) and failure ($P = .577$; revision 13% [2/15], primary 20% [6/30]) was not significantly different between revision and primary groups.

Conclusion: High rates of Patient Acceptable Symptom State achievement were observed after revision OCA transplantation. Although limited by sample size, no significant difference in graft survivorship free from failure was appreciated between revision versus primary OCA transplantation groups.

Keywords: knee; cartilage; OCA; revision

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Symptomatic focal chondral lesions represent a common source of knee pain and disability, representing a challenging treatment pathology facing clinicians.[11,17] While focal

lesions may be successfully managed nonoperatively with anti-inflammatory medication, activity modification, physical therapy, and injections, discrete lesions often progress in size and severity, resulting in increasing discomfort and the potential for early-onset osteoarthritis.[11,17] Over the past few decades, advancements in chondral restoration procedures, including autologous chondrocyte implantation, osteochondral autograft transplantation, and fresh osteochondral allograft (OCA) transplantation, have become increasingly utilized to treat symptomatic, focal chondral lesions in the knee.[17,19]

In appropriately selected patients, namely patients <40 years of age with focal, osteochondral defects measuring >2 cm^2, OCA transplantation has been shown to improve patient-reported outcomes at short-, mid-, and long-term follow-up.[8,9,12] Despite improvement, patients undergoing OCA transplantation are at risk for graft failure secondary to unaddressed malalignment, meniscal or ligamentous insufficiency, osteoarthritic progression, and lack of graft incorporation, among others. In cases after failed primary OCA transplantation, older patients may elect to undergo unicompartmental or total knee arthroplasty. However, arthroplasty represents a poor option in young and active patients because of concern for implant longevity and durability.[14] This makes revision OCA transplantation the preferred option to restore chondral integrity while addressing all other possible remaining causes for failure (malalignment and meniscal deficiency).[5]

Previous studies have observed promising short-term outcomes after revision OCA transplantation, resulting in significant improvement in pain relief, functional outcomes, and quality of life.[5,10] However, few studies have examined midterm (minimum 5-year) outcomes after revision OCA transplantation.[5] The purpose of this study was to examine midterm outcomes after revision OCA transplantation to the femoral condyle, as well as evaluate reoperation and survivorship compared with a matched cohort of patients undergoing primary OCA transplantation. The authors hypothesized that patients undergoing revision OCA transplantation would report improvement in outcomes with comparable reoperation and failure rates when compared with patients undergoing primary OCA transplantation at a minimum 5-year follow-up.

METHODS

Patient Population

Before study initiation, approval was obtained from local the Institutional Review Board at Rush University Medical Center. A prospectively collected database from a single institution was queried for patients who underwent revision OCA transplantation performed by the senior author (B.J.C.) between January 1, 1999, and April 1, 2018, with a minimum 5-year follow-up. Patients were included regardless of the presence of concomitant procedures at the time of revision OCA transplantation. Exclusion criteria consisted of patients with <5 years of follow-up. Figure 1 displays a detailed breakdown of participant selection.

Indications and Preoperative Planning

All revision OCA procedures were performed by the senior author, a fellowship-trained orthopaedic sports surgeon with a high-volume OCA transplantation and joint preservation practice. Before considering a patient for revision OCA transplantation, all underlying ligamentous and malalignment pathologies were identified and addressed with either previous surgery or concomitant procedures. Indications for revision OCA transplantation closely mirror those for primary OCA transplantation, which have been described previously.[6,20] Candidates include those with symptomatic, full-thickness, articular cartilage defects ≥2 cm^2 who experienced failure of primary OCA transplantation in the same location. Failure of the primary graft is typically determined via history, advanced imaging, and second-look arthroscopy, which also serves as a staging procedure for the revision OCA transplantation.

Given the nature of the senior author's practice, many patients are referred to the senior author's practice after failed primary OCA transplantation. The senior author prefers a trial of nonoperative management, including physical therapy, bracing, and steroid injections for a minimum of 6 to 8 weeks. Patients for whom this regimen of nonoperative management fails may then be considered for a revision OCA transplantation.

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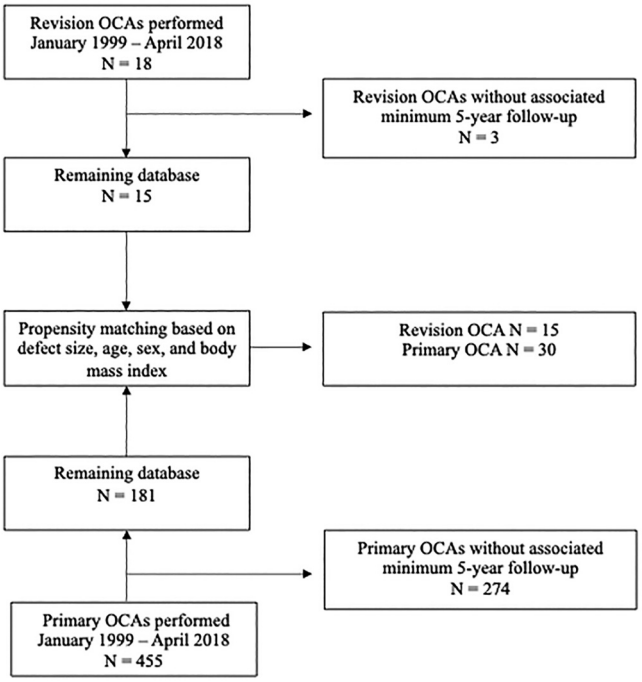

Figure 1. During the time frame selected, 18 patients underwent revision osteochondral allograft (OCA) transplantation, while 455 patients underwent primary OCA transplantation. Patients were excluded if they had <5 years of follow-up. Patients with revision and primary OCA transplantation were subsequently matched at a 1:2 ratio based on age, body mass index, osteochondral defect size, and sex.

Surgical Technique

The surgical technique for revision OCA transplantation was comparable to that for patients who underwent primary OCA transplantation, for which the senior author's technique has been previously described.[22] Briefly, in this series of patients, a mini-arthrotomy, generally utilizing the previous surgical incision, was created over the involved compartment to expose the condyle and the primary allograft. Any hardware from the previous OCA graft was removed, and the area of the failed primary allograft, as well as any additional damaged cartilage, was removed using a reamer to an appropriate depth, usually no more than 10 mm. Subsequently, a fresh OCA was harvested and appropriately sized and then gently inserted into the area of the reamed defect. To minimize the potential risk of graft failure, the senior author uses several graft preparation techniques in both primary and revision OCA transplantations, such as gradual rewarming, submerged harvesting, chamfering and groove generation, pulse lavage with normal saline, CO_2 preparation, and orthobiologics (ie, bone marrow aspirate concentration) soaking and application. These techniques have been shown to reverse metabolic suppression, reduce thermal necrosis, decrease graft impaction, improve deep zone access, reduce antigenicity, improve graft porosity for biologics and incorporation, and enhance graft incorporation.[15,18,21,23]

Rehabilitation Protocol and Postoperative Management

The senior author did not alter postoperative management for patients who underwent revision OCA transplantation when compared with primary OCA transplantation. In this series of patients, both patients who underwent primary OCA transplantation and those who underwent revision OCA transplantation were locked in full extension in a hinged knee brace for the first 2 weeks postoperatively and were limited to heel touch weightbearing for the first 6 weeks postoperatively. Initial rehabilitation focused on regaining passive as well as active-assisted range of motion, lower extremity strengthening through quadriceps sets, patellar mobilization, calf pumps, and straight leg raises. Patients progressed to full weightbearing as tolerated at weeks 6 to 8 postoperatively. By weeks 8 to 12, the brace was gradually removed after restoration of quadriceps strength, with no range of motion restrictions, as patients were encouraged to gradually introduce closed-kinetic-chain exercises. After week 12, patients were encouraged to bike, swim, and use an elliptical for exercise. At approximately 8 months postoperatively, patients were evaluated for return to sport and activity without restrictions. The senior author adjusted the rehabilitation protocol depending on the performance of any concomitant procedures.

Outcome Score Collection

Lysholm, International Knee Documentation Committee (IKDC) subjective form, and Knee injury and Osteoarthritis Outcome Score (KOOS) subscale surveys were completed preoperatively and at a 5-year minimum follow-up. In patients undergoing revision OCA transplantation, baseline scores were collected immediately before surgery. Previously established thresholds for achieving the Patient Acceptable Symptom State (PASS) were utilized for the Lysholm (70.0), IKDC (62.1), and KOOS subscales (Symptoms, 71.5; Pain, 72.2; Activities of Daily Living [ADL], 86.8, Sport, 43.8, Quality of Life [QOL], 50.0).[3,16] The incidence of any reoperations or treatment failures was recorded at the final follow-up. Reoperations were defined as any subsequent surgical intervention to the transplanted OCA, including second-look arthroscopy for graft evaluation, debridement, or loose-body removal. Failure was defined as subchondral collapse of the OCA as confirmed via second-look arthroscopy, revision OCA transplantation, or conversion to knee arthroplasty.

Statistical Analysis

Descriptive statistics for continuous variables are reported as means with standard deviations, while binomial variables are presented as frequencies and proportions. The chi-square and Fisher exact tests were utilized for comparing categorical variables. The Shapiro-Wilk test was used to determine the normality of the data, and the Mann-Whitney U test or independent-samples t test was used accordingly to compare continuous variables. Kaplan-

TABLE 1
Demographics and Intraoperative Variables for Patients Undergoing Revision and Primary OCA Transplantation[a]

	Primary OCA Transplantation, n = 30	Revision OCA Transplantation, n = 15	*P* Value
Sex			>.999[b]
Female	23 (77)	11 (73)	
Male	7 (23)	4 (27)	
Age, y	35.1 ± 7.6	31.4 ± 10.0	.221[c]
BMI	25.9 ± 3.8	25.9 ± 3.4	.998[c]
Laterality			.010[d]
Left	16 (53)	2 (13)	
Right	14 (47)	13 (87)	
Smoking status			.651[b]
Current	4 (13)	1 (6.7)	
Former	26 (87)	14 (93)	
WC	3 (10)	1 (6.7)	>.999[b]
Previous surgeries	2.5 ± 1.5	5.6 ± 1.6	<.001[c]
Symptom duration, y	4.7 ± 4.7	5.5 ± 5.6	.772[c]
Defect width, mm	19.9 ± 2.3	20.1 ± 2.6	.889[c]
Defect area, cm^2	3.11 ± .23	3.17 ± 0.26	.630[c]
Defect location			
MFC	17 (57)	7 (47)	.396[d]
LFC	13 (43)	8 (53)	.673[d]
Concomitant procedures			
Major concomitant surgery	22 (73)	11 (73)	>.999[b]
LMAT	9 (30)	5 (33)	>.999[b]
MMAT	9 (30)	3 (20)	.722[b]
HTO	2 (6.7)	1 (6.7)	>.999[b]
DFO	2 (6.7)	1 (6.7)	>.999[b]
TTO	1 (3.3)	1 (6.7)	>.999[b]

[a]Categorical variables are expressed as n (%), and continuous variables are expressed as mean ± SD. BMI, body mass index; DFO, distal femoral osteotomy; HTO, high tibial osteotomy; LFC, lateral femoral condyle; LMAT, lateral meniscal allograft transplantation; MFC, medial femoral condyle; MMAT, medial meniscal allograft transplantation; OCA, osteochondral allograft; TTO, tibial tubercle osteotomy; WC, workers' compensation.
[b]Pearson chi-square test.
[c]Wilcoxon rank-sum test.
[d]Fisher exact test.

Meier survival analysis was utilized to determine survival probabilities, which were compared between groups by log-rank testing. Statistical significance was defined as a *P* value <.05. All statistical analyses were performed using RStudio Version 4.3.0 (Posit).

Patient Matching

To create a control group of patients, propensity matching of patients who underwent primary OCA transplantation to patients who underwent revision OCA transplantation was performed. Propensity scores for each patient were generated using a multivariate logistic regression model based on defect size, age, sex, and body mass index (BMI) in a 1:2 case-control ratio. These variables were selected because they have been previously associated with failure after primary OCA transplantation.[12,13] Using the nearest-neighbor method, we matched patients without replacement and a maximum caliper distance of 0.2 of the standard deviation of the logit.[1,4] A total of 181 patients undergoing primary OCA transplantation were eligible for matching. Covariate balance information is available in Appendix Figure A1 (available in the online version of this article).

RESULTS

Patient Characteristics

A total of 15 patients who underwent revision OCA transplantation over the studied period were identified with a minimum 5-year follow-up (Appendix Table A1, available online). The mean follow-up in the revision OCA transplantation group was 9.3 ± 3.0 years (range, 5.1-14.7 years). The mean patient age was 31.4 ± 10.0 years (range, 19.9-52.7 years), with a mean BMI of 25.9 ± 3.4 (range, 20.8-30.4) (Table 1). The mean time between primary and revision OCA transplantation was 2.9 ± 1.4 years (range, 1.2-6.2 years). Concomitant procedures were performed in 73% (11/15) of patients undergoing revision OCA transplantation, most commonly consisting of meniscal allograft transplantation (lateral, n = 5; medial, n = 3). Compared with the primary OCA transplantation group, consisting

TABLE 2
Comparisons of Baseline and 5-Year Minimum Patient-Reported Outcomes Between Patients Undergoing Primary or Revision Osteochondral Allograft Transplantation[a]

	Primary Cohort, n = 26[b]	Revision Cohort, n = 13[b]	*P* Value[c]
IKDC score			
Preoperative	40.8 ± 13.2	41.5 ± 15.0	.831
Postoperative	75.2 ± 16.3	72.4 ± 15.5	.653
Lysholm score			
Preoperative	50.0 ± 25.4	45.0 ± 17.2	.647
Postoperative	79.4 ± 18.6	78.8 ± 7.8	.288
KOOS Pain score			
Preoperative	54.8 ± 13.9	53.0 ± 17.3	.819
Postoperative	83.9 ± 15.1	85.6 ± 7.9	.774
KOOS Symptoms score			
Preoperative	59.6 ± 18.6	57.8 ± 19.8	.804
Postoperative	70.7 ± 20.7	76.8 ± 13.0	.775
KOOS Sport score			
Preoperative	27.8 ± 25.0	33.6 ± 23.6	.640
Postoperative	57.8 ± 24.3	65.1 ± 21.6	.870
KOOS ADL score			
Preoperative	75.1 ± 15.9	71.4 ± 21.3	.676
Postoperative	66.7 ± 26.5	84.5 ± 23.9	.064
KOOS QOL score			
Preoperative	19.4 ± 14.9	30.4 ± 19.5	.125
Postoperative	94.7 ± 8.8	66.9 ± 23.1	**.008**

[a]Continuous variables are listed as mean ± SD. ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; QOL, Quality of Life. Bold signifies statistically significant values.
[b]Mean follow-up, 9.3 ± 3.0 years (range 5.1-14.7 years).
[c]Welch 2-sample *t* test.

of 30 patients with a mean age of 35.1 ± 7.6 years, patients undergoing revision OCA transplantation had a greater number of previous surgeries ($P < .001$) and more commonly underwent OCA transplantation in their right knee ($P = .010$). No other statistically significant differences were appreciated between primary and revision OCA transplantation groups.

Patient-Reported Outcome Measures and Clinically Significant Outcomes

Two patients undergoing revision OCA transplantation and 4 patients undergoing primary OCA transplantation were excluded from patient-reported outcome measure (PROM) analysis due to the lack of a 5-year follow-up. In the revision OCA transplantation group, all PROMs demonstrated significant improvement at the final follow-up when compared with baseline scores (all $P < .05$), with the exception of KOOS Sport ($P = .058$) (Table 2). When compared with patients undergoing primary OCA transplantation, postoperative KOOS QOL scores were lower in patients who underwent revision OCA transplantation ($P = .008$). A trend toward higher postoperative KOOS ADL scores was seen in patients who underwent revision OCA transplantation, compared with those under primary OCA transplantation ($P = .064$). No additional significant differences were identified when comparing PROMs at baseline or final follow-up between revision and primary OCA transplantation groups.

TABLE 3
Proportions of Patients Achieving Clinically Significant Outcomes at 5-Year Minimum Follow-up[a]

	Primary	Revision	*P* Value
Subjective IKDC score	7/9 (78)	7/10 (70)	>.999
Lysholm score	7/9 (78)	5/6 (83)	>.999
KOOS Pain score	8/9 (89)	10/10 (100)	.474
KOOS Symptoms score	4/9 (44)	7/10 (70)	.370
KOOS Sport score	7/9 (78)	9/10 (90)	.582
KOOS ADL score	3/9 (33)	8/10 (80)	.070
KOOS QOL score	9/9 (100)	8/10 (80)	.474

[a]Categorical variables listed as n/N (%), with N being the number of patients with final postoperative scores available. The number of patients achieving the Patient Acceptable Symptom State is listed for both primary and revision osteochondral allograft transplantation groups. ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; QOL, Quality of Life.

Final postoperative scores were available for 77% (10/13) of eligible patients undergoing revision OCA transplantation. There were no differences in the proportion of patients achieving the PASS between the revision and primary OCA transplantation groups ($P \geq .070$). (Table 3)

Reoperations and Failures

Eight (53% [8/15]) patients in the revision OCA transplantation group underwent reoperation at a mean of 3.9 ± 3.7 years (range, 0.6-11.2 years) after revision OCA transplantation. Articular cartilage debridement of the graft (n = 5) was the most common procedure performed, followed by lysis of adhesions and synovectomy (n = 2) and a second-look arthroscopy whereby only a partial medial meniscectomy was performed (n = 1). The primary indication for 1 patient who underwent articular cartilage debridement was for evaluation of their meniscal transplant, and they underwent partial meniscectomy in addition to a cartilage debridement. Comparatively, 13 patients (43% [3/30]) in the primary OCA transplantation group underwent reoperation at a mean of 2.7 ± 2.8 years after their index procedure. For patients who underwent revision OCA transplantation, the overall survival rates free from reoperation were 80.0%, 73.3%, 60.0%, and 52.5% at 1, 2, 5, and 10 years, respectively. For patients who underwent primary OCA transplantation, the overall survival rates free from reoperation were 86.7%, 76.7%, 60.0%, and 60.0% at 1, 2, 5, and 10 years, respectively (Figure 2A). No significant difference in survivorship free from reoperation between groups was observed ($P = .905$).

Two patients (13% [2/15]) underwent arthroplasty at a mean of 4.1 ± 3.2 years (range, 1.7-6.4 years) after

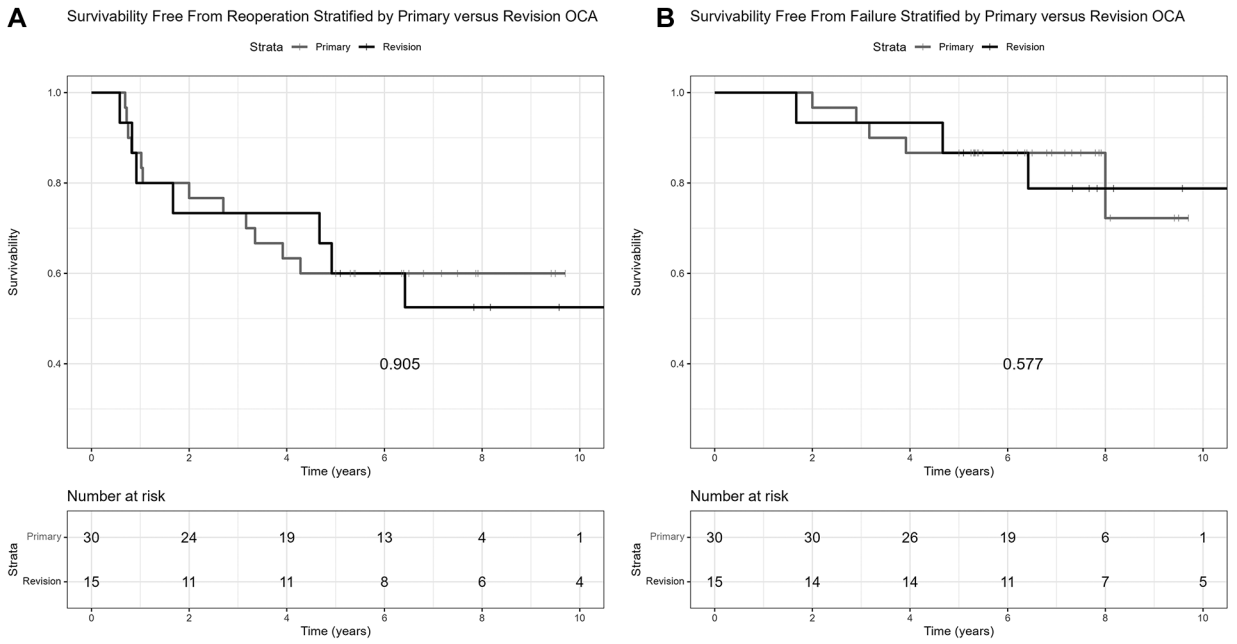

Figure 2. Sex-stratified Kaplan-Meier survival analysis for (A) reoperation and (B) failure (revision cartilage procedure or subsequent arthroplasty). For patients who underwent revision osteochondral allograft (OCA) transplantation, overall survival rates free from reoperation were 80.0%, 73.3%, 60.0%, and 52.5% at 1, 2, 5, and 10 years, respectively. For patients who underwent primary OCA transplantation, overall survival rates free from reoperation were 86.7%, 76.7%, 60.0%, and 60.0% at 1, 2, 5, and 10 years, respectively. For patients who underwent revision OCA transplantation, overall survival rates free from failure were 100.0%, 93.3%, 86.7%, and 78.8% at 1, 2, 5, and 10 years, respectively. For patients who underwent primary OCA transplantation, overall survival rates free from failure were 100%, 96.7%, 86.7% and 72.2% at 1, 2, 5, and 10 years, respectively. The log-rank test demonstrated no significant difference in survival distributions between patients who underwent revision or primary OCA transplantation for reoperation (P = .905) and failure (P = .577).

revision OCA transplantation. An additional patient had evidence of graft failure on second-look arthroscopy 4.7 years after revision OCA transplantation. However, at their final follow-up (9.7 years), the patient had not undergone subsequent reoperation. In the primary OCA transplantation group, 6 patients (20% [6/30]) reported failures, with 5 undergoing arthroplasty at a mean of 6.7 ± 2.0 years (range, 2.0-11.1 years) after index surgery. One patient had evidence of graft failure on second-look arthroscopy 3.9 years after primary OCA transplantation. For patients who underwent revision OCA transplantation, the overall survival rates free from failure were 100.0%, 93.3%, 86.7%, and 78.8% at 1, 2, 5, and 10 years, respectively. For patients who underwent primary OCA transplantation, the overall survival rates free from failure were 100%, 96.7%, 86.7% and 72.2% at 1, 2, 5, and 10 years, respectively (Figure 2B). No significant difference in survivorship between groups was appreciated (P = .577).

DISCUSSION

The primary finding from this investigation was that patients undergoing revision OCA transplantation reported a high rate of improvement in clinical outcomes at a minimum 5-year follow-up, with PASS achievement rates ranging from 70% to 100% for various PROMs. Reoperations after revision OCA transplantation were reported in 53% of patients, with failures observed in 20%. No significant difference in reoperations or failures was appreciated when comparing patients undergoing transplantation revision OCA transplantation versus a matched cohort undergoing primary OCA.

Previous studies examining outcomes after revision OCA transplantation are limited. Davey et al[5] reported on 9 patients undergoing revision OCA transplantation, with a median defect size of 4.0 cm^2 and a mean follow-up of 4.5 years. The authors observed reported improvements in PROMs, with no significant change in postoperative Kellgren-Lawrence grades (P = .102), with a 50% reoperation rate and a failure rate of 11% (defined as conversion to arthroplasty). Meanwhile, Horton et al[10] evaluated 33 patients, with a median defect size of 7.5 cm^2 at a mean follow-up of 10.0 years, undergoing revision OCA transplantation using either a shell (n = 19) or dowel (n = 14) technique. While no comparison of preoperative versus postoperative PROMs was performed, a patient satisfaction rate of 95% was reported; 67% of patients required reoperations, with 39% of patients undergoing subsequent arthroplasty. While the present study found slightly higher reoperation and failure rates (53% and 20%, respectively) compared with the study by Davey

et al, these differences are likely due to the longer length of follow-up after revision OCA transplantation. Both Horton et al and the present study report similar defect sizes (4.0 and 4.06 cm^2, respectively). When comparing failure rates, the lower incidence in this investigation compared with the findings from Horton et al may be attributed to differences in patient age (mean, 37 vs 31 years), a slightly greater mean follow-up (mean, 10.0 vs 9.3 years) and differences in median defect size (7.5 cm^2 vs 4.04 cm^2).[10] In addition, the performance of concomitant procedures at the time of revision OCA transplantation was not reported by Horton et al, which limits attribution of more failures to the complexity of the procedures performed.

Comparing the results of revision OCA transplantation to a matched group of patients who underwent primary OCA transplantation revealed no significant differences in clinical outcomes. Baseline PROMs were comparable and remained similar at a minimum 5-year follow-up, suggesting durability in clinical improvement after revision procedures. Although the number of previous procedures was significantly higher ($P < .001$) in the revision OCA transplantation group, the survivorship free from subsequent surgery was not found to be significantly different between groups ($P = .577$). Meanwhile, subsequent failures after revision OCA transplantation (20%) were not statistically significant ($P = .905$) when compared with patients undergoing primary OCA transplantation. As such, appropriate patient counseling regarding the risk for additional procedures after revision OCA transplantation is important to set realistic expectations.

A recent systematic review from Familiari et al[7] sought to report on clinical outcomes of patients undergoing primary OCA transplantation. Twelve of the 19 included studies reported on mean pre- (39.6) and postoperative (69.7) IKDC scores. Additionally, 3 of the 19 included studies reported mean pre- (42.8) and postoperative (68.6) Lysholm scores. The present study reports similar mean pre- (41.5) and postoperative (72.4) IKDC scores and similar mean pre- (45.0) and postoperative (78.8) Lysholm scores, further supporting the primary finding in the present study that patients undergoing revision OCA transplantation had high rates of improvement in clinical and functional outcomes at a minimum 5-year follow-up and suggesting that patients undergoing revision OCA transplantation can achieve comparable outcomes to those undergoing primary OCA transplantation. Nevertheless, additional studies are needed to examine long-term clinical and functional outcomes along with return to sport or ability to resume previous performance levels after revision OCA transplantation.

In a recent meta-analysis by Kunze et al,[12] the failure rates among 1401 patients after OCA transplantation were examined. Failure was defined variably among the included studies, with the most common criteria being performance of a revision cartilage procedure, conversion to arthroplasty, or gross failure of the allograft on second-look arthroscopy. Although no minimum follow-up was required for study inclusion, the overall failure prevalence (18.9%) was similar to that in the present investigation (20%). As such, patients undergoing revision OCA transplantation appear to achieve clinical success at a comparable rate to those undergoing primary OCA transplantation. However, additional investigation examining long-term outcomes after revision OCA transplantation compared with primary OCA transplantation is warranted to better understand revision OCA transplantation durability, while also accounting for patient- and defect-specific variables.

Limitations

This study is not without limitations. The present study included a relatively small sample size due to the specialized nature of the performed surgery and the limited indications for revision OCA transplantation. As such, there is a potential risk of a type 2 error for outcomes measured. A post hoc power analysis was performed for comparison of survival curves, which determined a power of approximately 0.1. With patient matching, an attempt was made to match patients who underwent revision OCA transplantation to patients who underwent primary OCA transplantation at a 1:3 ratio to reduce the potential for a type 2 error; however, an unacceptably high standardized mean difference was observed. Meanwhile, it has been shown that a 1:2 patient matching can improve precision without substantially increasing bias.[2,4] Therefore, interpreting comparisons between the primary and revision cohorts in this study should be approached cautiously due to the limited sample size. Further investigations with larger cohorts are warranted to validate the findings of this study.

Concomitant procedures were performed in 73% of patients undergoing revision OCA, potentially confounding and limiting the generalizability of our findings to patients undergoing isolated revision OCA transplantation. No postoperative radiographs or advanced imaging were routinely obtained in patients, nor was second-look arthroscopy performed unless clinically indicated. While the IKDC subjective form and KOOS Sport questionnaires examine sporting activity, long-term return-to-sport or ability to resume previous performance levels after revision OCA transplantation were not examined. Additionally, PROMs were only available for 10 of the 15 patients who underwent revision OCA transplantation, introducing the possibility of selection bias in the results. Lastly, a potential expertise bias is present, as all patients included were treated by a single surgeon who performs a high volume of OCA transplantations.

CONCLUSION

High rates of PASS achievement were observed after revision OCA transplantation. At a mean of 9.3 years after revision OCA transplantation, 53% of patients required reoperation, with 20% meeting failure criteria. Although limited by sample size, no significant difference in graft survivorship free from failure or reoperation was

appreciated between revision versus primary OCA transplantation groups.

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