Clinical Outcomes of Osteochondral Allograft Transplantation for Secondary Treatment of Osteochondritis Dissecans of the Knee in Skeletally Mature Patients

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Purpose: To report clinical outcomes of osteochondral allograft transplantation (OCA) for skeletally mature patients with osteochondritis dissecans (OCD) lesions of the knee in whom prior surgical intervention has failed, and to describe return-to-sport (RTS) rates and any predictive demographic or preoperative variables associated with a higher likelihood to RTS. **Methods:** Patients who underwent OCA by a single surgeon (B.J.C.) between October 1, 2002, and November 30, 2014, for a diagnosis of OCD with a minimum of 2 years' follow-up were included. Demographic, surgical history, operative, and postoperative data points including RTS were analyzed for all patients collectively, with subanalysis to identify any demographic and operative variables associated with the ability to RTS. Failure was defined as revision OCA, gross appearance of graft failure on second-look arthroscopy, or conversion to arthroplasty. **Results:** We identified 41 consecutive patients (43 knees), with 37 patients (39 knees, comprising 26 male and 13 female knees) available for clinical follow-up at an average of 7.29 ± 3.30 years. There was significant improvement ($P < .05$) in all patient-reported outcome scores, with the exception of the Short Form 12 mental subscale ($P = .910$). Most patients (81.6%) reported being either mostly satisfied or completely satisfied at final follow-up. Of patients self-identifying as athletes preoperatively (n = 22), 18 (81.8%) achieved RTS at an average of 14.0 ± 8.7 months. Athletes with failure to RTS had a significantly greater body mass index (RTS, 24.68 ± 3.67; no RTS, 27.82 ± 0.69; $P = .005$). Subsequent surgery was performed in 14 patients (35.9%), and primary OCA failed in 2 patients at an average of 6.2 ± 3.8 years. **Conclusions:** OCA is a successful secondary surgical treatment for OCD of the knee in skeletally mature patients and leads to clinically meaningful improvements in patient-reported outcome scores and high patient satisfaction and RTS rates in low-level athletes at an average of 7.29 years' follow-up. Athletes with failure to RTS were found to have a significantly higher body mass index. Although reoperation may be common after OCA (35.9%), the failure rate is low (5.1%) in this series. **Level of Evidence:** Level IV, case series.

Adult osteochondritis dissecans (OCD) lesions are focal lesions of subchondral bone thought to represent juvenile lesions that went unrecognized; however, authors have noted de novo cases.[1,2] OCD lesions are most commonly seen in the knee and occur most often in the medial femoral condyle (70%), followed by the lateral femoral condyle (15%-20%), patella (5%-10%), and trochlea (<1%).[3-5] Furthermore, these lesions can be debilitating, especially in active individuals who regularly place high stress loads across the knee joint, and may lead to an inability to perform activities of daily living or to return to sport (RTS).[6] Age and skeletal maturity are important variables influencing clinical decision making because older, skeletally mature individuals are less likely to succeed with nonoperative treatment and more likely to progress to surgery owing to a higher likelihood of

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unstable OCD fragments in the setting of an unfavorable healing environment.[3,5,7] Adult forms of OCD lesions, particularly advanced lesions in stage 3 (unstable but not dislocated fragment) or stage 4 (presence of loose body) according to the classification system proposed by Clanton and DeLee,[8] are commonly treated surgically because of the inferior healing potential compared with juvenile OCD.[2,9,10]

Surgical options for OCD have been classified as palliative, reparative, and restorative.[2,9,10] Palliative techniques such as loose body removal or debridement provide pain relief and improvement of mechanical symptoms but do not address underlying articular cartilage disease, and degenerative changes are often noted later on, especially in adult patients.[11] For patients in whom prior palliative or reparative interventions failed, restorative options including osteochondral allograft transplantation (OCA) have shown encouraging clinical outcomes.[12,13] OCA affords several biological advantages over marrow stimulation techniques including restoration of the articular surface with hyaline cartilage and has been shown to effectively treat lesions larger than 2 cm^2 in a single-stage procedure.[14,15] Until recently, there has been a paucity of literature regarding athletes' ability to RTS after OCA.[6,16-19] Although patients with OCD lesions treated with OCA have been included in RTS investigations, no study has reported RTS and return to recreational activities exclusively for this etiology using only a dowel technique for treatment of femoral condyle lesions.

The purposes of this study were to report midterm clinical outcomes of OCA as a secondary procedure for skeletally mature patients with OCD lesions and to describe RTS rates and any predictive demographic or preoperative variables associated with a higher likelihood to RTS. We hypothesized that patients would show significant clinical improvement after OCA, as well as high rates of RTS, with no significant associations between demographic or operative variables and the ability to RTS.

Methods

After institutional review board approval (No. 15050301), prospectively collected data from our electronic health record database were searched for all skeletally mature patients undergoing OCA for OCD by a single surgeon (B.J.C.) from October 1, 2002, through November 30, 2014, using Current Procedural Terminology codes 27415 (osteochondral allograft, knee, open) and 29867 (arthroscopy, knee, surgical; osteochondral allograft) and *International Classification of Diseases, Ninth Revision* code 732.7 (OCD) based on physical examination, radiographic, and/or magnetic resonance imaging findings. Indications for OCA included focal, symptomatic articular cartilage defects and failure of prior ipsilateral knee surgery. We excluded patients who underwent OCA without an OCD lesion, had an inaccurate diagnosis (i.e., not OCD despite being coded as such), underwent bone grafting at the time of allograft transplantation, received DeNovo NT (Zimmer, Warsaw, IN), or underwent allograft transplantation in a joint other than the knee.

Demographic information, mechanism of injury including traumatic versus insidious, medical and/or surgical history, intraoperative findings, and postoperative data were collected, as described in Table 1. A sports medicine fellow (R.M.F.) reviewed all preoperative radiographs for patients younger than 21 years to determine skeletal maturity. Preoperative and final follow-up patient-reported outcome (PRO) metrics were analyzed, including the following: International Knee Documentation Committee (IKDC) score, subscores of the Knee Injury and Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) subscores and overall score, and Short Form 12 (SF-12) mental and physical subscale scores. Patients who preoperatively self-identified as athletes, either recreational or competitive (high school or college), were asked whether they returned to sporting activities, at what level they returned to sporting activities, and how long it took them to RTS; if they did not RTS, they were

Table 1. Data Collected From All Patients Undergoing OCA for OCD

	Data
Demographic	Age at date of surgery, sex, BMI, and insurance status (including Workers' Compensation status)
Preoperative	Type and level of athlete before symptom onset, symptom duration, and number and type of prior ipsilateral knee surgical procedures
Intraoperative	Laterality; compartment involved; size of defect; depth of defect; and concomitant procedures including MAT, ligament repair or reconstruction, and/or osteotomy
Postoperative	Complications, reoperations, return to sport, satisfaction, whether patient would undergo procedure again, and validated PRO scores at minimum of 2 yr after surgery

BMI, body mass index; MAT, meniscal allograft transplantation; OCA, osteochondral allograft transplantation; OCD, osteochondritis dissecans; PRO, patient-reported outcome.

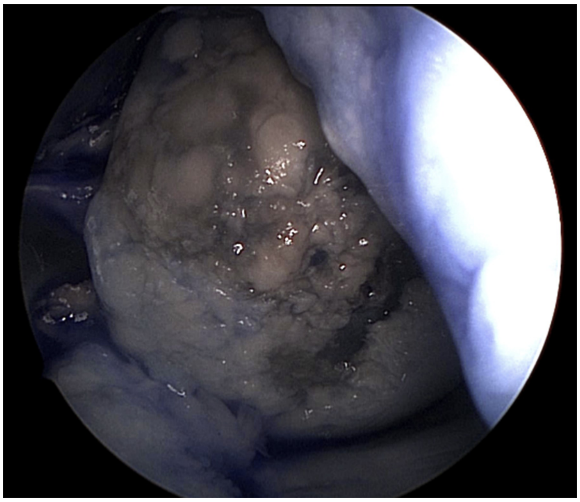

Fig 1. Intraoperative photograph of the right knee of a 22-year-old male patient showing an osteochondritis dissecans lesion of the lateral femoral condyle.

asked whether their knee was the primary reason. There were only 2 college athletes and no professional athletes in this study. In addition, all patients were asked how satisfied they were with their surgical outcome using a 4-point Likert scale (1, dissatisfied; 2, somewhat satisfied; 3, mostly satisfied; and 4, completely satisfied) and whether they would choose to undergo the procedure again. Demographic, medical and/or surgical history, intraoperative, and postoperative variables were analyzed first for all patients in this study; a subanalysis was then performed between those patients who did not RTS and those who did. Age-related differences in clinical outcomes were evaluated using regression analysis with age as a continuous variable. Failure was defined as revision OCA, gross appearance of graft failure on second-look arthroscopy, or conversion to arthroplasty.

Surgical Technique

The surgical technique for OCA of the senior author (B.J.C.) has been previously described.[20,21] The procedure is performed with the patient in the supine position. A diagnostic arthroscopy is performed to confirm that the focal chondral lesion is amenable to OCA and to evaluate for concomitant pathology. If necessary, concomitant procedures are performed before OCA. Next, a mini—parapatellar arthrotomy is performed to visualize and prepare the medial or lateral femoral condyle defect site (Figs 1 and 2). A cannulated, cylindrical sizing guide (Arthrex, Naples, FL) is placed flush over the defect to determine appropriate sizing of the graft. A 2.4-mm guide pin is then driven through the cannulated sizing guide into the base of the defect. The guide is removed and used to size the allograft at the appropriate topographic location. A cannulated cutting reamer of the same size is used to ream to a depth of approximately 6 to 8 mm. Next, a ruler is used to measure the depth of the defect socket at the 3-, 6-, 9-, and 12-o'clock positions. The donor condyle is then prepared using the same sizing guide, and the 12-o'clock position is marked with a marking pen. A donor harvester is passed through a metal bushing of the appropriate size corresponding to the defect and drilled through the entire depth of the donor tissue. The graft plug is trimmed to the previously measured depths using a sagittal saw. Pulsatile lavage is used on the allograft plug to remove any remaining marrow elements. The graft is carefully put into place by hand and gently impacted with an oversized tamp to secure a press fit. If fixation is required, the senior surgeon prefers resorbable compression screws (Arthrex). The wound is irrigated, and all layers are closed in standard fashion.

Rehabilitation Protocol

The preferred rehabilitation protocol of the senior author (B.J.C.) has been previously described.[20,21] Patients are placed in a hinged knee brace that is locked in extension for the first 2 weeks and is used for a total of 4 to 6 weeks with touch-down weight bearing. Use of the brace is discontinued once patients show the quadriceps strength necessary to support ambulation and perform a straight leg raise without extension lag. At 6 weeks, partial weight bearing on the surgical knee is allowed, with progression to full weight bearing as tolerated. At approximately 6 to 8 months after surgery, patients are permitted to begin higher-impact exercises, with progression to sport-specific activities after 8 months.

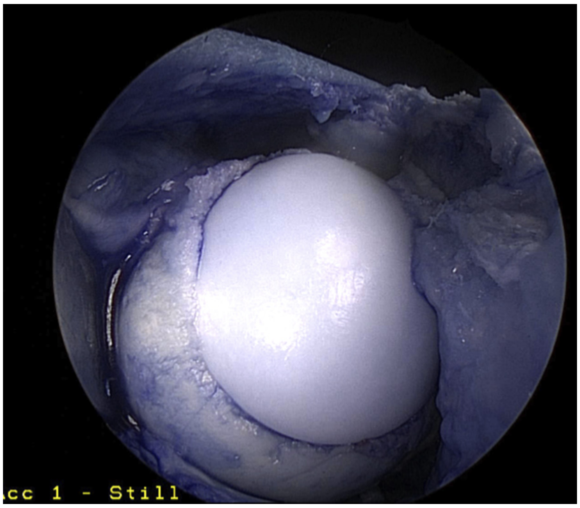

Fig 2. Intraoperative photograph of the right knee of the same 22-year-old male patient shown in Figure 1 showing the placement of an osteochondral allograft within the lateral femoral condyle lesion.

Statistical Analysis

Statistical analysis was performed using descriptive statistics; the χ^2 or Fisher exact test for comparison of categorical variables; and the Student *t* test and Mann-Whitney *U* test for comparison of parametric and nonparametric continuous variables, respectively. Binomial logistic regression analysis was used to compare patient age as a continuous variable with clinical outcome metrics including complications, reoperations, satisfaction, willingness to undergo the procedure again, RTS, RTS at the same level of sporting activity before the initial presentation of symptoms or higher, and failure. The Wilcoxon signed rank test was used for analysis of change in PROs from baseline to final follow-up. A Kaplan-Meier curve was generated to show graft survivorship. All reported *P* values are 2 tailed, with an α level of .05 detecting significant differences (SPSS Statistics, version 23.0; IBM, Armonk, NY).

Results

The retrospective review over the period from October 1, 2002, to November 30, 2014, yielded 67 patients (70 knees). A total of 25 patients (26 knees) were excluded for the following reasons: different treatment (DeNovo NT, 19 knee); iliac crest bone graft (1 knee); incorrect diagnosis (avascular necrosis due to medication, 1 knee); incorrect location of OCD lesion (ankle, 1 knee); skeletally immature on preoperative radiographs (1 knee); and/or concomitant patellofemoral compartment procedures including patellofemoral anteromedialization, medial patellofemoral ligament reconstruction, and/or microfracture (4 knees). We identified 43 knees in 41 patients for inclusion; 4 patients (4 knees) were lost to follow-up. Thus 39 knees (90.9%) in 37 patients (26 male and 13 female knees) were analyzed at a minimum 2-year follow-up. The average time to final follow-up was 7.29 ± 3.30 years. All patients underwent at least 1 previous ipsilateral surgery (mean, 2.3 ± 1.3 procedures). Of the knees, 32 (82.1%) underwent prior articular cartilage procedures whereas the remainder underwent previous knee surgery unrelated to the OCD lesion (meniscectomy and ligament reconstruction). Complete demographic information is provided in Table 2.

There were 21 lateral femoral condyle OCA and 24 medial femoral condyle OCA cases. Of note, 4 patients underwent OCA on both condyles concomitantly and 2 patients received 2 grafts (snowman technique), each to the medial femoral condyle for elongated or oblique lesions. The average defect size was 460.87 ± 168.12 mm^2. Major concomitant procedures were performed in 11 patients, including 6 meniscal allograft transplantations, 3 high tibial osteotomies, and 4 distal femoral osteotomies.

Table 2. Demographic and Surgical History of All Patients

	Data
No.	37 patients, 39 knees
Sex	26 male and 13 female knees
Age, yr	26.01 ± 9.96 (range, 15.78-49.25)
BMI	26.54 ± 4.77
Laterality	20 right (51.3%) and 19 left (48.7%) knees
Workers' Compensation cases	3 (7.5%)
No. of previous surgical procedures	2.3 ± 1.3
Duration of symptoms, yr	4.54 ± 4.38
Athlete (recreational, competitive, professional)	24 (60.0%)
Follow-up, yr	7.29 ± 3.30
No. of knees with failed articular cartilage procedures	32 (82.1%)
Failed OCD ORIF	17 (43.5%)
Failed loose body removal	13 (32.5%)
Failed microfracture and/or drilling	21 (52.5%)
Failed ACI	1 (2.5%)
Failed OATS	1 (2.5%)

NOTE. All percentages are based on the total number of knees. Data are presented as mean ± standard deviation or number.

ACI, autologous chondrocyte implantation; BMI, body mass index; OATS, osteochondral autograft transplantation; OCD, osteochondritis dissecans; ORIF, open reduction−internal fixation.

Clinical Outcomes

One patient did not respond to follow-up regarding satisfaction with the clinical outcome and whether he would choose to undergo the operation again. For 31 of the remaining 38 knees (81.6%), the patient stated that he or she was either mostly satisfied (19) or completely satisfied (12) at final follow-up. In addition, for 35 knees (92.1%), the patient stated that he or she would undergo the procedure again. There was a statistically significant improvement in all PROs ($P < .05$), with the exception of the SF-12 mental subscale ($P = .910$), from baseline to final follow-up (Fig 3). An important finding was that the minimal clinically importance difference (MCID) in improvement from the PRO preoperatively to the PRO at a minimum 2-year follow-up previously published for the IKDC score[22] was achieved (improvement by 25.54). In addition, MCID improvements were achieved for all KOOS subscores, specifically pain (20.68), symptom (14.28), activities of daily living (20.88), sport (25.96), and quality of life (30.56). For WOMAC subscores, the MCID was not achieved for the WOMAC pain subscore (3.74) or WOMAC symptom subscore (14.73).[22]

Return to Sport

There were 7 basketball athletes (29.2%), 4 football athletes (16.7%), 3 running athletes (12.5%), 3 cycling athletes (12.5%), 2 skiers (8.3%), 2 soccer athletes (8.3%), 2 wrestling athletes (8.3%), and 1 hockey

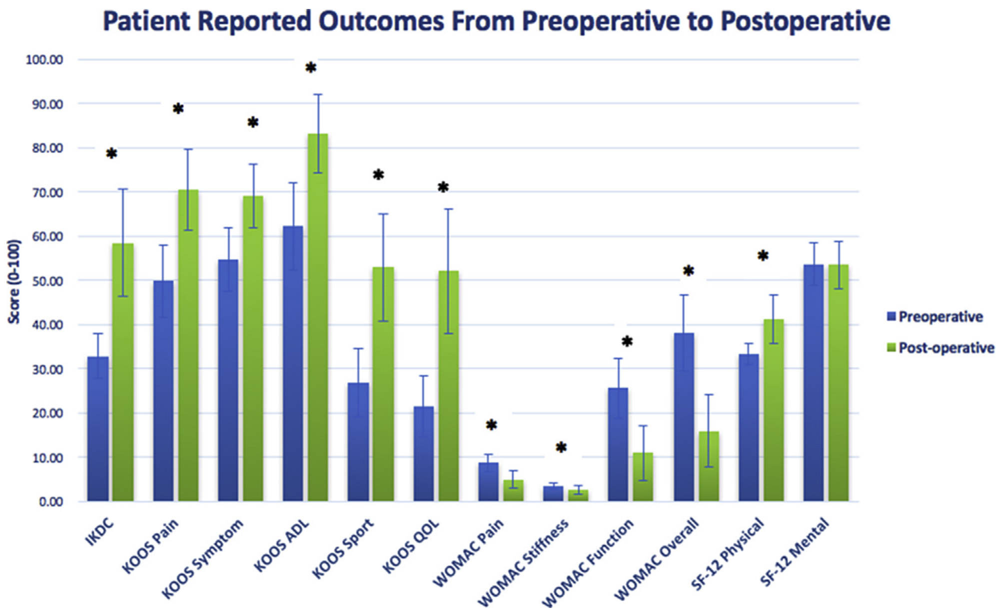

Fig 3. Summary of patient-reported outcome metrics for patients undergoing osteochondral allograft transplantation for treatment of osteochondritis dissecans lesions in the knee at an average follow-up of 7.36 ± 3.29 years. Significant differences (asterisks) were noted for the following: International Knee Documentation Committee (IKDC) score ($P < .0001$), all subscores of the Knee Injury and Osteoarthritis Outcome Score (KOOS) ($P < .0001$ for each), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain score ($P < .0001$), WOMAC stiffness score ($P = .002$), WOMAC function score ($P < .0001$), WOMAC overall score ($P < .0001$), and Short Form 12 (SF-12) physical subscale score ($P = .002$). (ADL, activities of daily living; QOL, quality of life.)

athlete (4.2%). Two patients were unable to be reached to ask whether they achieved RTS; however, 18 of the remaining 22 patients (81.8%) who preoperatively self-identified as athletes achieved RTS at an average of 14.0 ± 8.7 months, with 13 of 18 (72.2%) returning at the same level or higher. On subanalysis between those patients who returned to sport and those who did not, only body mass index (BMI) was shown to be significantly different between groups, with those with failure to RTS having a higher BMI (RTS, 24.68 ± 3.67; no RTS, 27.82 ± 0.69; $P = .005$) (Table 3). Of the 4 athletes who did not RTS, 3 were recreational athletes whereas 1 was a college hockey player. All 4 identified continued discomfort and/or lack of confidence in their knee as primary reasons for not returning to sport.

Age Analysis

Shapiro-Wilk testing confirmed a normal distribution of patient age (mean, 26.01 ± 9.96 years; range, 15.78-49.25 years). There was no significant difference in age between patients who self-identified as athletes (24 knees; mean, 23.94 ± 8.12 years) at preoperative office visits and non-athletes (15 knees; mean, 30.01 ± 12.02 years; $P = .095$). On logistic regression analysis of age (continuous) with postoperative outcomes, no significant differences were noted in any outcome variable. Specifically, no significant relations with complications (odds ratio [OR], 1.010; $P = .852$), reoperation (OR, 1.028; $P = .414$), patient satisfaction (OR, 1.022; $P = .957$), willingness to undergo the procedure again (OR, 1.022; $P = .977$), RTS (OR, 0.990; $P = .875$), RTS at the same level or higher (OR, 1.227; $P = .150$), and failure (OR, 1.121; $P = .159$) were shown. Complete analysis with reported 95% confidence intervals can be found in Table 4.

Complications

Complications occurred in 4 patients, including a low-grade incisional infection (n = 1), superficial skin

Table 3. Demographic, Preoperative, Operative, and Outcome Variable Comparisons Between Athletes Who Returned to Sport and Those Who Did Not

Variable	RTS	No RTS	*P* Value
Age, yr	24.26 ± 8.19	24.96 ± 10.29	.883
BMI	24.68 ± 3.67	27.82 ± 0.69	.005*
Symptom duration, yr	5.94 ± 5.17	1.25 ± 1.06	.235
Failed previous cartilage surgery	15 (83.3%)	4 (100%)	.999
Failed OCD ORIF	8 (44.4%)	3 (75%)	.586
Failed microfracture	8 (44.4%)	2 (50%)	.999
Major concomitant surgery	6 (33.3%)	0 (0%)	.541
Reoperation	6 (33.3%)	3 (75%)	.264
Complications	3 (16.7%)	0 (0%)	.999
Mostly or complete satisfied	16 (88.9%)	2 (50%)	.135

NOTE. All percentages are based on the total number of knees. Data are presented as mean ± standard deviation or number.

BMI, body mass index; OCD, osteochondritis dissecans; ORIF, open reduction−internal fixation; RTS, return to sport.

*Statistically significant.

Table 4. Binomial Logistic Regression for Demographic Characteristics and Outcomes Based on Patient Age (Continuous)

Variable	OR	95% CI	*P* Value
RTS	0.990	0.869-1.127	.875
RTS at same level or higher	1.227	0.929-1.621	.150
Complications	1.010	0.911-1.119	.852
Satisfaction	1.002	0.922-1.090	.957
Willing to undergo procedure again	1.002	0.889-1.129	.977
Reoperation	1.028	0.962-1.098	.414
Failure	1.121	0.956-1.313	.159

NOTE. Higher ORs signify that the outcome variable was more likely to occur as patient age increased.

CI, confidence interval; OR, odds ratio; RTS, return to sport.

dehiscence (n = 1), an acute hematoma that required evacuation and washout (n = 1), and a transient peroneal nerve palsy (n = 1) that resolved after 7 months.

Reoperations

In 14 patients (35.9%), subsequent surgery was performed at an average of 2.93 ± 2.47 years after index OCA. The reoperations included hardware removal from a distal femoral osteotomy (n = 1), partial lateral meniscectomy (n = 1), debridement and plica excision procedures (n = 11), and separate-site microfracture (n = 1); all patients were found to have intact allografts at the time of secondary surgery.

Graft Survivorship

In 2 patients (5.1%), progression to failure occurred at an average of 6.2 ± 3.8 years. Specifically, a 32-year-old male patient underwent revision OCA at 3.57 years and a 41-year-old female patient underwent a unicompartmental knee arthroplasty at 8.97 years after the index procedure. Both had an insidious onset of symptoms and had previous failure of microfracture at the site of eventual OCA, in each case involving the medial femoral condyle. The 32-year-old man was previously active running and playing basketball, whereas the 41-year-old woman did not identify as an athlete. Neither patient had postoperative complications, and both underwent a subsequent second-look arthroscopy 2.55 and 4.3 years after the index procedure, respectively, showing mild, clinically insignificant graft degeneration. A Kaplan-Meier curve showed 97.0% graft survivorship at 5 years (Fig 4).

Discussion

The principal findings of this study suggest that OCA is an effective procedure for secondary treatment of OCD of the knee in skeletally mature patients, as shown by the 82.1% of patients who were mostly or completely satisfied with their clinical outcome, significant improvements from baseline to final follow-up in all PRO metrics except the SF-12 mental subscale, and 92.1% of patients stating they were willing to undergo the procedure again. MCID improvements from previously published literature[22] were achieved for the IKDC score, all KOOS subscores, the WOMAC function score, and the WOMAC total score, indicating clinically significant improvement in outcomes. Furthermore, the results show that OCA for OCD has high utility in returning athletes (predominantly recreational and high school athletes) to sport (81.8%). Athletes with failure to RTS were shown to have a significantly higher BMI ($P = .005$), with all other analyzed demographic and operative variables found to have no association with the ability to RTS. In addition, regression analysis based on patient age did not identify any patient-, injury-, or surgery-specific variables associated with inferior clinical outcomes. This information can be used to counsel patients with OCD lesions of the knee, especially low-level athletes, in whom previous surgical intervention has failed regarding OCA as a viable knee joint preservation procedure regardless of patient age.

An interesting finding was that both patients with failure had undergone previous marrow stimulation procedures at the site of OCA. Recently, Gracitelli et al.[23] reported no significant differences in graft survival or clinical outcomes between patients undergoing primary OCA and patients undergoing OCA after a failed marrow stimulation procedure in a control-matched analysis of 46 patients, 42 of whom had a preoperative diagnosis of OCD. Furthermore, in a recent study of 180 patients who underwent OCA, the authors performed a Kaplan-Meier analysis to evaluate what effect, if any, previously failed microfracture had on graft survivorship.[20] They reported no significant

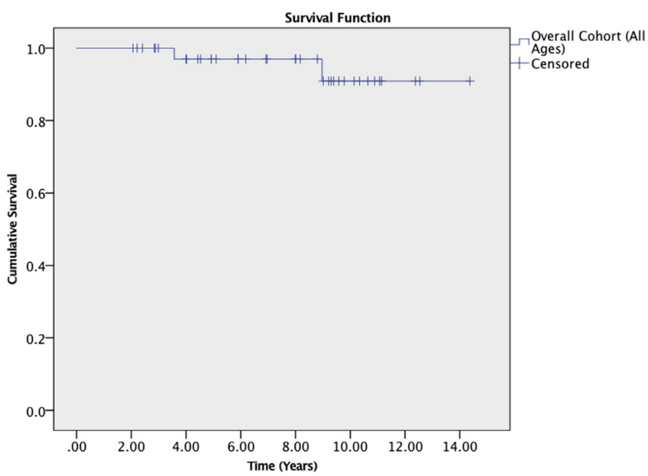

Fig 4. Kaplan-Meier survival analysis curve showing survival at an average follow-up of 7.29 ± 3.3 years. There were 2 graft failures, with 1 patient undergoing revision osteochondral allograft transplantation at 3.57 years and another undergoing unicompartmental knee arthroplasty at 8.97 years. At 5 years, the graft survival rate was 97%.

difference (P = .370). In our study, there was an insignificant number of patients who underwent previous marrow stimulation to reach a safe, accurate conclusion on whether this may have had a significant effect on failure for these 2 patients.

In this study, 81.8% of athletes were able to RTS and 72.2% were able to RTS at the same level. There was no significant difference in RTS (OR, 0.990; P = .875) or same-level RTS (OR, 1.227; P = .150) based on patient age. Other authors have reported slightly higher rates of RTS after OCA. Krych et al.[16] noted an 88% RTS rate at an average of 9.6 months, with 79% achieving the preinjury activity level, in a study of 43 patients treated with OCA not specific to only OCD. However, they showed that age of 25 years or older and a preoperative duration of symptoms greater than 12 months were risk factors for an inability to RTS, neither of which was seen in our study.

More recently, Nielsen et al.[6] conducted the largest RTS study regarding treatment of focal cartilage lesions of the knee of any etiology with OCA. Of the 149 knees included, 112 (75.2%) were able to RTS or return to recreational activity after OCA, with 91% of athletes reporting being satisfied or extremely satisfied with their clinical outcome. None of the aforementioned RTS investigations reported a relation between a higher BMI and inability to RTS as shown in our investigation. Although the 4 athletes who did not RTS had a mean BMI of 27.82, this may be an incidental finding given the relatively small number of athletes who did not RTS or may be indicative of the effects of added load across the knee joint. Furthermore, the results of our study suggest that lower-level athletes treated with OCA for OCD lesions of the knee have a comparable, if not slightly improved, opportunity to RTS when compared with OCA for any etiology.

Sadr et al.[13] recently published the largest investigation to date of clinical outcomes after OCA for treatment of OCD lesions in the knee. In a population of 149 knees with a minimum 2-year follow-up, they reported high patient satisfaction (95% satisfied or extremely satisfied), excellent graft survival (95% at 5 years and 93% at 10 years), and significantly improved clinical outcome scores at final follow-up. However, their investigation used both dowel and shell techniques and included patellofemoral grafts, differing from our study, in which only a dowel technique was used and patellofemoral lesions were excluded because of inherently unique biomechanical and concomitant pathology considerations. Similarly to the results of Sadr et al.,[13] previous investigations have reported good to excellent clinical outcomes and graft survival with OCA for the treatment of OCD. Garrett[24] reported graft survival in 16 of 17 patients at a 2- to 9-year follow-up in patients who had undergone at least 1 prior surgical procedure for OCD. In addition, Emmerson et al.[25] reported excellent outcomes in 47 of 65 knees (72%) that underwent OCA for the treatment of OCD, with 95% survivorship at 5 years and 76% survivorship at 10 years. Although 11 patients (27.5%) in our study underwent subsequent second-look arthroscopy and debridement indicative of the presence of symptoms, this is not uncommon for this procedure and all were shown to have intact grafts without degeneration.

Other authors have reported good clinical outcomes of OCA in investigations that included but were not exclusive to patients with OCD lesions of the knee. Levy et al.[26] reported an 82% 10-year survival rate in a long-term follow-up study of 129 knees, with a mean age of 33 years, after OCA treatment of femoral condyle lesions. They found a significant association between age older than 30 years at the time of surgery and allograft failure. This finding differs from the results of a recent investigation by Frank et al.[20] of 224 consecutive patients undergoing OCA for any indication. They reported a mean 5-year graft survival rate of 87% with no significant relation between patient age and graft failure on logistic regression analysis. The only independent predictor of failure found in their analysis was a greater BMI, similar to the effects of BMI presented in our study associated with the inability of athletes to RTS.[20]

Because OCA involves replacing the subchondral bone and articular cartilage in a single block, the outcomes of OCA are likely less affected by the involvement of the subchondral bone that occurs in OCD. In fact, because of the nature of cartilage lesions in OCD—well-circumscribed, usually unipolar lesions involving the subchondral bone in an otherwise healthy knee—OCA may prove to be an ideal treatment option when fixation or repair is contraindicated or unsuccessful.[24,25] This study provides a valuable addition to the literature regarding the outcomes of OCA for the treatment of OCD as a rigorous analysis of RTS. A strength of this study is the mean patient follow-up period of 7.29 years, with a minimum of 2 years, which limits detection bias.

Limitations

There are several limitations to this study. There is potential for performance bias because this study was conducted based on a single surgeon's case logs at a single academic institution. The patients comprised a heterogeneous group with a large age range. The heterogeneity is both an advantage, because it shows the breadth of clinical presentations of patients who may be good candidates for OCA and treated successfully, and a limitation, in that it introduces the potential for confounding variables such as concomitant procedures performed at the time of OCA.

Conclusions

OCA is a successful secondary surgical treatment for OCD of the knee in skeletally mature patients and leads to clinically meaningful improvements in PROs and high patient satisfaction and RTS rates in low-level athletes at an average of 7.29 years' follow-up. Athletes with failure to RTS, however, were found to have a significantly higher BMI. Although reoperation may be common after OCA (35.9%), the failure rate is low (5.1%) in this series.

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