Can Competitive Athletes Return to High-Level Play After Osteochondral Allograft Transplantation of the Knee?

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Purpose: To investigate functional outcomes among competitive athletes undergoing osteochondral allograft (OCA) transplantation of the knee, including rates of return to play (RTP), and factors preventing RTP. **Methods:** A retrospective review identified all competitive athletes (high school, intercollegiate, professional) undergoing isolated femoral condyle OCA from 2004 to 2013. Patient-reported outcome (PRO) questionnaires (Lysholm, International Knee Documentation Committee [IKDC], Knee Injury and Osteoarthritis Outcome Score [KOOS], Western Ontario and McMasters Universities Arthritis Index [WOMAC], 12-Item Short Form Health Survey [SF-12], Tegner, and Marx) and custom RTP surveys were administered. All subsequent reoperations were documented. **Results:** Thirteen athletes (4 intercollegiate, 9 high-school) were identified with an average follow-up of 5.9 ± 2.5 years. Seven athletes (54%) returned to competitive sport at an average of 7.9 ± 3.5 months, 5 of whom returned to preinjury functional levels. Of the 8 athletes who either did not return to competitive sport or failed to sustain their high level of play, the most common reasons cited were graduation from high school or college (4 patients, 50%) or fear of reinjury (3 patients, 38%). All 4 patients citing graduation as the primary factor preventing return to preinjury level of competitive sport resumed recreational sport without limitations, yielding an adjusted RTP rate of 10 patients (77%) who either returned to competitive play or believed they could return if they had not graduated. At final follow-up, athletes reported significant improvements in all PRO scores except for KOOS-Sport, WOMAC-Stiffness, and SF-12 Mental subscales. There were 3 reoperations at an average of 3.8 ± 3.3 years after the index OCA. There were no instances of graft failure. **Conclusions:** OCAs provide an adjusted RTP rate of 77% for high-level adolescent athletes. Social factors may be more likely than persistent pain to prevent return to sport. **Level of Evidence:** Level IV, therapeutic case series.

Articular cartilage injuries of the knee are being recognized with increased frequency in high-level athletes and often lead to persistent pain and swelling.[1-3] These injuries present a clinical challenge in determining the extent to which the noted chondral defect affects current performance and which treatment modality will optimally restore function. Marrow stimulation and cell-based restoration treatments have yielded high rates of return to sport in smaller (<2.5 cm^2) lesions.[4-8] However, in larger lesions and those involving subchondral bone, osteochondral allograft (OCA) transplantation has been shown to provide durable structural integrity,[9,10] restore appropriate contour to the articular surface,[11,12] and produce excellent functional outcomes.[10,13,14]

Data on return to activity after cartilage restoration surgery exists, with 2 systematic reviews noting an approximately 65% return to preinjury activity level.[8,15] One recent retrospective review reported return-to-sport

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rates up to 88% after OCA at an average follow-up of 2.5 years.[16] However, long-term rates of return to high-level sport after cartilage restoration surgery, particularly OCA, remain unknown.[17] The purpose of this study was to investigate functional outcomes among competitive athletes undergoing OCA transplantation of the knee, including rates of return to play (RTP) and factors preventing RTP. Given prior published data on improvement in pain and function after OCA,[10,14] the authors hypothesized that athletes would return to a high level of performance within 1 year and that pain would not limit a return to sport.

Methods

Patient Selection

This study was approved by the Institutional Review Board at Rush University Medical Center (no. 15050301). A retrospective review of prospectively collected data was performed to identify all patients who underwent isolated femoral condyle OCA between 2004 and 2013 with minimum 2-year follow-up. The primary indication for OCA was the presence of a large (>2.5 cm^2), symptomatic, full-thickness cartilage defect (Fig 1). All patients who could be unequivocally categorized as high-level high-school, intercollegiate, or professional athletes based on clinical documentation were included. Patients with less than 2-year follow-up or those who underwent simultaneous meniscal allograft transplantation or non-OCA chondral procedures were excluded.

Operative Technique

Lesions were assessed radiographically and confirmed via diagnostic arthroscopy by either the senior author (B.J.C.) or a referring orthopaedic surgeon in the months leading up to OCA to identify any additional intra-articular pathology. The senior author (B.J.C.) performed all surgical procedures. In all cases, OCA was accomplished using fresh (within 28 days postmortem) allograft tissue stored at 4°C. Once operative exposure was obtained via an ipsilateral parapatellar mini-arthrotomy, an appropriately sized graft was harvested from the donor knee using an OCA harvest system (Osteochondral Autograft Transfer System, Arthrex, Naples, FL) and inserted into the prepared defect. These procedures were all single, large graft plugs, and fixated with biocomposite screws (5 patients) or press-fit technique (8 patients). After surgery, the knee was closed in standard fashion without a drain. Patients were braced in extension and placed in a rehabilitation protocol involving touchdown weight bearing and continuous passive motion machine for 6 weeks. Beyond 6 weeks, patients were followed by a physical therapist and progressed to unrestricted range of motion as tolerated (Table 1).

Clinical Assessment

Clinical course before index OCA transplantation was documented along with each patient's postoperative course and subsequent surgeries. Patient-reported outcome (PRO) questionnaires (Lysholm; International

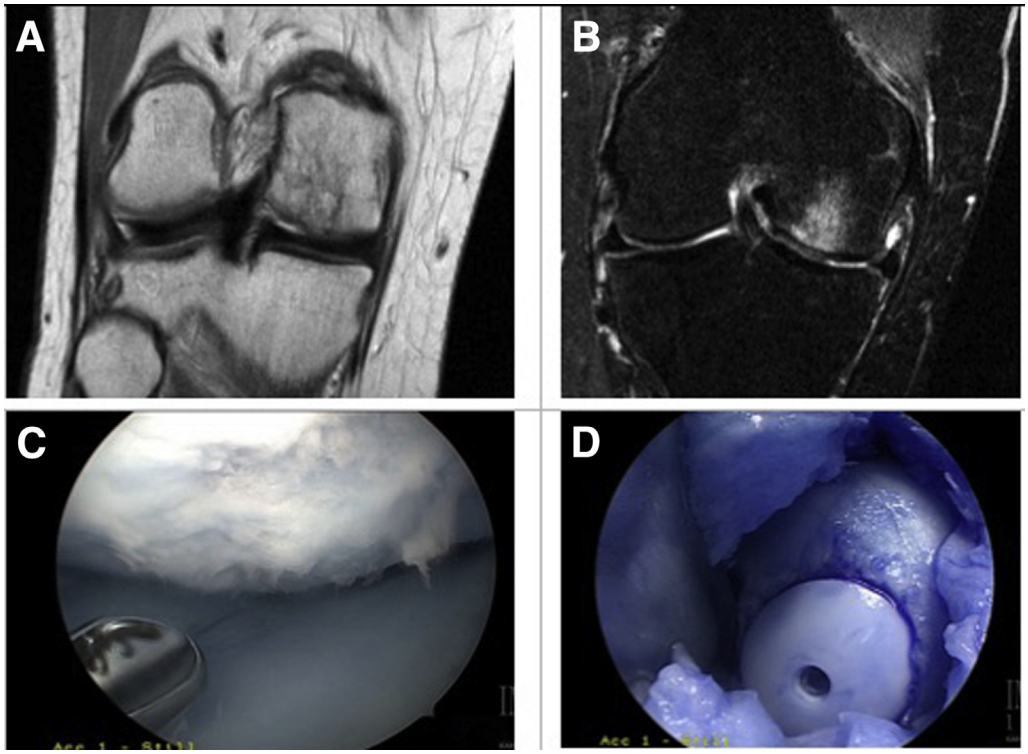

Fig 1. 22-year-old soccer player with a history of osteochondritis dissecans has pre-operative magnetic resonance images demonstrating a focal chondral lesion (A) with associated subchondral edema (B). (C) Arthroscopy demonstrates a full-thickness cartilage defect, (D) which was treated with osteochondral allograft transplantation. The patient returned to athletic activity after 8 months.

Table 1. Standardized Rehabilitation Protocol for All Patients Who Underwent Femoral Condyle OCA

	Weight Bearing	Brace	ROM	Exercises
Phase I 0-6 weeks	Heel touch	0-2 weeks: Locked in full extension at all times Offer for CPM and exercise only Discontinue after 2 weeks	0-6 weeks: Use CPM for 6 hours/day, beginning at 0°-40°, advanced 5°-10° daily as tolerated	0-2 weeks: Quad sets, SLR, calf pumps, passive leg hangs to 90° at home 2-6 weeks: PROM/AAROM to tolerance, patella and tibiofibular joint mobs, quad, hamstring, and glut sets, SLR, side-lying hip and core
Phase II 6-8 weeks	Advance 25% weekly until full	None	Full	Advance phase I exercises
Phase III 8-12 weeks	Full	None	Full	Gait training, begin closed chain activities: wall sits, shuttle, mini-squats, toe raises. Begin unilateral stance activities, balance training
Phase IV 12 weeks-6 months	Full	None	Full	Advance phase III exercises; maximize core/glutes, pelvic stability work, eccentric hamstrings May advance to elliptical bike, pool, as tolerated
Phase V 6-12 months	Full	None	Full	Advance functional activity Return to sport-specific activity and impact when cleared by MD after 8 months

AAROM, active assisted range of motion; CPM, continuous passive motion; MD, physician; OCA, osteochondral allograft; PROM, passive range of motion; SLR, straight-leg raise.

Knee Documentation Committee [IKDC]; Knee Injury and Osteoarthritis Outcome Score [KOOS] subscales for pain, symptoms, activities of daily living, sport, and quality of life; Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC] subscales for pain, stiffness, and function; 12-Item Short Form Health Survey [SF-12] subscales for physical and mental health) were administered to all patients before their index OCA. Patients were also asked to rate the overall condition of their knee function on a scale of 0 to 10. Upon return to the clinic at more than 2 years of follow-up, patients filled out the same PRO questionnaires, along with customized return-to-sport surveys and Tegner and Marx questionnaires. Changes in PRO scores were compared with minimal clinically important difference cut-offs as defined in the American Orthopaedic Society for Sports Medicine Outcomes Task Force report.[18] For KOOS, the value of 10 was used as described in previous investigations.[19,20] Subsequent operations were documented, with failure being defined by revision OCA or progression to total knee arthroplasty. Descriptive statistics were calculated, including means, standard deviations, and minimum and maximum ranges. Pre- and postoperative PRO scores were compared using 2-tailed Student *t* tests (SPSS v.18; IBM, Armonk, NY) with significance set at $P < .05$.

Results

A total of 13 athletes and 15 isolated femoral OCA (1 bilateral, 1 on both the medial and lateral femoral condyles) with greater than 2 years of follow-up were identified. There were 7 male athletes and 6 female athletes with an average follow-up of 5.9 ± 2.5 years (range, 2.2-9.6 years). Eight lesions occurred on the right femur, whereas 7 occurred on the left femur. Nine lesions occurred on the medial femoral condyle, whereas 6 lesions occurred on the lateral femoral condyle. Mean age at the time of surgery was 19.2 ± 2.8 years (range, 15.4-26.1 years), and mean body mass index was 22.7 ± 6.0. Four athletes competed at an intercollegiate level (2 in division I, 2 in division III), whereas the remaining 9 were high-level high-school athletes. The most common sports played were soccer (4 patients, 31%) and football (3 patients, 23%) (Table 2).

Five patients experienced a contact injury necessitating OCA transplantation, while the remaining 8 patients experienced gradual progression of chondral disease. Of the athletes experiencing contact damage, 2 injuries occurred outside of the patient's main sport. One patient experienced a biking injury and 1 sustained a twisting injury while stepping into a hole. All patients had undergone at least 1 operation prior to their index OCA (mean 2.0 ± 0.8, range 1-3). The most common prior surgeries performed were arthroscopic debridement with loose body removal (9 patients, 69%) and microfracture (7 patients, 54%) (Table 2). At the time of OCA transplantation, none of the athletes were able to participate in their sports due to pain.

During index OCA transplantation, mean lesion size was found to be 450 ± 175 mm^2. The most commonly utilized OCA plug was 25 mm (5 patients), followed by an 18-mm plug (3 patients). There were no instances of "snowman," or multiple adjacent OCA plugs. There were no surgical complications.

Table 2. Prior, Index, and Subsequent Surgical Procedures for Each Individual Athlete

Patient	Sport Played	Condyle	Prior Surgeries	Index OCA Surgery and Graft Size (mm)	Subsequent Operations
1	Soccer	MFC	MFX	OCA (15 × 15)	
2	Soccer	LFC	ACL repair, debridement × 2	OCA (25 × 25)	
3	Soccer	MFC	ORIF of OCD, MFX	OCA (25 × 25), debridement, loose body removal	
4	Volleyball	MFC	Debridement	OCA (18 × 18)	
5	Football	MFC	MFX	OCA (18 × 18)	Debridement
6	Cheerleading	(L) LFC (L) MFC	Synovectomy, lateral meniscectomy, chondroplasty, bicondylar MFX, debridement	OCA (25 × 25)	Debridement
7	Basketball	MFC	MFX, debridement	OCA (22 × 22), debridement	
8	Soccer	LFC	ORIF of OCD, loose body removal, debridement	OCA (25 × 25)	
9	Cheerleading	MFC	Debridement	OCA (15 × 15)	
10	Equestrian	R: MFC L: MFC	R: MFX L: Debridement	R: OCA (18 × 18) L: OCA (15 × 15)	
11	Football	LFC	MFX × 2, debridement	OCA (25 × 25)	
12	Wrestling	LFC	Debridement	OCA (25 × 25)	Debridement
13	Football	LFC	Debridement	OCA (25 × 25), loose body removal, plica excision	

ACL, anterior cruciate ligament; L, left; LFC, lateral femoral condyle; MFC, medial femoral condyle; MFX, microfracture; OCA, osteochondral allograft; OCD, osteochondritis dissecans; ORIF, open reduction internal fixation; R, right.

At a mean follow-up of 5.9 ± 2.5 years, Lysholm, IKDC, KOOS, WOMAC, and SF-12 scores all improved significantly, with the exception of the KOOS-Sport, WOMAC-Stiffness, and SF-12 Mental subscales (Table 3). Tegner and Marx activity scores at final follow-up were 4.5 ± 2.1 and 5.7 ± 5.3, respectively. Marx scores ranged from 0, indicating minimal physical activity, to a maximum score of 16, indicating running, pivoting, and decelerating without difficulty multiple times per week. Changes in Lysholm, IKDC, and KOOS at the time of follow-up exceeded accepted minimal clinically important difference values. Changes in WOMAC subscores did not.

A total of 10 athletes (77%) returned to sports after index OCA at an average of 7.9 ± 3.5 months, 5 of whom returned to preinjury levels of play (4 patients graduated from their school teams, 1 suffered a separate reinjury). All 4 patients citing graduation as the primary factor preventing return to preinjury level of competitive sport resumed recreational sport without limitations. The 1 patient suffering reinjury tore his meniscus during the subsequent football season, but eventually returned to play recreational sports. As such, this sample of young athletes undergoing OCA either returned to competitive play or believed they could return to play if they had not graduated—given their current recreational activity levels—at an adjusted rate of 77%. Of the 8 athletes who either did not return to competitive sport or did not return to the same level of competition, the most common reasons cited were graduation from high school or college (4 patients, 50%) or a fear of reinjury (3 patients, 38%) (Fig 2). Of note, only 2 patients did not return to sport because of continued pain. Three patients (23%) underwent debridement at an average of 3.8 ± 3.3 years after index OCA. Of these 3 patients, 1 returned to high-level

Table 3. Comparison of Preoperative and Postoperative Patient-Reported Outcomes in High-Level Athletes Undergoing Isolated Femoral Osteochondral Allograft Transplantation

	Preoperative	Final Follow-up	*P* Value
Lysholm	41 ± 13	64 ± 18	**.002***
IKDC	38 ± 12	63 ± 22	**.014***
KOOS			
Pain	61 ± 13	76 ± 17	**.009***
Symptoms	52 ± 16	72 ± 15	**.012***
ADL	74 ± 17	86 ± 18	**.049***
Sport	33 ± 19	55 ± 25	.112
QOL	25 ± 15	58 ± 24	**<.001***
WOMAC			
Pain	5.6 ± 2.4	3.8 ± 2.8	**.015***
Stiffness	3.8 ± 1.2	2.9 ± 2.0	.407
Function	18 ± 12	9.2 ± 12	**.049***
Total	27 ± 15	16 ± 16	**.040***
Overall knee function	2.6 ± 1.2	6.6 ± 2.8	**.007***
Tegner	N/A	4.5 ± 2.1	N/A
Marx	N/A	5.7 ± 5.2	N/A
SF-12 Physical	35 ± 6.3	44 ± 3.4	**.002***
SF-12 Mental	56 ± 6.9	55 ± 9.4	.227

ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; N/A, not applicable; QOL, quality of life; SF-12, 12-Item Short Form Health Survey; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

*Boldface indicates statistical significance ($P < .05$).

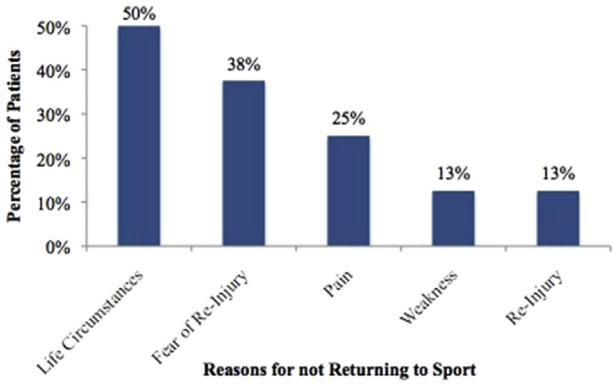

Fig 2. Reasons for not returning to preinjury level of competitive sport after index osteochondral allograft transplantation. Patients were able to cite multiple reasons for not returning.

sport, 1 returned to lower-level sport after graduating, and 1 did not return to sport because of continued pain. There were no instances of graft failure.

Discussion

In the current study, competitive adolescent athletes reported rapid RTP (8-9 months), significant subjective improvements in knee pain and function, low rates of reoperation, and a same-level RTP rate of 38% at an average almost 6-year follow-up. Social factors were found to prevent return to sport more often than pain or reinjury. Subjective improvements in knee pain and function exceeded currently accepted minimal clinically important difference values in Lysholm, IKDC, and all KOOS subscales but not in the WOMAC subscales.

Of the 5 patients who did not return to same-level play at the time of follow-up, 4 believed that they would be able to return to the same level had they not graduated, given their current recreational activity levels. This adjusted RTP rate of 77% suggests that prognosis for return to sport may depend more on patient-related factors, including life circumstances and pending graduation, than previously expected. Only 3 patients (23%) were unable to return to sport because of functional knee deficits (pain, weakness, or reinjury). One of these 3 patients underwent reoperation and was still unable to return to sport. Psychological constraints, such as fear of reinjury, also appear to play a role in those who cannot return to their competitive sport.

Social factors, such as graduation from high school or college, were the leading cause preventing return to preinjury levels of competitive sport. However, this finding suggests a potential flaw in RTP reporting among the adolescent/student athletic population. Of the 5 patients who returned to sport at a lower level, only 1 cited the index injury as the primary reason for not returning to play (fear of reinjury). The other 4 of these patients indicated that they were highly functional once they returned to play, and they believed they could have returned to their previous level of sport if they had not graduated. To resolve this, we combined those returning to competitive sport (5 of 13), those who graduated or suffered a separate injury but believed, based on current and postsurgical knee function, that they could have returned to the same level had they not graduated or suffered a separate injury (5 of 13), to yield an adjusted RTP rate of 10 of 13 (77%).

Previous studies have reported similar positive outcomes in regard to activity after OCA. Krych et al.[16] reported on 38 athletes at an average 2.5 years of follow-up and found that 88% returned to sport in a limited fashion, whereas 79% returned to preinjury levels of play after 9.6 months. Poor prognostic indicators of return to sport included age greater than 25 years and duration of symptoms greater than 12 months. Although these reported percentages of RTP were higher, the majority of patients (74%) were recreational athletes returning to sport at short-term follow-up. Furthermore, the significantly older patient population in the study (average age 32.9 years) would not be graduating high school or college after index OCA, which was the leading reason for not returning to sport among our study sample.

Several studies have demonstrated excellent functional outcomes after OCA transplantation. Williams et al.[21] reported improvements in clinical (SF-36 and activities of daily living scale) and MRI outcomes in 19 patients after fresh OCA. Emmerson et al.[13] reported significant functional improvements (modified d'Aubigne and Postel scores and patient satisfaction) in 64 patients with OCA performed for osteochondritis dissecans. More recently, studies by Levy et al.[10] and Briggs et al.[14] have demonstrated higher than 80% 10-year survival and more than 80% long-term patient satisfaction rates, respectively. Despite the abundance of literature, however, no study to date has reported on long-term rates of RTP for competitive athletes after OCA, nor has any study explored subjective reasons for not returning to sport. The fact that social factors are more likely than functional deficits to prevent RTP after OCA in a younger population of athletes remains critical when counseling patients and families. Given our rate of return to sport, cautious consultation of high-level athletes must take into account the athlete's life circumstances, pending graduation, and desire to play at the "next level."

Limitations

Our study is limited by a small number of patients and its retrospective nature. Beyond this, the young patient population in this study participated predominantly in high school and collegiate athletics. Their graduation and subsequent inability to return to the same level of

athletic competition clouds RTP reporting by forcing evaluation of recreational activity as a proxy for competitive sport. This presents a challenge for all studies regarding competitive adolescent athletes and suggests that other metrics, such as PROs and rates of reinjury, may more accurately reflect the extent of each patient's recovery. Ultimately, prospective data are needed to further refine indications for OCA in competitive athletes and to improve counseling on expected outcomes. As the orthopaedic community moves toward more concise and comprehensive reporting of outcomes, objective measurements of knee function, and radiographic documentation of osteoarthritis progression should also be considered.[22]

Conclusions

OCAs provide an adjusted RTP rate of 77% for high-level adolescent athletes. Social factors may be more likely than persistent pain to prevent return to sport.

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