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Accelerated Return to Sport After Osteochondral Autograft Plug Transfer

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Background: Previous studies have reported varying return-to-sport protocols after knee cartilage restoration procedures.

Purpose: To (1) evaluate the time for return to sport in athletes with an isolated chondral injury who underwent an accelerated return-to-sport protocol after osteochondral autograft plug transfer (OAT) and (2) evaluate clinical outcomes to assess for any consequences from the accelerated return to sport.

Study Design: Case series; Level of evidence, 4.

Methods: An institutional cohort of 152 OAT procedures was reviewed, of which 20 competitive athletes met inclusion and exclusion criteria. All patients underwent a physician-directed accelerated rehabilitation program after their procedure. Return to sport was determined for all athletes. Clinical outcomes were assessed using International Knee Documentation Committee (IKDC) and Tegner scores as well as assessment of level of participation on return to sport.

Results: Return-to-sport data were available for all 20 athletes; 13 of 20 athletes (65%) were available for clinical evaluation at a mean 4.4-year follow-up. The mean time for return to sport for all 20 athletes was 82.9 ± 25 days (range, 38-134 days). All athletes were able to return to sport at their previous level and reported that they were satisfied or very satisfied with their surgical outcome and ability to return to sport. The mean postoperative IKDC score was 84.5 ± 9.5 . The mean Tegner score prior to injury was 8.9 ± 1.7 ; it was 7.7 ± 1.9 at final follow-up.

Conclusion: Competitive athletes with traumatic chondral defects treated with OAT managed using this protocol had reduced time to preinjury activity levels compared with what is currently reported, with excellent clinical outcomes and no serious long-term sequelae.

Keywords: osteochondral autograft plug transfer; accelerated rehabilitation; return to sport; knee chondral injury

Injuries to knee articular cartilage have significant clinical consequences due to a limited capacity for healing.^{6,7,30} An increasing frequency of chondral injuries has been noted in populations of both highly competitive and recreational

athletes, especially in athletes participating in pivoting sports such as soccer, basketball, and football.^{3,11,31,38,40}

Articular cartilage injury also frequently occurs in association with other knee injuries, and up to 50% of athletes undergoing an anterior cruciate ligament reconstruction have a concomitant cartilage defect.^{13,40,46} Left untreated, an articular cartilage injury in the setting of anterior cruciate ligament deficiency portends significantly inferior outcome scores.⁴⁸

Regardless of etiology or chronicity, knee articular cartilage injuries can be particularly devastating to athletes, limiting their continued participation in sports as well as predisposing them to marked lifestyle changes and future joint degeneration.^{13-15,36,39,40,47,49} Athletes in pivoting sports are reported to have a 4.4- to 12-fold increased risk for knee osteoarthritis due to the increased repetitive mechanical stresses encountered during sport.^{12,15,36,47} A proper restoration of the articular surface has long-term implications in preventing the negative outcomes associated with the inability to maintain an active lifestyle after the end of an athlete's career.⁴⁷

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Pivoting athletes with articular cartilage injuries present a significant clinical challenge, as any restorative procedure must withstand the repetitive, forceful nature of the knee movements demanded by their sport.^{30,51} Osteochondral autograft plug transfer (OAT) utilizes a healthy osteochondral plug from a low-weightbearing cartilage surface and transplants it to the defective site.²²⁻²⁴ This technique establishes a new hyaline cartilage surface, as opposed to traditional techniques such as microfracture, which yield a fibrocartilage repair.^{1,2,4,16,22,24,27} Because of the potential for harvest site morbidity, OAT is typically limited to focal femoral defects with an area less than 2 to 3 cm².⁸ Previous studies have demonstrated improved outcomes in young athletes using OAT compared with microfracture and superior clinical and histological results compared with autologous chondrocyte transplantation,^{18,26} although a recent study demonstrated comparable cost-effectiveness between OAT and microfracture.⁴¹ In a recent systematic review of 20 studies including 1363 patients, OAT had the highest return-to-sport rates for athletes (91%) as well as the highest durability of preinjury level of performance (96%). The mean time to return to sport in this review was 8 months after microfracture, 7 months after OAT, and 18 months after autologous chondrocyte transplantation.⁴³ Similar results were reported in a second systematic review, which identified 11 studies including 658 patients, in which athletes who underwent OAT had a 93% return-to-sport rate at a mean 6.5 months, better than microfracture (59%, 17 months) and autologous chondrocyte transplantation (78%, 25 months).²⁵ However, although there are some benefits with regard to return to sports, there is little evidence of superior clinical results with OAT compared with other cartilage restoration techniques, including microfracture.^{9,34}

The purpose of this study was to (1) evaluate the time for return to sport in athletes with an isolated chondral injury who underwent an accelerated return-to-sport protocol after OAT and (2) evaluate clinical outcomes to assess for any consequences from the accelerated return to sport. The null hypothesis was that athletes with isolated knee chondral injury who underwent an accelerated return-to-sport protocol after OAT would be able to return to sport more quickly and return to their preinjury level of sport.

METHODS

Patients

After institutional review board approval was obtained, an institutional cohort of 152 OAT procedures performed from 2005 to 2012 at a single institution were retrospectively reviewed. Inclusion criteria were the following: (1) an articular cartilage defect or osteochondral defect of the medial or lateral femoral condyle confirmed on magnetic resonance imaging, (2) isolated knee OAT procedure, and (3) participation in competitive athletics at an International Cartilage Repair Society level I or II equivalent.⁵ Exclusion criteria were the following: (1) concomitant osteoarthritis; (2) concomitant ligamentous, meniscus repair, or surgical

TABLE 1
Patient Cohort^a

Demographics	
Age, y, mean ± SD	21.1 ± 7.6
BMI, kg/m ² , mean ± SD	25.0 ± 3.0
Male sex, n (%)	14 (70)
Sports, n (%)	
Soccer	5 (25)
Football	4 (20)
Basketball	4 (20)
Lacrosse	3 (15)
Baseball	1 (5)
Softball	1 (5)
Swimming	1 (5)
Distance running	1 (5)
Surgical details	
Lesion size, cm ² , mean (range)	1.34 (0.15-2.8)
Lesion location	
MFC, n (%)	8 (40)
LFC, n (%)	12 (60)
No. of plugs, mean (range)	2 (1-4)
Plug diameter, cm, mean (range)	0.7 (0.4-1.0)

^aBMI, body mass index; LFC, lateral femoral condyle; MFC, medial femoral condyle.

procedure other than OAT on the operative knee; and (3) cartilage defect in a location other than the medial or lateral femoral condyle, such as the trochlea or patella.

The final cohort consisted of 20 consecutive competitive athletes (Table 1). The mean age was 21.1 ± 7.6, and the mean body mass index was 25.0 ± 3.0 kg/m². Fourteen (70%) patients were male. Ten patients (50%) were collegiate or professional athletes, 7 patients (35%) were varsity high school athletes, and the remaining 3 patients were regional or national competitive athletes who had graduated college. Athletes participated in soccer (n = 5), football (n = 4), basketball (n = 4), lacrosse (n = 3), baseball (n = 1), softball (n = 1), swimming (n = 1), and distance running (n = 1). The mean lesion size was 1.34 cm² (range, 0.15-2.8 cm²). On average, 2 plugs (range, 1-4 plugs) were used. The mean plug diameter was 0.7 cm (range, 0.4-1.0 cm). Eight lesions were located on the medial femoral condyle, while the remaining 12 were located on the lateral femoral condyle. There was a mix of etiologies, including acute traumatic, remote traumatic, and more insidious.

OAT Procedure

All procedures were performed by 1 of 3 fellowship-trained orthopaedic surgeons. Diagnostic arthroscopy was completed to evaluate and measure the articular cartilage defect as well as evaluate for any concomitant knee pathology. The lesion was then debrided to a healthy cartilage rim. Donor osteochondral plugs were harvested from a lower weightbearing cartilage surface of the affected knee, typically the superolateral trochlear ridge, using a small arthrotomy of approximately 2.5 cm. The harvested plug(s) were then transplanted arthroscopically into the cartilage defect to create a congruent surface with the existing

healthy cartilage. Care was taken to assure perpendicular placement of the OAT plug. Additional operative procedures that did not specifically meet exclusion criteria were performed in 30% of patients, including partial lateral or medial meniscectomy (25%) and platelet-rich plasma injection into the patellar tendon (5%).

Accelerated Postoperative Rehabilitation Protocol

A physician-directed accelerated rehabilitation protocol was followed for each patient postoperatively. Patients were allowed to be up to 50% weightbearing immediately postoperatively. Postoperative visits within the first month emphasized regaining full range of motion. After 4 weeks, patients progressed to full weightbearing as tolerated and as dictated by their clinical progress with physical therapy. Patients with 1 or 2 plugs advanced more quickly, with transition to full weightbearing at 2 weeks postoperatively, pending normalization of quad control, gait, and diminished effusion. At the final standard scheduled clinical visit, between 6 and 10 weeks postoperatively, patients were permitted to progress to full athletic activities as tolerated. Those patients with 1 to 2 plugs ($n = 14$) were permitted to return as early as 6 weeks if they demonstrated sufficient functional abilities for their respective sport without effusion or increased pain.

Return to Sport

Return to sport was determined by a retrospective review of the patient's visit documentation and a review of athletic training and team participation logs. We defined the date of return as the date that patients resumed full and unrestricted athletic activities, including practices during off-season and competitive play when in-season.

Clinical Outcomes

Clinical outcomes were assessed using the International Knee Documentation Committee (IKDC) subjective knee score^{20,28,29} and the Tegner activity scale.¹⁹ These were obtained by in-person interview, phone questionnaire, or mailed survey.

RESULTS

Return to Sport

All (100%) of the patients were able to successfully return to sport postoperatively at a mean of 82.9 days (range, 39-134 days). Three patients were outliers with a mean return to sport of 120 days. Two of these athletes were collegiate soccer players who had surgery in the off-season and had no scheduled practice or games when released to sport. The patient with the longest return to sport (134 days) was late for their clearance appointment but had normal function and was pain free at 2-month follow-up. All (100%) patients reported that they were satisfied or very satisfied with their surgical outcome and ability to return to sport. The

TABLE 2
Summary of Results^a

Clinical outcome measures	
Successful return to sport, n (%)	20 (100)
Time to return to sport, days, mean (range)	82.9 (39-134)
Pain score during subsequent season, mean \pm SD	4.4 \pm 1.5
IKDC score, mean \pm SD	84.5 \pm 9.5
Tegner score, mean \pm SD	7.7 \pm 1.9
Symptoms, n (%)	
Mild/no swelling or stiffness	10 (50)
Moderate swelling or stiffness	10 (50)
Pain at the time of return to sport	5 (25)
Knee effusion after return to sport	5 (25)
Required joint aspiration or injection after return	5 (25)

^aIKDC, International Knee Documentation Committee.

reported mean pain score during the ensuing athletic season was 4.4 \pm 1.5 (out of 10). Fifty percent had mild or no knee swelling or stiffness, and 50% reported "moderate" swelling or stiffness. A total of 75% of respondents noted that during the ensuing athletic season, they were able to perform "strenuous to very strenuous activities without significant swelling." All (100%) patients were able to perform most or all of the physical demands of their sport without significant instability.

Clinical Outcomes

Clinical outcome scores were obtained in 13 of 20 athletes (65%) at a mean follow-up of 4.4 \pm 1.7 years (Table 2). The mean postoperative IKDC score was 84.5 \pm 9.5. The mean Tegner score prior to injury was 8.9 \pm 1.7, and 7.7 \pm 1.9 at final postoperative follow-up. Five athletes (25%) reported pain at the time of return to sport or later during clinical follow-up visits. These same 5 athletes (25%) reported having a knee effusion at the time of return or later during clinical follow-up visits, and all 5 of these athletes (25%) required joint aspiration and/or injection postoperatively. No athletes required reoperation, and no persistent mechanical symptoms were noted.

DISCUSSION

In the present study, the efficacy and safety of an accelerated return-to-sport protocol after OAT for isolated knee chondral injury was evaluated. Athletes in the present study were able to return to sport in less than 3 months on average after this procedure, with the longest return to sport being 4.5 months, although a quarter of patients had persistent pain and effusions that required aspiration or injection. This accelerated time for return to sports participation is unique when compared with studies reporting return to sport for athletes undergoing knee cartilage restoration. Several prior studies have evaluated return to sport after microfracture.^{4,16,33,42-44,50} Blevins et al⁴ reported a mean return to sport of 9.3 months for both highly competitive and recreational athletes after

microfracture. A recent retrospective study noted a return to regular activities between 6 and 8 months after microfracture.³⁵ These outcomes were summarized in a recent systematic review of 1363 patients in which the mean time for return to sports participation after microfracture was 8 ± 1 months postoperatively.⁴³ Other articular cartilage repair techniques are reported to have slightly longer times before an athlete can expect to return to unrestricted activities. Krych et al³⁵ reported a mean of 9.6 months until return to sport after osteochondral allograft transplantation. Average return to sport after autologous chondrocyte implantation is significantly longer, averaging 18 ± 4 months.^{35,42}

A potential advantage of OAT is that athletes may return to sports participation at a quicker rate due to the direct incorporation of autologous bone with an already intact, healthy hyaline cartilage articular surface.^{22,23} The impetus for allowing early return to activities after OAT is based on the improved and more rapid integration of the transplanted cartilage and bone. Experimental studies in dogs²¹ and horses¹⁰ have demonstrated that at 4 weeks, there is osseous integration of the bony portion of the graft, although a gap remains between the donor cartilage and the recipient site. At 8 weeks, fibrocartilage formed between the hyaline cartilage plugs.²¹ With bony integration demonstrated in animal models as early as 4 weeks postoperative, it is reasonable to consider earlier return to sport. Conversely, microfracture relies on the influx of marrow products to form a fibrin clot, which is slowly remodeled into fibrocartilage. This results in a less durable construct initially and over time and requires prolonged protection prior to initiating activities.^{8,37,42,45}

Reported time for return to sport after OAT is more rapid than what is cited for the other articular cartilage repair techniques.^{17,18,42} A recent systematic review reported a mean time of 7 ± 2 months for return to sport after OAT.⁴² Athletes in a prospective randomized trial returned to full athletic participation at a mean of 6.5 months after OAT.¹⁷ Additional literature report a mean return to sport ranging from 6 to 9 months after OAT.^{18,32} All competitive athletes in the present study were able to successfully return to sport postoperatively at a mean of 2.8 months (83 days)—more than 50% faster than any previous study of athletes undergoing OAT.

In our study, 100% of patients were able to successfully return to their prior sport, although a quarter of patients reported persistent pain and effusions, requiring aspiration and/or injections. In a systemic review, the overall return to sports participation averaged $73\% \pm 5\%$ for all cartilage repair techniques.⁴² Of those, OAT procedures yielded the highest rate of return at $91\% \pm 2\%$, which is consistent with the data in our study. In that same review, $70\% \pm 3\%$ of athletes returned to their preinjury level after OAT.⁴²

This retrospective study has several limitations. First, the small number of patients within the athlete cohort offers room for various biases. Second, the retrospective nature of the study may be a source of recall bias. Additionally, no preoperative scores were collected, so it is not possible to quantify the amount of improvement patients experienced. Neither were routine postoperative

radiographs performed, nor were mechanical axis radiographic views obtained, which limits our ability to ascertain whether malalignment contributed to outcomes. Many of the players likely had a variety of different non-operative treatments or interventions prior to presenting to the surgeon, particularly those who were in season; however, these data were not routinely documented in the medical record. We also could only assess return to sport and not truly measure return to prior level of performance. Finally, the study lacks a control or comparison group, such as a nonoperative group, microfracture group, or other cartilage restoration group, requiring comparisons with historical published data.

CONCLUSION

The present study demonstrates the feasibility of an accelerated return-to-sport protocol after an OAT procedure. Athletes with isolated traumatic knee chondral defects treated with OAT managed using this protocol had substantially reduced time to preinjury activity levels compared with what is currently reported, although a quarter of players had persistent pain and effusions requiring aspiration and/or injection after return to sport.

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