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Microfracture in Football (Soccer) Players: A Case Series of Professional Athletes and Systematic Review

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Abstract

Background: Little information is available on the results of microfracture in competitive football (soccer) players. We aimed to evaluate the efficacy of this technique to restore joint function to a level that allows return to this popular high-impact sport. *Methods:* This article provides an overview of the basic science and the current published scientific evidence for articular cartilage repair using the microfracture technique in elite football (soccer) athletes. In addition, the senior author documents his results in a case series of professional football (soccer) players treated with microfracture. *Results:* Twenty-one professional male soccer players underwent microfracture for knee articular cartilage defects. Nineteen players had isolated cartilage injuries, and 2 players had simultaneous anterior cruciate ligament injuries. Average age of the player was 27 years (range, 18-32 years). Twelve players (57%) had single defects, and 9 (43%) had multiple defects. All players complied with the postoperative rehabilitation program. Twenty players (95%) returned to professional soccer the season following microfracture surgery and continued to play for an average of 5 years (range, 1-13 years). Years of continued play inversely correlated with player age at the time of microfracture ($r = -0.41$). *Conclusion:* Articular cartilage repair with the microfracture technique followed by appropriate rehabilitation provides restoration of knee joint function in professional football (soccer) players with a high rate of return to football (soccer) and continued participation under the significant demands of professional football (soccer). Thorough understanding of the technical aspects, rehabilitation, and literature can help to optimize the results of microfracture in the athletic population.

Keywords

sport, athletics, football, soccer, cartilage, microfracture, injury, repair

Introduction

Articular cartilage injuries of the knee have been reported with increasing frequency in athletes, including football (soccer) players, that result from either acute traumatic injuries in association with ligament or meniscal injuries or from chronic pathological joint loading patterns in high-impact sports like football.[1-5] These joint surface injuries have been found with increasing incidence in competitive, professional, and world-class football players and often lead to activity-related symptoms, limited performance, and ability to play football.[2] High-impact joint loading after traumatic injury to the knee joint as well as in laboratory models has been shown to reduce cartilage proteoglycan content, increase joint levels of cartilage-degrading enzymes, and cause focal chondrocyte death.[6,7] The high demand on the joint surface and incidence of acute cartilage injury may predispose football players to progressive joint degeneration with 5- to 12-fold increased risk for knee osteoarthritis particularly at the elite level.[8-10] Untreated chondral damage in high-impact athletes has been shown to result in a gradual decline of athletic activity, emphasizing the need for an effective joint surface restoration in this high-demand population.[3]

Microfracture has been described as the most popular method for cartilage repair in both professional and recreational athletes including football players.[11,19,20,32] Described by Steadman *et al*.,[12] systematic perforation of the subchondral bone plate with specially designed awls leads to formation of a blood clot in the cartilage defect that contains marrow-derived undifferentiated mesenchymal progenitor cells. With the appropriate rehabilitation, a mixed fibrohyaline

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Table 1. Key Rehabilitation Points

Lesions of the femoral condyle or tibial plateau
Immediate continuous passive motion, 8 hours daily for 8 weeks; 1 cycle per minute at 30° to 70°
No brace
Touch-down (20%-30%) crutch walking for 8 weeks
Cycling (light resistance): start 2 weeks postoperatively
Deep water exercise: start 2 weeks postoperatively
After 8 weeks, full weightbearing and active range of motion
No cutting, turning, or jumping for at least 4 to 9 months depending on the patient
May be longer for competitive or larger patients
Patellofemoral lesions
Immediate continuous passive motion, 8 hours daily for 8 weeks at 0° to 50°
Brace locked at 0°; full weightbearing at 2 weeks
Stationary bike (light resistance): start 2 weeks postoperatively
Water program (no impact): start 2 weeks postoperatively
After 8 weeks, begin walking with a brace
Treadmill at 7° incline starting at 12 weeks postoperatively
Biking and water program: increase intensity at 8 to 12 weeks
Elastic resistance program with 0° to 30° knee bends starting at 12 weeks

repair cartilage tissue develops with varying amounts of hyaline content.[13-15] Due to the frequent use of microfracture in high-impact athletes like football players, in this article, we review the pertinent literature, and the senior author (R.J.S.) reports his personal experience with microfracture in professional football (soccer) players.

Basic Science Literature

Several animal studies have been carried out to assess the microfracture technique. In our experience, the equine model is one of the best models to use for cartilage research. The first study on microfracture in the horse was to determine if microfracture produced more repair tissue than an untreated lesion.[13] Large chondral defects were created in the radial carpal bones and in both medial femoral condyles of the horses. One carpal bone and one femoral condyle of each horse were treated with microfracture, while the others were left untreated. In 5 horses at 4 months, and 5 horses at 12 months, gross, histological, and histomorphometric examinations of defect sites and repair tissues were performed. The repair tissues were also evaluated for collagen typing. The results showed a significant amount of repair tissue in the defects that were treated with microfracture. An increase in type II collagen and earlier bone remodeling, as documented by changes in porosity, was also seen in the defects treated with microfracture.

In another study, defects were made in mature horses on the axial weightbearing portion of both medial femoral condyles.[16] The calcified cartilage layer was removed from one defect in each horse. At 4 months and 12 months, removal of calcified cartilage resulted in improved grade of overall repair tissue and increased histological filling of the defect. The study concluded that removal of the calcified cartilage layers provided the optimal amount and attachment of repair tissue. The results of this study led to changes in the microfracture surgical technique. Removal of the calcified cartilage was determined to be an important step in the microfracture procedure.

To assess key matrix component expression in early cartilage healing with microfracture, microfracture and control samples were collected at 2, 4, 6, and 8 weeks.[17] Analyses included determining qualitative impression of cellular and molecular changes. Comparisons of histomorphometric data and molecular and protein expression of critical cartilage components were performed at 8 weeks. The results demonstrated a gradual and significant increase in mRNA content for both type II collagen and aggrecan over the 8-week period. The type II collagen expression was enhanced with microfracture. This enhancement of type II collagen protein after microfracture was supported by the previous long-term study.[13] It is significant that aggrecan expression appears to be uninfluenced by microfracture treatment, whereas another critical matrix component is enhanced (type II collagen). The study by Frisbie *et al*. confirmed that microfracture significantly increases type II collagen expression as early as 8 weeks after treatment.[17] The results of this study provided a molecular and biochemical basis for the development of our current rehabilitation protocol and philosophy after microfracture (**Table 1**).

Systematic Review

A comprehensive search of the English literature was performed to identify any published and unpublished clinical

Table 2. Athletic Activity after Microfracture

Study	Patients	Follow-up (mo)	Outcome evaluation	Results
Saris *et al.*[14]	118	36	KOOS	Improved KOOS sports subscales, 62% treatment responders
Van Asche *et al.*[15]	67	24	ARS, Baecke	Microfracture improves activity scores, low loading beneficial
Riyami and Rolf[19]	24	18	Cincinnati	88% complete healing ICRS second look/MRI, 100% return to play
Mithoefer *et al.*[20]	32	41	ARS, Tegner	Improved ARS/Tegner, 44% RTS
Gudas *et al.*[21]	57	36	ICRS, HSS, RTS	76% good/excellent at 1 year, 52% good/excellent at 2 years, 52% RTS at preinjury level
Blevins *et al.*[22]	236	43	RTS, Functional score, Second look	77% RTS, 71% at same level, competitive athletes with better results
Gobbi *et al.*[23]	109	72	RTS, Tegner, IKDC, Lysholm	All scores improved, 80% RTS, 55% sports at 6 years
Gudas *et al.*[24]	60	37	HSS, ICRS, MRI, RTS	All scores increased, 52% RTS, 52% surface restoration
Kon *et al.*[25]	80	70	RTS, IKDC, Tegner	75% (nearly) normal IKDC, 50% RTS at same level
Namdari *et al.*[30]	24	108	RTS	66% RTS
Cerynik *et al.*[31]	24	24	Performance, RTS	79% RTS, reduced performance first season
Steadman *et al.*[32]	25	54	RTS, Pain, Lysholm	76% RTS, Lysholm/pain improved, continued sport for 5 seasons

Note: KOOS = Knee injury and Osteoarthritis Outcome Score; ARS = activity rating scale; ICRS = International Cartilage Repair Society score; HSS = Hospital for Special Surgery score; RTS = return to sport; IKDC = International Knee Documentation Committee score; MRI = magnetic resonance imaging.

studies on microfracture in athletes from January 1966 through December 2010. The medical databases were searched using the terms "sport", "athlete", "return to sport", "athletic activity", "chondral defect", "condylar lesion", "condyle lesion", "patellofemoral lesion", "trochlear defect", "knee lesion", "joint surface defect", "articular resurfacing", "articular cartilage repair", "chondroplasty", "microfracture", and "marrow stimulating technique". In addition, searches were also performed in the bibliographies of identified studies, review articles on articular cartilage repair in athletes, and abstract books of relevant scientific meetings. Any study reporting clinical information on microfracture in the athletic population was selected for primary review. Specific attention was placed on identifying studies that described sports activity–related functional outcome scores, the postoperative ability to return to sport after microfracture, and the continued participation in athletic activity over time.

We identified 46 clinical studies reporting on microfracture and athletics. The abstracts of these studies were evaluated in a primary screening process, and only studies reporting high grade III or IV chondral or osteochondral defects of the knee were included. Studies including individual cartilage repair procedures and comparative studies were accepted. All prospective randomized controlled studies (levels I and II) on microfracture of the knee in athletes were included. Level III and IV studies were accepted into the study only if they included follow-up ≥2 years, ≥30 athletes, or macroscopic or histological data of the repair tissue. Twelve studies met these primary inclusion criteria and were carefully analyzed in a secondary screening process to extract information about sports participation such as activity scores, rate of return to sport, time and level of return, and continuation of sports participation at the preinjury level. Tegner activity scale and Knee injury and Osteoarthritis Outcome Score (KOOS) were included as outcome measures because they have been evaluated for articular cartilage repair in the knee and provide sport activity information.[18]

The collected data were analyzed using established statistical software (version 17.0, SPSS, Chicago, IL). Differences between independent parameters were evaluated using the Kruskall-Wallis test. Differences between variable proportions were measured by χ^2 analysis. Differences were considered significant with a P value <0.05. Data are presented as mean ± standard error of the mean (SEM).

Twelve studies describing 611 patients were included in the review with an average follow-up of 46 ± 6 months (**Table 2**). Most studies included isolated defects with an average defect size of 3 ± 0.5 cm^2. Duration of symptoms averaged 29 ± 7 months. One third of the studies included patients with concomitant ligament or meniscal procedures. Good and excellent results were reported in 67% ± 7% of athletes after microfracture. Tegner activity scores increased in 75% ± 6%, and KOOS subscales for sports and recreation significantly increased by 20 points following microfracture. One study reporting on microfracture in professional

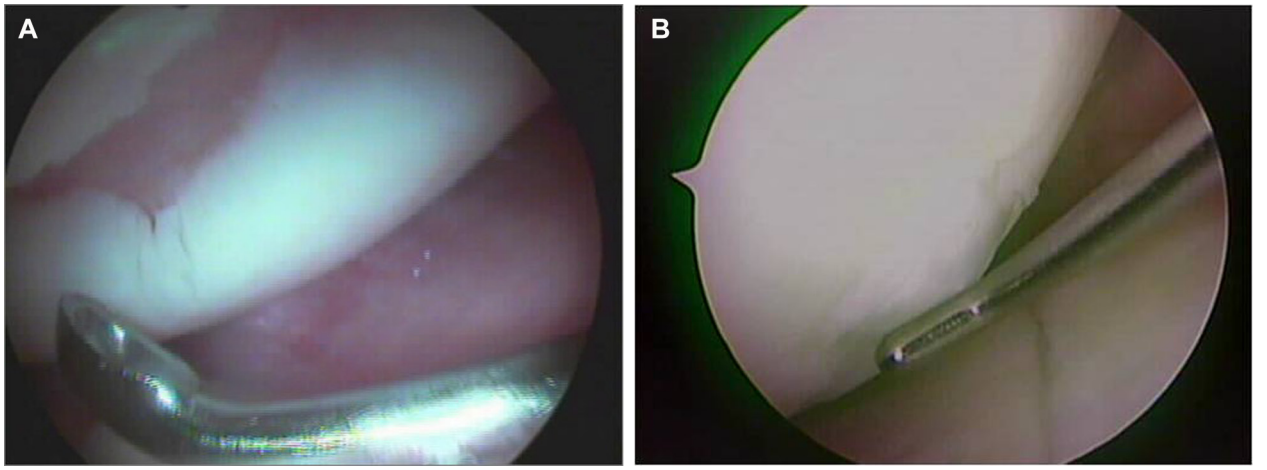

Figure 1. Medial femoral condyle cartilage defect in a 27-year-old professional footballer (**A**) and the same defect 18 months following microfracture (**B**).

football players reported normal or nearly normal knee function in 42% of operated players at 6 months with subsequent gradual increase to 100% after 18 months.[19] After initial significant improvement, decreasing activity scores were observed in 36% of the studies between 24 to 60 months postoperatively. However, the decreased activity scores were still higher than the preoperative scores. Return to sports participation including football was achieved in 67% ± 6% (range, 44%-100%) after microfracture in athletes. Time to return to sports averaged 8 ± 1 months after microfracture. In professional football players, there was a gradual increase of the return rate from 38% at 6 months, to 83% by 12 months, and to 100% after 18 months. Return to sport occurred at the preinjury level in 67% ± 5% of athletes and continued competition at this level in 51% ± 9% 2 to 5 years after microfracture. Sixty-five percent of athletes younger than 40 years of age returned to sports after microfracture compared to 20% of older patients ($P < 0.05$).[20] However, few if any athletes older than 40 years play football at the professional or elite levels. The time between injury and microfracture also significantly affected the ability to return to sport. If athletes were symptomatic ≤1 year before microfracture, the return rate was 67% compared to 14% if preoperative intervals were longer ($P < 0.01$).[20] Eighty-six percent of athletes undergoing microfracture as a first-line procedure were able to return to sport compared to 33% with prior surgeries ($P < 0.01$).[20] Lesion size of <2 cm^2 was associated with a significantly higher rate of return after microfracture ($P < 0.05$).[20,21] Return to sports was significantly better in high-level competitive athletes (71%) than recreational athletes (29%) after microfracture ($P < 0.01$). Concurrent surgical procedures such as reconstruction of the anterior cruciate ligament (ACL) were associated with better results when performed with microfracture.[14] While all athletes with normal or nearly normal macroscopic repair tissue morphology were able to return to preinjury activity levels, only 36% of athletes with abnormal repair tissue morphology were able to return ($P < 0.001$). Histological evaluation showed predominantly fibrohyaline hybrid repair tissue without association between histological tissue quality and return to sport.[19,21-24]

Case Series

The senior author (R.J.S.) identified 21 consecutive professional soccer players who underwent microfracture between 1996 and 2009. All players were male, and the average age of the player was 27 years (range, 18-32 years). There were 11 midfielders, 2 forwards, and 8 defenders. They had been playing soccer an average of 14 years prior to their inciting injury. Two players had concomitant ACL injuries and required ACL reconstruction. Three players had medial femoral condyle lesions, 7 had lateral femoral condyle lesions, 1 had a lateral tibial plateau lesion, and 1 had a patella lesion. The remaining 9 players had combined lesions. Two patients had a medial femoral condyle lesion and a lateral femoral condyle lesion, 2 had medial femoral condyle and trochlear groove lesions, 2 had lateral femoral condyle and patella lesions, 1 had lateral femoral condyle and trochlear groove lesions, and 2 had kissing lesions in the lateral compartment.

Twenty of the 21 (95%) players returned to professional soccer the season following their microfracture surgery. The one player who did not return was the oldest player of the cohort at age 32 years. He had been playing soccer for 25 years prior to his most recent inciting injury. The players

who did return to professional soccer continued to play an average of 5 years (range, 1-13 years) (**Fig. 1**). Years of continued play negatively correlated with years of age (r = –0.41). Prior to microfracture, the players appeared in an average of 32 matches, and following microfracture, the players appeared in an average of 28 matches ($P > 0.05$).

Discussion

Articular cartilage injuries are observed with increasing frequency, and microfracture presents one of the most frequently used surgical techniques for their treatment.[2,11] The present article describes the basic science behind the microfracture technique and the rationale for the rehabilitation protocol. The systematic review of the literature revealed a high percentage of good and excellent ratings and increased knee function and activity scores, thus confirming that microfracture improves activity levels even under high mechanical demands in the sports and football population. Following the initial improvement, 38% of the reviewed studies reported a decrease in activity scores 2 to 5 years after microfracture.[20,21,23-25] Despite the observed average score decrease, activity and function remained improved compared to preoperative function status in these athletes. The reasons for the observed functional decline are thought to be multifactorial. Deterioration of knee function occurred primarily in athletes with poor repair cartilage morphology and fill after microfracture, emphasizing the importance of repair cartilage volume on durability of postoperative improvement after microfracture.[22,26] Increasing age in these athletes must also be considered.[27] The functional decrease observed after microfracture in some athletes certainly requires further systematic study, but the fact that 72% of studies did not report any functional deterioration supports the durability of the technique even under high demands.

Our study confirms that microfracture can successfully return athletes with knee articular cartilage defects to demanding, high-impact sports participation like football. The observed average return rate of 66% after microfracture is comparable to return rates of 71% after ACL reconstruction and 74% after meniscal repair.[28,29] Analysis of return to sport after microfracture provides important information for the perioperative management of the athlete and his postoperative expectations. The observed variability in the return rates between the individual studies is also observed for the other sports medicine procedures and can be attributed to multiple factors. Patient compliance with strict rehabilitation protocols is critical for success in the athlete population. It is also difficult to compare return to sport between multiple studies. The definition of return to sport may be different among studies. Other factors, such as other injuries, contract negotiations, and competition level, will also determine if a player returns to play. Considering all these factors and the marked mechanical demands placed on the repaired cartilage defects in high-level competitive athletes, the better than average return rate in competitive athletes is encouraging. Earlier diagnosis, surgery with less delay, better access to rehabilitation, and personal motivation all may be factors that promote the better rate of return in this competitive population. However, return to sport may not immediately equate to return to performance at the preinjury level, but performance levels may develop gradually with increasing competition.[30,31] Some athletes may experience persistent performance limitations after returning to sport, a phenomenon that has been observed after many different orthopaedic procedures. This performance lag may result from incomplete recovery of sport-specific fitness, quadriceps inhibition, pain, joint effusion, and altered joint proprioception that is still present at the time of return to high-impact sports.[32,33] The reasons why athletes return to sports and continue participation are certainly complex, and further study is needed to systematically evaluate the influence of clinical and nonclinical factors on sports participation after articular cartilage repair with microfracture.

Several factors were found to affect the return to play after microfracture. The athlete's age may significantly affect sports participation after microfracture. Qualitative and quantitative age differences in metabolic activity and repair cartilage synthesis offer a biological explanation for this effect. However, other factors such as a slower overall recovery and socioeconomic lifestyle changes also must be considered because they have also been described to have a significant effect on return to sport after other sport-related procedures such as ACL reconstruction.[27,34-36] Delayed surgery with prolonged preoperative intervals had a significant negative influence on the return rate after microfracture with a 5-fold better return rate if surgery was performed within 12 months after cartilage injury.[20] Development of an unfavorable degenerative joint environment and prolonged absence from athletic activity may explain the decreased rate of sports participation after delayed microfracture.[22] This observation is also consistent with the better results found in athletes who underwent microfracture as a primary procedure.[20] More rapid diagnosis, earlier surgery, better access to postoperative rehabilitation, and socioeconomic factors may also explain the higher return rate in professional compared to recreational players. Our findings from the systematic literature review emphasize the critical importance of early surgical intervention for articular cartilage injury in the football player's knee to optimize successful return to play.

Postoperative care and the rehabilitation protocol are critical to successful outcomes following microfracture. To optimize the results of microfracture, the rehabilitation program should be followed closely. The rehabilitation protocol promotes the optimal physical environment for the undifferentiated mesenchymal progenitor cells to differentiate

and produce new extracellular matrix that eventually matures into durable repair tissue. The surgically induced marrow clot provides the basis for the most ideal chemical environment to complement the physical environment.[13,16,17] This newly proliferated repair cartilage then fills the original defect. The specific protocol recommended depends on both the anatomic location and the size of the defect. These factors are critical to determine the ideal postoperative plan (**Table 1**).

The senior author's experience and outcomes in the case series of professional soccer players reported above as well as his previously reported experience and outcomes with professional American football players[32] show a higher rate of return to sport compared to the other reports referenced in this article. We believe that these improved results are testament to the meticulous lesion preparation,[16] strict adherence to the refined surgical techniques, and the rigorous and scientifically based[17] rehabilitation protocol used for patients undergoing microfracture.

In conclusion, articular cartilage repair in the athlete's knee with microfracture provides a high rate of return to sports including football (soccer). Athletes are often able to return to sports participation at the preinjury level, even at the highest competitive levels. Further investigation is warranted to improve our understanding of why athletes do not return to sport or show decreasing knee function and activity levels after initial improvement. Refined definition of the indications, postoperative protocol, and timing for microfracture in high-impact athletes like football players will help further to optimize functional outcomes and ability for return to football after microfracture.

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