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Knee Injuries in Elite Level Soccer Players

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Take-Home Points

- Soccer is one of the most popular sports in the world and has a high incidence of resultant knee injuries.
- Significant, identifiable risk factors put soccer players at risk for serious knee injuries, such as ACL ruptures; age, female sex, and position played influence injury susceptibility.
- ACL injury most commonly occurs via non-contact mechanisms, and female players are at a significantly higher risk of ACL injury than male counterparts.
- The prevalence of osteoarthritis in retired soccer players is high, underscoring the need to be familiar with meniscal and cartilage repair/restoration techniques and associated outcomes.
- The FIFA11+ program reduces injury by 30%, with reported relative risk of 0.70 for lower limb injuries, highlighting the significant preventative importance of this warm-up program.

Soccer is among the most popular sports played worldwide. According to the Fédération Internationale de Football Association (FIFA), an estimated 270 million soccer players are registered worldwide.[1,2] Recreational participation in soccer across the globe probably increases the number of soccer athletes substantially.[2] Although injury rates may be lower than those experienced by American football players, it is clear that soccer-related injuries continue to remain among the highest experienced by athletes.[3] As such, the significant impact of lower extremity injuries, particularly to the knee, is of major interest to those involved in the care of these athletes. An alarmingly increasing trend of anterior cruciate ligament (ACL) injuries, among other significant knee injuries, highlights the need to critically review the current state of knee injury care and prevention in soccer players.[4] This article reviews the unique epidemiology of knee injuries in soccer, including ACL and other ligamentous injuries, cartilage and meniscal injuries, degenerative sequelae, and injury prevention initiatives, in soccer athletes.

Epidemiology

There are currently 28 players on each of the Major League Soccer (MLS) teams, and during the 2013 to 2014 academic year, the National Federation of State High School Associations (NFHS) reported that 417,419 boys and 374,564 girls played high school soccer and the National Collegiate Athletic Association (NCAA) reported that 23,602 males and 26,358 females played collegiate soccer.[5] As such, knee injuries in this population are a major concern for those involved in sports medicine. Several injuries occurring during soccer involve the lower extremity, particularly the knee.[1] In fact, multiple reports estimate that up to 17.6% of soccer-related injuries presenting to the emergency room involved the knee.[1,6-9] The majority of these injuries are noncontact injuries, although contact injuries do still occur.[10,11]

Risk factors for injuries in soccer may be non-modifiable (such as age and gender) and modifiable (such as level of conditioning, force, balance, and flexibility). Inadequate lower motor coordination may result in injury in the adolescent population, and advanced age >28 years in males and >25 years in females is considered as a high-risk factor for injury.[12,13] Importantly, gender and age have been reported to play a significant role as risk factors for ACL injury.[6] In fact, female players have a 3 to 5 times higher risk of significant knee injury, including ACL injuries, than male players.[4,14-16] Preventative programs such as the FIFA 11+ program have been set forth to augment conditioning as part of managing the modifiable risk factors.

Like American football, playing on artificial turf has been questioned as a contributor to injury compared to playing on natural grass.[17,18] In recent years, newer generations of artificial turf have been developed to more closely replicate the characteristics of natural grass. Meyers[19] compared the incidence, mechanisms, and severity of match-related collegiate men's soccer injuries on artificial turf and those on natural grass and demonstrated no significant difference in knee injuries between the 2 surfaces. This finding was consistent with previous studies that reported no difference in the incidence of knee injuries on either surface in women's collegiate and elite-level soccer.[15,20,21]

ACL Injuries

ACL injuries are life-changing events that can significantly affect the career of a soccer athlete. As a major stabilizer of the knee, the ACL primarily prevents anterior tibial translation with the anteromedial bundle and secondarily resists tibial rotation with the posterolateral bundle. The ligament takes origin from the posteromedial aspect of the lateral femoral condyle and inserts anterior to the tibial intercondylar eminence. Grading of ACL injuries is based on the Lachman test, which is performed between 20°and 30° of knee flexion and measures the amount of anterior tibial translation relative to the femur (A = firm endpoint, B = no endpoint; grade I: 3-5 mm, grade II (A/B): 5-10 mm, grade III (A/B): >10 mm).

ACL injury may occur via contact or noncontact mechanisms. Noncontact mechanisms of ACL injury in soccer athletes contribute to about 85% of injuries.[6,22-25] Typical noncontact mechanism of injury involves a forceful valgus collapse with the knee near full extension and combined external or internal rotation of the tibia[23,26] (**Figure 1**). This on-field scenario generally involves cutting and torsional movement, as well as landing after a jump, particularly in 1-legged stance. Similarly, a disturbance in balance caused by the opponent may incite a noncontact mechanism resulting in ACL rupture.[6,27] Video analyses of professional soccer players have also demonstrated a higher risk of noncontact ACL injury within the first 9 minutes of the match, with the most common playing situation resulting in injury being pressing, followed by kicking and heading.[24,25,28] Contact mechanisms resulting in ACL injury, however, are not an uncommon occurrence in soccer players with higher risk

for certain positions. Brophy and colleagues[29] reviewed ACL injuries in professional and collegiate soccer players and reported a higher risk of ACL injury during defending and tackling. Similarly, Faude and colleagues[30] found the risk of injury to be higher in defenders and strikers than in goalkeepers and midfielders.

Female athletes participating in elite-level athletics, especially soccer, represent a high-risk group for ACL injury. In fact, these soccer athletes experience ACL injury at an incidence 3 times higher than that in male athletes.[31-35] Female soccer athletes may also be at risk for reinjury to the ACL and contralateral ACL injury. Female gender, in combination with participation in soccer, thus represents a high-risk group for ACL tear in athletics. Allen and colleagues[36] retrospectively reviewed 180 female patients who had undergone ACL reconstruction (ACLR) (90 soccer players and 90 non-soccer players) over a mean period of 68.8 months. In their series, soccer players sustained significantly more ACL injuries than non-soccer players, including graft failures (11% vs 1%) and contralateral ACL tears (17% vs 4%).

ACLR is the gold standard treatment for elite soccer athletes. A recent survey of MLS team orthopedic surgeons revealed several important details regarding decision-making in ACLR in this population. From a technical standpoint, the vast majority of surgeons used a single incision, arthroscopically assisted, single-bundle reconstruction (91%). Femoral tunnel drilling was almost equally split between transtibial (51%) and use of an accessory medial portal (46%). Bone-patella-tendon-bone (BPTB) autograft was the most preferred graft choice (68%), and quadriceps tendon autograft was the least preferred. The majority of surgeons preformed ACLR within 4 weeks and permitted return to sport (RTS) without restrictions at 6 to 8 months.[37]

There is a scarcity of literature regarding the use of soft tissue and BPTB allografts in soccer athletes. However, one study reported no difference in patient-reported outcomes and return to preinjury level of activity (including soccer) with the use of either autograft or allograft BPTB in ACLR.[38] The authors' preference was to avoid the use of allograft in elite-level soccer athletes as the reported rate of ACL re-tear was 4 to 8 times higher than that with autograft reconstruction, as shown in athletes and military personnel.[39,40] BPTB autograft and hamstring autograft (semitendinosus and/or gracilis) are common graft choices for soccer athletes. Gifstad and colleagues[41] compared BPTB autograft and hamstring autograft in 45,998 primary ACLRs performed in Scandinavia. Although the cohort included, but was not limited to, soccer players, the authors reported an overall risk of revision that was significantly lower in the BPTB autograft group than in the hamstring autograft group (hazard ratio, 0.63; 95% confidence interval, 0.53-0.74).[41] Mohammadi and colleagues[42] prospectively compared the functional outcomes of 42 competitive soccer players who underwent ACLR with BPTB autograft vs those who underwent ACLR with hamstring autograft at the time of RTS. Players who had undergone ACLR with hamstring autograft demonstrated greater quadriceps torque, as well as better performance with triple-hop, crossover-hop, and jump-landing tests; however, both groups demonstrated similar hamstring torque and performance in 2 other hop tests.[42] In the authors' opinion, there may be a concern regarding the use of hamstring autograft in elite soccer players considering that hamstring strains are extremely common in this athletic population; however, further research would be necessary to elucidate whether this is an actual or a theoretical risk. Although not yet studied in elite-level athletes, early clinical results of ACL repair with suture augmentation show promise for certain injury patterns. These include proximal femoral ACL avulsion injuries (Sherman type 1) of excellent tissue quality that have the ability to be reapproximated to the femoral origin[43] (**Figures 2A, 2B**). In a recent series,[43-45] early clinical outcomes were found to be excellent and maintained at midterm follow-up.

In the NCAA soccer athletes, an overall RTS rate of 85% has been reported in those undergoing ACLR, with a significantly higher rate observed in scholarship versus non-scholarship athletes.[46] Howard and colleagues[46] reported median time to unrestricted game play of 6.1 months, with 75% returning to the same or higher level position on the depth chart. Among their studied collegiate soccer athletes, 32% reported continued participation in soccer on some level after college (recreational, semiprofessional, or professional).[46] RTS rates for MLS soccer

players have also been reported to be high, ranging from 74% to 77%, most of them returning within the following season at 10 ± 2.8 months.[47,48] These findings were consistent with the RTS rate of 72% reported by the Multicenter Orthopaedic Outcomes Network (MOON) group, which analyzed 100 female and male soccer players undergoing ACLR at a minimum 7-year follow-up. In this series, Brophy and colleagues[29,49] reported an RTS at 12 ± 14.3 months, with 85% returning to the same or a higher level of play prior to their injury. Erickson and colleagues[47] analyzed a series of 57 ACLRs performed in MLS athletes and reported no significant difference in preinjury or postoperative performance, or between cases and uninjured controls. Arundale and colleagues[48] demonstrated no significantly increased risk of lower extremity injury in MLS athletes after ACLR, but the athletes had significantly shorter careers than their uninjured counterparts. Curiously, RTS rates for European professional soccer athletes have been reported to be substantially higher at 95% to 97%.[50,51] Although we can only speculate the reasons for such a discrepancy, the difference in RTS rates for similar athletes highlights a need for objective criteria to determine and report RTS rates, while also providing guidelines to prevent reinjury. Such a consensus among orthopedists is not yet present in the literature.

Soccer players and adolescent age in combination have been shown to portend a 3-fold increased risk of revision surgery for ACL failure in a cohort of 16,930 patients from the Swedish National Knee Ligament Register.[52] Published data regarding ACL failure and management of revision ACLR in elite-level soccer athletes are currently lacking. However, low failure rates of 3% to 10% requiring revision reconstruction have been reported.[47,49] Arundale and colleagues[48] reported 2 incidences of players with ACL graft failures, 1 BPTB autograft and 1 BPTB allograft, both of whom were able to return to MLS after revision ACLR. It is the authors' preference to use ipsilateral hamstring autograft or contralateral BPTB autograft when an ACL revision reconstruction is required.

Other Ligamentous Injuries

The majority of research efforts regarding knee injuries in this population are focused on the ACL. Correspondingly, literature regarding injury to the collateral ligaments and the posterior cruciate ligament (PCL) in soccer players is sparse. The lateral collateral ligament (LCL) and the medial collateral ligament (MCL) play important roles as primary stabilizers to varus and valgus forces, respectively. The PCL is the primary posterior stabilizer of the knee, preventing posterior translation of the tibia. Injury to these structures may result in significant time lost from soccer and risk of reinjury.[53,54]

The MCL is the one of the most commonly injured ligaments in sports, including soccer.[53,55] The injury mechanism generally involves contact with a resulting valgus force applied to the knee.[55] Grading of MCL injuries is based on the amount of medial joint gapping with applied valgus force during examination (grade I: <5 mm, grade II: 5-10 mm, grade III: >10 mm). Kramer and colleagues[53] reviewed collateral ligament injuries in the adolescent population and found that MCL injuries occurred 4 times more often than LCL injuries and about 25% were grade III injuries, most commonly occurring in American football and soccer players. Soccer also touts the highest sport-specific MCL injury rate for high school and collegiate athletics, particularly for female NCAA soccer players.[56] At the professional level, Lundblad and colleagues[55] reported 346 MCL injuries in 27 European teams over an 11-year period, of which 70% were contact-related, and the average time-off from soccer was 28 days.

Most surgeons treat isolated MCL injuries nonoperatively, regardless of grade.[57,58] This includes activity modification, use of a hinged knee brace, quadriceps strengthening, and progressive return to play. The literature currently lacks substantial data to guide MCL injury management, specifically in elite soccer athletes. In our experience, grade I injuries are managed nonoperatively and RTS is allowed at 4 to 6 weeks. Grade II injuries are also managed nonoperatively and RTS is allowed at 6 to 8 weeks. Grade III injuries are generally allowed RTS at 8 to 12 weeks and may be considered for surgery in the context of concomitant injuries (eg, posteromedial capsular

injury, multiligamentous knee injuries, and meniscal injuries). In some athletes, we consider using a varus unloader brace to help maximize decreased stress on the MCL while still allowing the athlete to be fully weight-bearing. We have found it less ideal to limit weight-bearing in elite athletes, which may negatively affect overall lower extremity neuromuscular proprioception and potentially prolong a safe return to play. Some athletes may experience prolonged soreness at the MCL femoral or tibial attachment despite being able to return to play. It is important to counsel athletes about these prolonged symptoms to set expectations, as this may even occur with grade I MCL injuries. Other rare instances where surgical management may be indicated include persistent pain and instability following nonoperative treatment of grade III injuries and highly displaced tibial avulsions of the ligament resulting in poor healing.[59,60]

Data regarding LCL injuries in soccer are extremely sparse. In our experience, treatment and RTS rates for isolated LCL injuries are similar to those for MCL injuries. However, it is worth noting that one-quarter of LCL injuries may occur in combination with injury to other posterolateral corner structures.[53]

PCL injuries are more commonly associated with vehicular trauma but have also been reported to occur in sports at a rate of 33% to 40%.[61,62] The mechanism of injury in athletes generally involves a fall onto the hyperflexed knee with the foot in plantarflexion or a direct blow to the anterior tibia in a flexed knee.[62,63] Classification of PCL injuries is based on posterior translation of the tibia relative to the femur with the knee flexed to 90°(grade I: 1-5 mm, grade II: 6-10 mm, grade III: >10 mm). In one cohort of 62 patients with isolated PCL injuries, soccer was found to be among the top 5 causes of injury.[64] A Scandinavian review of 1287 patients who underwent PCL reconstruction found soccer to be the sport with the highest number of injuries (13.1%).[65] The goalkeeper was most commonly subjected to this injury.[62] Krutsch and colleagues[54] compared PCL injuries in new, professional soccer players to those in players at the closest amateur level of play. In their series, 90% of PCL injuries occurred during preseason in players who were at a lower level of play in the previous season. This finding suggested that a rapid increase in training and playing intensity may have been a significant risk factor for PCL injury. Substantial literature supporting nonoperative or operative management of PCL injuries in soccer athletes is currently lacking. Historically, nonoperative treatment has been the initial management for isolated PCL injuries; however, surgical intervention has become increasingly used for both isolated and combined PCL injuries.[66]

Cartilage and Meniscal Injuries

The prevalence of osteoarthritis (OA) in retired soccer players is high.[67,68] Articular cartilage degeneration with subsequent OA occurs in up to 32% of soccer players and ultimately leads to significant disability and retirement from the sport. High physical demands and concomitant knee injuries probably predispose to the development of posttraumatic OA.[69-71]

Several techniques addressing cartilage débridement or restoration have been reported, with successful RTS but with variable durability.[72-75] Recently, Andrade and colleagues[76] performed a systematic review of 217 articular cartilage defects in soccer players that were treated using restoration techniques, including chondroplasty, microfracture, autologous chondrocyte implantation (ACI), and osteochondral autograft. Although no superior technique could be ascertained, microfracture and osteochondral autograft procedures led to the quickest return to play, and ACI techniques enhanced long-standing clinical and functional results.[76] More recently, osteochondral allograft transplantation has also been described with an 84% return to some level of activity (including soccer) and 60% of athletes returning to high-level sports participation at a mean follow-up of 4.5 years[77] (**Figures 3A-3C**). Although chondroplasty may be successful and allow for a quicker return to play in some soccer players (return to play from 6-12 weeks), the authors believe that a strong cartilage scaffold repair strategy with early weight-bearing, including osteochondral autograft and allograft procedures (return to play from 6-9 months), must

also be considered in focal chondral defects to optimize both short-term and potential long-term success.

Meniscal injuries are also prevalent in the soccer population, and consistent with ACL injuries, female players are at least twice as likely to sustain a meniscal tear.[78,79] Meniscal damage can occur in isolation or in association with ACL rupture. Repair techniques should be strongly considered as chondral changes in the setting of meniscal deficiency are a significant short- and long-term concern for elite athletes. However, due to intrinsically poor healing potential, partial meniscectomy is unfortunately more often performed.[79,80] In either case, meniscal deficiency is recognized as a precursor to the development of OA as meniscal functionality is lost and the articular cartilage is subjected to increased biomechanical loading.[81,82] Nawabi and colleagues[83] analyzed RTS in 90 professional soccer players following partial meniscectomy. Median RTS was at 7 weeks for lateral meniscectomies and at 5 weeks for medial meniscectomies. RTS probability was 5.99 times greater after medial meniscectomy at all time points. Lateral meniscectomies were associated with an increased risk of postoperative adverse events, reoperation, and a significantly lower rate of return to play.[83] In the case of severe meniscal deficiency, particularly post-meniscectomy, meniscal allograft transplantation (MAT) may be considered. In a series of MATs in lower division Spanish players, 12/14 (85.7%) returned to play at an average of 7.6 months.[84] A more recent series of professional players reported 9/12 (75%) RTS as professionals and 2/12 (17%) as semiprofessionals at an average of 10.5 months.[85] The authors' strong preference is to perform meniscus-saving procedures whenever possible. Due to the longer recovery and return to play associated with meniscus repair than partial meniscectomy, most of the soccer players will often prefer to proceed with partial meniscectomy. Despite the ultimate treatment, it is critical that the surgeon and the soccer player have an in-depth conversation concerning the risks and benefits for each procedure and individualize treatment to the individual soccer player accordingly.

Injury Prevention

Given the breadth and the prevalence of soccer-related injuries, the FIFA11+ program was developed in 2006 as an injury prevention measure (**Figure 4**). The warm-up program includes 15 structured exercises emphasizing core stabilization, thigh muscle training, proprioception, dynamic stabilization, and plyometric exercises. The routine is believed to be easily executed and effective at preventing the incidence of noncontact injuries.[86,87] Recently, Sadigursky and colleagues[1] performed a systematic review of randomized clinical trials examining the efficacy of FIFA11+. The authors reported a reduction in injuries by 30% and a relative risk of 0.70 for lower limb injuries, highlighting the significant preventative importance of the program.[1] Post-training programs may also be beneficial as it has been shown that performing FIFA11+ both before and after training reduced overall injury rates in male, amateur soccer players.[88] Regardless of the prevention program, it is critical that every league, team, medical team, and athlete have a thorough injury prevention strategy to help keep players healthy and not wait until they have instead sustained a significant injury.

Conclusion

Knee injuries are common in soccer, with an alarming number of ACL injuries, as well as other significant pathology. Understanding the unique epidemiology, risk factors, treatment, and injury prevention strategies is critically important in helping medical professionals provide care for all levels of elite soccer players.

Key Info

Figures/Tables

Figures / Tables:

roth_soccer_f1.jpg

Figure 1. Anterior cruciate ligament injury involving a forceful valgus collapse with the knee near full extension and combined external or internal rotation of the tibia.

roth_soccer_f2.jpg

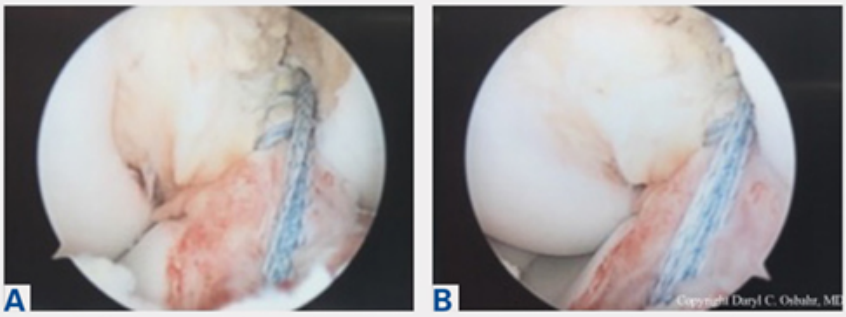

Figure 2. Author's anterior cruciate ligament (ACL) repair technique. (A) Three looped braided polyethylene sutures are passed through the proximal ACL stump, then passed through a small tunnel in the femoral condyle, and fixed via suspensory cortical fixation. (B) Polyethylene tape is included in the suspensory cortical femoral fixation, passed through a small tunnel in the tibial footprint, and fixed with a suture anchor.

roth_soccer_f3.jpg

Figure 3. (A-C) Large femoral condyle osteochondral defect treated with osteochondral allograft transplantation.

roth_soccer_f4.jpg

Figure 4. FIFA 11+ program overview.

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Multimedia

Product Guide

Product Guide

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

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