

Treatment of Anterior Cruciate Ligament Injuries by Major League Soccer Team Physicians

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Background: The treatment and rehabilitation procedures of anterior cruciate ligament (ACL) injuries in elite soccer players are controversial. Points of debate include surgical timing, technique, graft choice, rehabilitation, and return-to-sport criteria and timing.

Purpose: To identify practice preferences among current Major League Soccer (MLS) team orthopaedic surgeons for ACL injuries.

Study Design: Cross-sectional study; Level of evidence, 4.

Methods: The survey was administered at the MLS team physician annual meeting in January 2013. At least 1 orthopaedic surgeon representative from each of the 19 clubs (16 from the United States, 3 from Canada) was in attendance. Teams with more than 1 affiliated orthopaedic surgeon were given an additional survey to be completed either at the meeting or returned via e-mail. Descriptive statistics, Wilcoxon Mann-Whitney (return-to-play parameters, running, and ball drills), and Fisher exact tests (graft selection, bracing, continuous passive motion) were applied to the various data sets from the survey responses.

Results: A 100% survey participation rate was achieved (22 team orthopaedic surgeons representing 19 MLS teams). A single-incision, arthroscopically assisted, single-bundle reconstruction was the most common technique (91%). Surgeons were split regarding femoral tunnel drilling (50% transtibial, 46% accessory medial). Autograft bone-patellar tendon-bone (BPTB) was the most common preferred graft choice (68%). The biggest concerns about BPTB autograft and hamstring autograft were anterior knee pain (76%) and hamstring weakness (46%), respectively. Most surgeons did not recommend postoperative continuous passive motion (64%) or functional bracing (68%). Most surgeons permitted return to sport without restrictions at 6 to 8 months following surgery (82%). Surgeons who routinely used functional bracing after ACL surgery more frequently used hamstring autograft than those who used BPTB autograft ($P = .04$).

Conclusion: This article successfully describes current management of ACL injuries among MLS team orthopaedic surgeons. The preference for single-bundle BPTB autograft is similar to published data in the National Football League and National Basketball Association.

Keywords: ACL; anterior cruciate ligament; soccer; football; Major League Soccer

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The authors have declared that they have no conflicts of interest in the authorship and publication of this contribution.

The Orthopaedic Journal of Sports Medicine, 2(11), 2325967114559892

DOI: 10.1177/2325967114559892

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Soccer is one of the fastest growing sports in the United States, with approximately 20 million registered players and an annual increase in participation of over 20%.^{10,25} Approximately 60% to 80% of severe soccer injuries occur in the lower extremity, most commonly at the knee (29%) or ankle (19%).^{6,9,20} One of the most serious and common knee injuries in soccer is a tear of the anterior cruciate ligament (ACL).^{8,20} A study of elite European soccer demonstrated that a high-level men's team can anticipate 0.4 ACL injuries per season.³⁰ Composed of 19 teams representing the United States and Canada, Major League Soccer (MLS) represents the highest level of professional soccer in North America. There are up to 30 players on the active rosters of teams in MLS and Union of European Football Associations (UEFA) Champions League. Since 2000,

there has been at least 1 ACL tear per year (mean, 4.4 per year) in MLS.¹⁰ Furthermore, this number is increasing significantly with time.¹⁰ If soccer players at the collegiate and semiprofessional levels are included, the prevalence of ACL injury in elite players increases substantially. ACL injuries in soccer have been associated with delayed return to play and may threaten the player's competitive career.^{25,26}

ACL injury practice patterns of other elite North American sports team physicians have been recently reported in the National Football League (NFL), National Collegiate Athletic Association (NCAA), and National Basketball Association (NBA).^{3,12,18} However, these encompass sports inherently different from soccer. Although agility, cutting, and pivoting are necessities in football, basketball, and soccer, there are significant differences in mechanisms of ACL injury in the NFL (more contact injuries) and NBA (no kicking) versus MLS.^{1,3} Return to sport following ACL reconstruction has several important financial implications in elite professional sports, including contracts, scholarships, bonuses, publicity, and endorsements, among others. Thus, players, coaches, agents, teammates, and family will often push the envelope on "cutting-edge surgical techniques" so the player can return to sport as quickly as possible. Therefore, professional team physician surveys are important in that they provide expert opinion on the current management practices of ACL injuries in these high-level athletes. The purpose of this investigation was to determine practice preferences for MLS team orthopaedic surgeons regarding management of ACL injuries in elite soccer players in North America. We hypothesized that single-bundle, bone-patellar tendon-bone (BPTB) autograft, accessory medial portal femoral tunnel drilled ACL reconstruction would be the most commonly utilized technique. We also hypothesized that return to competitive sport would be permitted without a brace after 6 months following surgery, with a normal physical examination, and after successfully completing a combination of various return-to-sport "tests."

MATERIALS AND METHODS

The MLS ACL treatment survey (Figure 1) focused on several aspects of timing, surgical technique, graft choice, bracing, rehabilitation, and return to play in elite soccer players. The survey consisted of 19 questions, several of which were adapted from a previously published survey completed by NFL team physicians regarding American professional football players.³ The survey was administered at the annual meeting of MLS team physicians in January 2013. The MLS team physician society approved the survey. Any responses not collected by the end of the meeting were obtained via e-mail. An "elite soccer player" was defined as a male collegiate, semiprofessional, MLS developmental team member, or MLS professional soccer player.

Descriptive statistics were calculated. Analysis was performed to identify associations between responses to different questions within groups of surgeons with similar practice patterns. Specifically, the surgeon's timing of surgery, graft preference, method of femoral tunnel drilling,

yearly volume of ACL cases, and use of bracing and continuous passive motion (CPM) postoperatively were investigated. The nonparametric analysis included Wilcoxon Mann-Whitney (return-to-play parameters, running, and ball drills) and Fisher exact tests (graft selection, bracing, CPM). These methods were applied to the various data sets from the survey responses. A P value $< .05$ was deemed statistically significant.

RESULTS

A participation rate of 100% was achieved. There was at least 1 orthopaedic surgeon participant from each of the 19 MLS teams. Three teams reported having 2 team orthopaedic surgeons. Therefore, of the 22 possible completed surveys, all 22 (100%) were completed and included in the analysis (Figure 1).

After an ACL tear, most surgeons perform reconstruction within 4 weeks (48% within 2 weeks, 33% at 2-4 weeks) (Figure 2). A single-incision, arthroscopically assisted, single-bundle reconstruction was the most common technique (91%). Surgeons were split regarding femoral tunnel drilling (50% transtibial, 46% accessory medial). Autograft BPTB was the most common preferred graft choice. Ranking of top 5 graft choices reiterated BPTB as the most preferred choice and the autograft quadriceps tendon as the least preferred choice. The biggest concerns about BPTB autograft and hamstring autograft were anterior knee pain (76%) and hamstring weakness (46%), respectively. Most surgeons did not recommend postoperative CPM (64%) or functional bracing (68%). Most surgeons permitted return to sport without restrictions at 6 to 8 months following surgery (82%) (Figure 3). Fifty-nine percent of surgeons felt that at least 80% of players are not only able to return to sport following ACL reconstruction but do so at the preinjury level or higher.

No statistically significant differences were identified between surgeons utilizing transtibial and accessory medial portal drilling for graft selection ($P = .33$), use of functional bracing ($P = .36$), beginning straight-ahead running ($P = .13$), return to noncontact ball drills ($P = .30$), or return to full play ($P = .36$). Surgeons who preferred BPTB autograft were compared with those surgeons preferring all other graft choices. In this analysis, there were no statistically significant differences with regard to beginning straight-ahead running ($P = .34$), return to noncontact ball drills ($P = .27$), or return to full play ($P = .32$). Surgeons who preferred hamstring autograft were also compared with those surgeons preferring all other graft choices. In this analysis, no statistically significant differences were identified with regard to beginning straight-ahead running ($P = .58$), return to noncontact ball drills ($P = .77$), or return to full play ($P = .23$). Surgeons who routinely used functional bracing after ACL surgery did have a statistically significant difference in graft selection, with brace use being more common in those using hamstring autograft ($P = .04$). There were no statistically significant differences between high-volume (>50 ACL reconstructions per year) and low-volume (<50 ACL reconstruction per year)

1. If an elite soccer player sustains an isolated acute tear of the ACL, how long do you prefer to wait until surgery is performed?
 - a. Immediate surgery (4.8%)
 - b. 1-2 weeks (48%)**
 - c. 2-4 weeks (33%)
 - d. 4-6 weeks (14%)
 - e. >6 weeks (0%)
 2. What is your preferred surgical technique for performing ACL reconstruction in an elite soccer player?
 - a. Single-incision, arthroscopic-assisted single bundle (91%)**
 - b. Single-incision, arthroscopic-assisted double bundle (0%)
 - c. Two-incision, arthroscopic-assisted single bundle (4.5%)
 - d. Two-incision, arthroscopic-assisted double bundle (0%)
 - e. Open, mini-arthrotomy reconstruction (0%)
 - f. Other ____ (0%)
 3. What is your preferred surgical technique for reaming the femoral tunnel in an elite soccer player?
 - a. Transtibial (50%)**
 - b. Accessory medial portal (46%)
 - c. Outside-in (0%)
 - d. Two-incision (4.5%)
 4. What is your preferred ACL graft choice in elite soccer players?
 - a. Autograft BTB (68%)**
 - b. Autograft quadrupled hamstring tendons (18%)
 - c. Autograft quadriceps tendon (0%)
 - d. Allograft BTB (9%)
 - e. Allograft Achilles tendon (0%)
 - f. Other ____ (4.5%)
 5. Please rank the following graft choices (1-5) based on your preference for use in soccer players.

___ **Autograft BTB (avg 1.4)**

___ Autograft quadrupled semitendinosus-gracilis (avg 2.5)

___ Autograft quadriceps tendon (avg 4.2)

___ Allograft BTB (avg 3.0)

___ Allograft Achilles tendon (avg 3.7)
 6. What is your biggest concern if using autograft patellar tendon (BTB) in a soccer player?
 - a. Anterior knee pain including, but not limited to, pain with kneeling (76%)**
 - b. Quadriceps weakness from insult to the extensor mechanism (14%)
 - c. Graft failure – rupture or loss of fixation (0%)
 - d. Other ____ (9.5%)
 7. What is your biggest concern if using autograft quadrupled semitendinosus-gracilis tendons in an elite soccer player?
 - a. Hamstring weakness (46%)**
 - b. Graft strength (4.5%)
 - c. Graft loosening or rupture (41%)
 - d. Tunnel widening (0%)
 - e. Other ____ (0%)
 8. Do you think that allografts have an increased rate of failure, compared to autografts, in elite soccer players?
 - a. Yes (73%)**
 - b. No (37%)
 9. Do you use CPM following ACL reconstruction in soccer players?
 - a. Yes (36%)
 - b. No (64%)**
- For Questions 10-12:** The following questions refer to rehabilitation following ACL reconstruction and assume that the player has achieved full range of motion, strength, and has no effusion.
10. During which time do you allow them to begin straight ahead running?
 - a. <3 months (27%)
 - b. 3-4 months (64%)**
 - c. 4-6 months (9%)
 - d. 6-8 months (0%)
 - e. 8-10 months (0%)
 - f. >10 months (0%)
 11. At what point do you allow them to begin noncontact ball handling and/or ball drills?
 - a. 2-4 months (37%)
 - b. 4-6 months (59%)**
 - c. 6-8 months (4.5%)
 - d. 8-10 months (0%)
 - e. >10 months (0%)
 12. At what point following surgery do you allow an elite soccer player to return to play without restrictions?
 - a. <4 months (0%)
 - b. 4-6 months (9%)
 - c. 6-8 months (82%)**
 - d. 8-10 months (9%)
 - e. >10 months (0%)
- For Questions 13-15:** The following questions refer to use of functional braces following ACL reconstruction.
13. Do you routinely recommend use of a functional brace? (circle)
 - a. Yes (32%)
 - b. No (68%)**
 14. If Yes to Question 13, at which point in time do you initiate the brace?
 - a. <8 weeks (0%)
 - b. 2-3 months (25%)
 - c. 4 months (37%)**
 - d. 5-6 months (25%)
 - e. >6 months (13%)
 15. If Yes to Question 13, 14, for what duration?
 - a. <8 weeks (0%)
 - b. 2-4 months (0%)
 - c. 4-6 months (25%)
 - d. 6-12 months (75%)**
 - e. >12 months (0%)
 16. In your experience, what percentage of elite soccer players return to play after an ACL reconstruction?
 - a. <10% (0%)
 - b. 10-20% (0%)
 - c. 20-40% (0%)
 - d. 40-60% (4.5%)
 - e. 60-80% (37%)**
 - f. 80-90% (32%)
 - g. >90% (27%)
 17. In your experience following ACL reconstruction, what percentage of players eventually return to play at their prior level of performance (or greater) when compared to their pre-injury level?
 - a. <10 % (0%)
 - b. 10-20% (0%)
 - c. 20-40% (0%)
 - d. 40-60% (4.5%)
 - e. 60-80% (37%)**
 - f. 80-90% (32%)
 - g. >90% (27%)
 18. Approximately how many ACL reconstructions do you perform per year?
 - a. <25 (0%)
 - b. 25-50 (23%)
 - c. 50-100 (37%)**
 - d. 100-200 (32%)
 - e. >200 (9%)
 19. Approximately how many ACL reconstructions do you perform per year specifically on soccer players of all levels?
 - a. <10 (0%)
 - b. 10-25 (32%)
 - c. 25-50 (37%)**
 - d. 50-100 (27%)
 - e. 100-200 (4.5%)
 - f. >200 (0%)

Figure 1. Anterior cruciate ligament injuries in Major League Soccer (MLS): current treatment trends among team physicians. For the purposes of this survey, elite soccer player is defined as a male college, semiprofessional, MLS developmental team member, or professional soccer player. ACL, anterior cruciate ligament; BTB, bone–patellar tendon–bone; CPM, continuous passive motion.

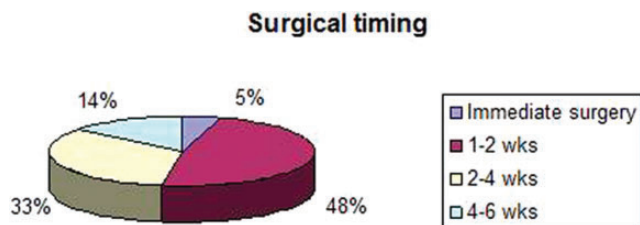


Figure 2. Time from anterior cruciate ligament injury to surgery preference in Major League Soccer team physicians.

surgeons with regard to graft selection ($P = .26$), use of functional bracing ($P = .99$), beginning straight-ahead running ($P = .77$), return to noncontact ball drills ($P = .09$), or return to full play ($P = .32$).

DISCUSSION

ACL tears in MLS players are significant injuries. This survey of MLS team orthopaedic surgeons, with a 100% response rate, has revealed several important findings. Nearly all surgeons prefer an autograft (86%), single-incision, single-bundle technique (91%), partially confirming the investigation's hypothesis. Although 76% of surgeons cite anterior knee pain as their biggest concern regarding BPTB autograft, it was the most preferred choice overall (68%). Surgeons nearly equally selected transtibial (50%) and accessory medial portal (46%) femoral tunnel drilling, rejecting the investigation's hypothesis. Most surgeons permit elite soccer athletes to return to sport without restrictions at 6 to 8 months following surgery (82%) and without a brace (68%). Over half of the surgeons surveyed (59%) felt that at least 80% of players return to sport at or above their preinjury levels of performance.

The number of reported ACL tears in elite professional athletes may be increasing with time (MLS, NBA, NHL).^{10,18,19} Although one can speculate on the reasons for this trend regarding changes in player and/or game characteristics (or simply, more transparency in reporting of player injuries in the media), no proof has been substantiated to date. This increase, illustrated in not just professional soccer, is present in many different cutting and pivoting sports. Thus, identifying the optimal treatment for these athletes is of paramount importance. Although not a randomized controlled trial, this survey investigation of expert opinions demonstrates an accumulation of over 200 years of anecdotal experience in managing ACL tears.

There are only 2 similar studies in the peer-reviewed literature that examine ACL injury management practice patterns in elite athletes, and both are on NFL team physicians.^{3,12} The more recent study¹² surveyed NFL and NCAA Football Bowl Subdivision team orthopaedic surgeons. The latter concluded that most surgeons, for elite NFL or NCAA running backs, perform a single-bundle (99.3%), single-incision, BPTB autograft (86.1%) using an accessory medial portal (67%). Further, at least 55% of surgeons required a postoperative minimum of 6 months,

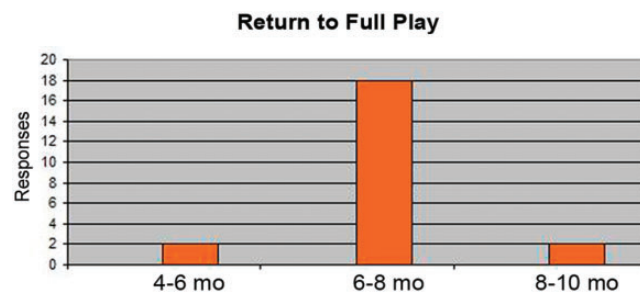


Figure 3. Timing of permission to return to sport without restriction in Major League Soccer by team physicians.

normal physical examination, or successful completion of return-to-sport ACL tests (35% required all 3). That study also queried the survey participants regarding their preferred graft choice in 25- and 35-year-old recreational athletes. Interestingly, only 50% and 15% of surgeons chose a BPTB autograft in these populations, respectively.

The current investigation has a few important similarities and differences to Erickson et al.¹² Similarly, both investigations demonstrated a preference for a single-bundle technique. The anatomy, biomechanics, and postoperative clinical outcomes after single- versus double-bundle reconstruction have been controversial topics in recent literature. No significant differences have been identified in patient-reported clinical outcomes between the 2 techniques in multiple high-level evidence systematic reviews and meta-analyses.^{7,29,31} Double-bundle reconstruction is a technically difficult surgery to perform, and tunnel coalescence is a potentially catastrophic complication that may jeopardize complete graft function and knee stability.^{16,28}

The use of allograft for any elite soccer player is quite surprising, and it rejected our hypotheses. The rate of ACL retear following allograft reconstruction is significantly higher (4-8 times higher) than autograft reconstruction, including athletes and US military.^{21,22} The survey posed the question, "Do you think allografts have an increased rate of failure, compared to autografts, in elite soccer players?" The responses were surprising here, in that 73% selected "yes" and 27% "no." One possible explanation is the avoidance of graft morbidity (anterior knee pain in BPTB harvest and hamstring weakness in semitendinosus/gracilis harvest). Erickson et al¹² had survey responses from 137 surgeons (vs 22 in the current investigation), and only 1 surgeon selected allograft as a preferred choice.

The method of femoral tunnel drilling is controversial and illustrated well in the current study, as no significant preference was exhibited (50% transtibial, 46% accessory medial portal, 4.5% 2-incision). In the study by Erickson et al,¹² an accessory medial portal was more frequently used (67%) versus transtibial (26%). Accessory medial portal femoral tunnel drilling has been shown to cover more of the native ACL femoral footprint than transtibial drilling has in several biomechanical studies.^{15,24} However, consistent statistically significant and clinically relevant clinical outcomes differences are currently lacking.⁵ If using a

BPTB graft, anatomic femoral tunnel placement using a transtibial technique can be achieved, but this requires meticulous tibial tunnel positioning that is far proximal with little room for error and at the margin of practical.²³ Traditional tibial tunnel placement is likely to result in less anatomic femoral tunnels. If using a hamstring autograft, anatomic femoral tunnel placement may not be possible using a transtibial technique given the constraints imposed by the smaller tunnel size than with BPTB grafts.²⁷ Given these biomechanical and clinical studies, our hypotheses were rejected. We cannot speculate as to the reason for this selection distribution.

Although ACL reconstruction is one of the most frequently performed surgeries in the US, there is a clear lack of consensus in objective criteria to permit return to sport among surgeons. In a recent systematic review investigating only the highest level of evidence in ACL reconstruction (all randomized clinical trials reporting minimum 2-year follow-up after ACL reconstruction [49 trials; 4179 subjects; mean age, 28 years; 96% used autograft and 87% were single-bundle reconstructions]), only 5 studies (10%) reported whether athletes were able to successfully return to sport.¹⁷ Ninety percent and 65% of studies failed to use objective criteria or any criteria, respectively, to permit return to sport. Twenty-four percent of studies failed to report when subjects were allowed to return to sport without restrictions. Overall, 39% of studies permitted running at 3 months, 45% of studies permitted cutting and pivoting at 6 months, and 51% of studies permitted return to sport without restrictions at 6 months. These findings coincide with the results from the current investigation's survey. Nonetheless, these aforementioned limitations are found within the highest quality literature of the most studied topic in orthopaedic surgery and sports medicine. These deficiencies have prompted investigators to better design, conduct, and report investigations on ACL reconstruction.

The rate of return to sport in elite professional sports ranges from 70% to 100%.^{10,11,17-19} On average, players return to competitive sport at 7.8 to 13 months following surgery.^{10,11,18,19} Most players (83%-100%) return the season following surgery.^{10,11,18,19} Although many athletes analyzed in these studies are still playing competitively, overall length of career is 4.0 to 4.9 years.^{10,11,18,19} Most players are able to successfully return to sport at their preinjury levels of performance, with very few, if any, significant differences between control athletes.^{10,11,18,19} However, the definition of "preinjury level of performance" is variable. Regardless, from this study's survey, the majority of team orthopaedic surgeons believe that elite soccer players are able to return successfully to preinjury levels of sport (95% of surgeons believe that at least 60% return at preinjury level, 59% of surgeons believe that at least 80% return at preinjury level). This is consistent with Erickson et al,¹⁰ who reported the largest number of ACL reconstructions in MLS (57 knees) with a 77% return-to-sport rate and no significant differences in performance preinjury and postoperatively or between cases (ACL reconstruction players) and controls (age-, sex-, body mass index-, position-, performance-, and MLS experience-matched). The Multicenter Orthopaedic Outcomes

Network (MOON) group published outcomes of 100 male and female soccer players undergoing ACL reconstruction at mean 7-year follow-up.⁴ They found a return-to-sport rate of 72%, similar to that of Erickson et al.¹⁰ The latter results of Brophy et al⁴ and Erickson et al¹⁰ illustrate North American teams, which are apparently less successful in rate of return to sport versus European teams. Zaffagnini et al,³² in a European study of 21 professional male soccer players, reported a 95% return-to-sport rate at preinjury level. We are unable to speculate as to the reason for a higher rate of return to sport in European versus American soccer. Although one can hypothesize the reason(s) based on technique, graft choice, or rehabilitation, among others, no consistent geographic trend has been demonstrated. Whether the limitations on return to soccer are perceived and/or actual is irrelevant. Once an athlete is cleared to return to sport, certain physical (strength, motion, or stability) and psychological (fear of reinjury or kinesiophobia) factors may play a role in ability to achieve preinjury level of sport while concurrently avoiding reinjury.^{13,14} Ardern et al² demonstrated that significant independent contributors to return to play include psychological readiness to return to sport, fear of reinjury, sport locus of control, and the athlete's estimation of the number of months it would take to return to sport. Elite professional athletes may have the largest incentive to return to sport quickly and at the highest level without any reduction in performance. Scholarships, contracts, bonuses, trade deadlines, media exposure, and performance statistics and records, among numerous other tangible and intangible factors, surely play a role. In the last 3 studies, however, a common theme was observed: a trend for decreased return to soccer over time following ACL reconstruction.^{4,10,32}

Strengths of this investigation include the 100% full participation from all 19 MLS teams in the United States and Canada. This is a very unique select group of team physicians treating elite athletes. Although the data are considered level 5 evidence, the expert opinions of surgeons treating these athletes with over 200 years of cumulative experience is not without merit. However, the exact number of ACL reconstructions performed for each participating surgeon was unknown, and the treatment of MLS players does not, in and of itself, define a surgeon as an expert. Limitations of the investigation also include analysis of only male soccer players and at an exclusive elite professional level. Future practice preference surveys should include evaluation of female soccer players (National Women's Soccer League), and those at collegiate and other elite amateur levels. The test administration was with paper and pencil, with fewer potential errors versus those seen with digital accidental "clicking" with online surveys. This survey did not address concomitant pathologies in the knee such as meniscal tears, articular cartilage injuries, other ligamentous injury(ies), and malalignment. The survey inquired the timing of surgery following injury as a quantitative, which is not always consistent, rather than a qualitative value, such as effusion, motion, strength, and pain, which may be better used to evaluate an athlete's readiness for surgery. Other rehabilitation guidelines similarly asked the number of

months for timing of return to straight-ahead running, non-contact drills, and return to play without restrictions rather than the completion of functional assessments and evaluations. Furthermore, it did not analyze fixation techniques, knee flexion level at time of fixation, notchplasty effects, use of platelet-rich plasma, or graft diameter, among others. It did not analyze the effect of surgeon experience (number of years) on selection of technique. Further, this study did not analyze the actual clinical outcomes including physical exam findings, radiographs, magnetic resonance imaging, complications, reoperations, clinical outcome general health, quality of life, and limb- or knee-specific outcome scores. The lack of finding significant differences in specific survey responses may be due to the low number of surgeon participants (beta error). The arbitrary dichotomization of high- and low-volume ACL surgeons (50 ACL reconstruction threshold) may not be applicable to all countries in which surgeons treat soccer-related ACL injuries.

CONCLUSION

This article successfully describes current management of ACL injuries among MLS team orthopaedic surgeons. The preference for single-bundle, BPTB autograft is similar to published data in the NFL and NBA.

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