Anterior Cruciate Ligament Reconstruction Practice Patterns by NFL and NCAA Football Team Physicians

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Purpose: This study aimed to determine practice patterns for National Football League (NFL) and National Collegiate Athletic Association (NCAA) Division I football team orthopaedic surgeons regarding management of anterior cruciate ligament (ACL) tears in elite, young, and middle-aged recreational athletes. **Methods:** Two hundred sixty-seven NFL and NCAA Division I team orthopaedic surgeons were surveyed through an online survey. A 9-question survey assessed surgeon experience, graft choice, femoral tunnel drilling access, number of graft bundles, and rehabilitation after ACL reconstruction. **Results:** One hundred thirty-seven team orthopaedic surgeons (51%) responded (mean experience 16.75 ± 8.7 years). Surgeons performed 82 ± 50 ACL reconstructions in 2012. One hundred eighteen surgeons (86%) would use bone–patellar tendon–bone (BPTB) autografts to treat their starting running backs. Ninety (67%) surgeons drill the femoral tunnel through an accessory anteromedial portal (26% through a transtibial portal). Only 1 surgeon prefers a double-bundle to a single-bundle reconstruction. Seventy-seven (55.8%) surgeons recommend waiting at least 6 months before return to sport, whereas 17 (12.3%) wait at least 9 months. No surgeon recommends waiting 12 months or more before return to sport. Eighty-eight (64%) surgeons do not recommend a brace for their starting running backs during sport once they return to play. **Conclusions:** BPTB is the most frequently used graft for ACL reconstruction by NFL and NCAA Division I team physicians in their elite-level running backs. Nearly all surgeons always use a single-bundle technique, and most do not recommend a brace on return to sport in running backs. Return to sport most commonly occurs at least 6 months postoperatively, with some surgeons requiring a normal examination and normal return-to-sport testing (single leg hop).

There are currently 32 teams in the National Football League (NFL) and 123 National Collegiate Athletic Association (NCAA) Division I Football Bowl Subdivision (FBS) college football teams. This totals nearly 12,000 elite players annually (1,696 NFL—roughly 53 players per team and 10,400 NCAA FBSs—roughly 85 players per team). Further, the number of participants in elite-level football continues to rise with the increasing number of NFL and NCAA teams. The total revenue in 2011 for the NFL alone was $9 billion,[1] whereas for the NCAA it was 871 million.[2] There are approximately 400 to 500 knee injuries each year.[3] These numbers are proportionately higher than for other sports because football players are at significant risk for both contact and noncontact injuries.[4]

There are more than 200,000 ACL tears occurring annually in the general population of the United States.[3] Dragoo et al.[5] recently showed the incidence of anterior cruciate ligament (ACL) tears in NCAA athletes to be 1.42 per 10,000 athletic exposures (defined as 1 student athlete participating in 1 practice or competition in which there was the possibility for athletic injury, regardless of the duration of that participation).[5] The optimal ACL reconstruction technique for these elite athletes has yet to be definitively determined. Although Bradley et al.[3] did determine that most (84%) NFL team physicians use bone–patellar tendon–bone (BTPB) autografts in their ACL reconstructions, this study did not address femoral tunnel drilling or single- versus double-bundle techniques, as well as several

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Table 1. Nine-Question Survey

1. In your career, how many years have you performed ACL reconstructions?
2. In 2012, approximately how many ACL reconstructions did you perform?
3. During ACL reconstruction for a 20-year-old starting NCAA Division 1 or NFL running back, what is your preferred graft choice?
   a. Bone–patellar tendon–bone (BPTB) autograft
   b. BPTB allograft
   c. 4-strand semitendinosus-gracilis autograft
   d. Quadriceps tendon autograft
   e. Achilles tendon allograft
   f. Anterior tibial allograft
   g. Other (please specify)
4. During ACL reconstruction for a 25-year-old recreational athlete, what is your preferred graft choice?
   a. BPTB autograft
   b. BPTB allograft
   c. 4-strand semitendinosus-gracilis autograft
   d. Quadriceps tendon autograft
   e. Achilles tendon allograft
   f. Anterior tibial allograft
   g. Other (please specify)
5. During ACL reconstruction for a 35-year-old recreational athlete, what is your preferred graft choice?
   a. BPTB autograft
   b. BPTB allograft
   c. 4-strand semitendinosus-gracilis autograft
   d. Quadriceps tendon autograft
   e. Achilles tendon allograft
   f. Anterior tibial allograft
   g. Other (please specify)
6. During ACL reconstruction for your starting running back, do you prefer femoral tunnel drilling through an anteromedial portal or a transtibial portal?
   a. 2-incision
   b. Transtibial
   c. Anteromedial
7. During ACL reconstruction for your starting running back, do you prefer single-bundle or double-bundle ACL reconstruction?
   a. Single bundle
   b. Double bundle
8. After ACL reconstruction in your starting running back, what criteria do you use to permit return to sports in a regular season competitive game–type setting? Please select all answers that apply.
   a. After a minimum of 6 months postoperatively
   b. After a minimum of 9 months postoperatively
   c. After a minimum of 12 months postoperatively
   d. After normal range of motion, no pain, full strength, and subjective stability are present
   e. After a set of "return-to-sport" tests has been completed and passed (e.g., Vail, single-leg hop)
   f. Other (please specify)
9. Once your starting running back has returned to sport after ACL reconstruction, do you recommend use of a knee brace during sport?
   a. Yes
   b. No

other technique points.[3] Controversy still exists as to the ideal technique to treat both high-level and recreational athletes. The elite football athletes we chose to conduct a survey about were running backs. Of all the positions in football, running backs change direction

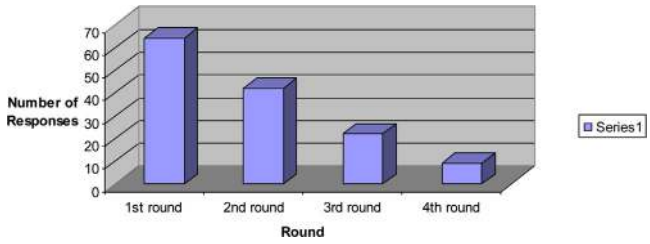

Fig 1. Number of responses per round of survey e-mails.

the quickest and sustain the greatest amount of contact while doing so.[6]

NFL players who have sustained an ACL tear have performed well on return to sport, although the rate of return to sport has been less than optimal.[7] However, because the majority of patients who experience ACL tears are recreational athletes, it is important to elucidate how prominent team orthopaedic surgeons address ACL tears in their recreational athletes as well as their elite athletes.

The purpose of this study was to determine practice patterns for NFL and NCAA Division I football team orthopaedic surgeons regarding management of ACL tears in elite, young, and middle-aged recreational athletes. We hypothesized that BTPB autografts would be the most commonly chosen graft in starting running backs, using a single-bundle technique. We also hypothesized that surgeons would permit athletes to return to sport without a brace at a minimum of 6 months after surgery, with a normal physical examination and after successfully completing a structured battery of return-to-play tests. Finally, we hypothesized that BPTB grafts would be used much more commonly in elite athletes compared with recreational athletes.

Methods

The authors created a 9-question survey (Table 1). The survey was created on the website SurveyMonkey (http://www.surveymonkey.com) and was sent to 267 NFL and NCAA Division I team orthopaedic surgeons. The head of the NFL Physicians Society was notified of and approved this study. The team surgeons were determined by Internet web searches and direct contact with team public relations departments. In 2013, the survey was sent out to the surgeons first on May 16 (round 1), and reminder e-mails were sent May 29 (round 2), June 10 (round 3), and June 17 (round 4) to those who had not yet completed the survey (Fig 1). The responses were kept confidential, and the data were organized through the SurveyMonkey web tool. The surgeons' names were not known to us. The team physicians were instructed to respond to all relevant questions, and the survey was arranged so that the participant could not complete the survey without

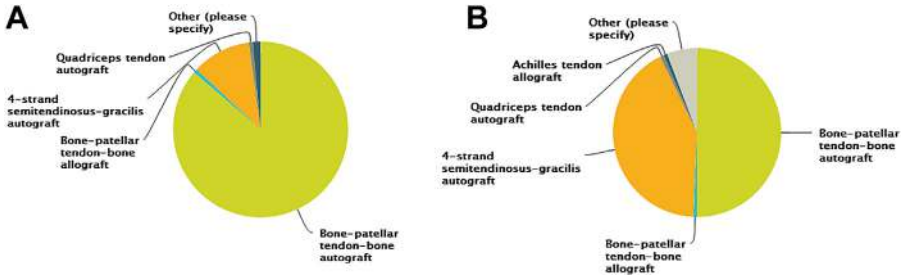

Fig 2. (A) Pie chart of responses to the question: During anterior cruciate ligament (ACL) reconstruction for a 20-year-old starting National Collegiate Athletic Association (NCAA) Division 1 or National Football League (NFL) running back, what is your preferred graft choice? (B) Pie chart showing response to the question: During ACL reconstruction for a 25-year-old recreational athlete, what is your preferred graft choice?

answering all the questions. Descriptive statistics were calculated for each study and parameter analyzed/variable. Continuous variable data were reported as mean ± standard deviation (weighted means when applicable). Categorical data was reported as frequencies with percentages.

Results

The survey was sent to 267 NFL and NCAA Division I football team orthopaedic surgeons' e-mail addresses. One hundred thirty-seven team orthopaedic surgeons (51%) responded (mean experience with performing ACL reconstructions 16.8 ± 8.7 years, range 2 to 33 years). Surgeons performed 82 ± 50 (range 10 to 250) ACL reconstructions in 2012. One hundred thirty-six (99.3%) surgeons chose autografts, whereas 1 surgeon (0.7%) chose allografts (BTBP allograft) for their starting running back (survey question 3) (Fig 2A). Of the surgeons who chose autografts, 118 (86.1%) stated they would choose a BPTB autograft to treat an ACL tear in their starting running back (survey question 3). Sixty-eight (49.6%) surgeons stated they would choose BPTB autografts in their 25-year-old recreational athletes, whereas 58 (42.3%) would use 4-strand semitendinosus-gracilis autografts (survey question 4) (Fig 2B). Sixty-two (45.3%) stated they would use 4-strand semitendinosus-gracilis autografts in their 35-year-old recreational athletes (survey question 5) (Fig 3A).

Ninety (67%) surgeons use an accessory anteromedial portal for drilling the femoral tunnel, 35 (25%) use a transtibial approach, and 12 (8%) use a 2-incision technique (survey question 6) (Fig 3B). Nearly all (99.3%) surgeons always use a single-bundle reconstruction technique (survey question 7). One hundred two (74.5%) permit their starting running back to return to regular season game play after he has undertaken a set of return-to-sport tests and passed them (e.g., Vail, single-leg hop), although 78 (56.9%) require normal range of motion, no pain, full strength, and subjective stability. Seventy-six surgeons (55.47%) wait a minimum of 6 months postoperatively to allow their athletes to return to sport (survey question 8; physicians could choose more than 1 answer for this question) (Fig 4). Forty-eight surgeons (35%) require 6 months to have passed since the operation, with a normal examination and passing return-to-sport tests. Eighty-eight (64.23%) surgeons do not recommend brace use after surgery for their starting running back on return to sport (survey question 9).

Discussion

ACL tears in both recreational and elite athletes are a problem that many orthopaedic surgeons face. All study hypotheses were confirmed—86.1% of surveyed physicians use BPTB autografts as their graft choice when treating their starting running back, 99.3% use the single-bundle technique, 64% do not require a brace on return to sport, and at least 55% require 1 of the following before they allow participation in competitive sport: postoperative minimum of 6 months, normal physical examination, and successful completion of return-to-play tests (35% required all 3 conditions). Finally, 86.23% used BPTB grafts in their elite athletes, whereas only 50% and 15% used BPTB grafts in their 25- and 35-year-old recreational athletes, respectively.

The subject of ACL reconstruction in elite athletes is one that we are very interested in, having evaluated performance and return-to-sport rate in major league soccer players, National Basketball Association players, X-Game players, and so on and finding encouraging results.[8-10] However, these results were limited because the surgical technique and graft choice could not be consistently located for each player. To our knowledge, only 1 previous study, Bradley et al.,[3] has surveyed football team physicians, and the previous study was limited to NFL team orthopaedic surgeons. This is the first study, to our knowledge, to report the current team physician treatments for ACL reconstructions in both professional and FBS collegiate football players by team orthopaedic surgeons. Because the incidence of ACL tears and reconstructions is increasing, it is important to determine the ideal treatment for both

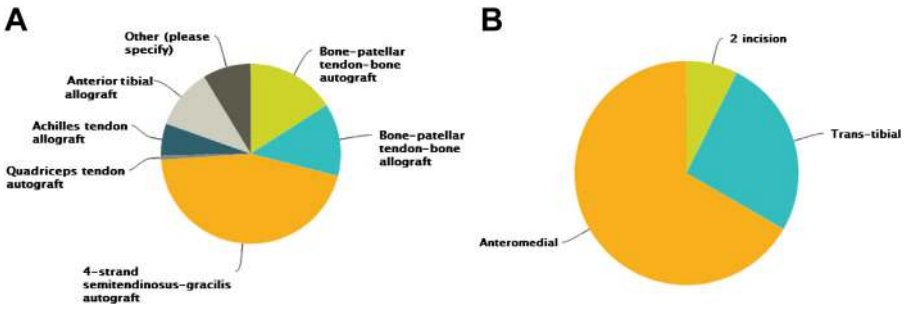

Fig 3. (A) Pie chart showing response to the question: During ACL reconstruction for a 35-year-old recreational athlete, what is your preferred graft choice? (B) Pie chart showing response to the question: During ACL reconstruction for your starting running back, do you prefer femoral tunnel drilling through an anteromedial or transtibial portal?

high-level athletes and recreational athletes because both demographics are at risk for ACL tears.[11] Given that orthopaedic surgeons may treat high school athletes who intend to play in the NCAA, as well as recreational athletes, it is beneficial to analyze current team physicians' preferences for both elite and recreational athletes. Dragoo et al.[5] analyzed the incidence and risk factors for ACL tears in NCAA athletes between the 2004 to 2005 and 2008 to 2009 seasons. They discovered that there were 318 ACL tears in NCAA football during that period, correlating to an incidence of 1.42 per 10,000 athletic events. They defined an athletic event as 1 student athlete participating in 1 practice or competition in which there was the possibility for athletic injury, regardless of the duration of that participation.

In a survey done by Bradley et al.[3] in 2002 of only 32 NFL team physicians, it was noted that 83% of team physicians would uses a BPTB autograft for their graft choice. Although the percentage of graft choice of BPTB autografts was almost identical to Bradley et al.'s, there were several novel interesting findings in this survey. The first is that all but 1 of the 137 surgeons surveyed use the single-bundle technique when performing an ACL reconstruction. The evidence comparing single- and double-bundle ACL reconstruction has largely shown no statistically significant differences.[12] Despite the potential rotational advantage with a reduction in the pivot shift phenomenon exhibited in basic science and clinical studies with double-bundle reconstruction, thereby theoretically making this reconstruction technique better in elite athletes, clinical outcome studies have not revealed significant differences between single- and double-bundle reconstructions.[13,14] Given surgeon familiarity and decreased operating room time with the single-bundle technique, it follows that the overwhelming majority of team physicians choose to use a single-bundle technique. However, this discrepancy could be caused by the incompatibility of the BPTB graft with the double-bundle technique.

The next interesting finding was how graft choice changed when the level of competition and age of the patient were factored into the decision. Although only 1 surgeon surveyed stated that allografts were the graft of choice when treating the starting running back, and 1.4% would use allografts in their 25-year-old recreational athletes, 30% said they would use allografts in treating their 35-year-old recreational athletes. This is in contrast to a study by Spindler et al.,[15] who found that surgeons who participated in their study used BPTB grafts 43% of the time and hamstring grafts 48% of the time. However, in our study, it should be noted

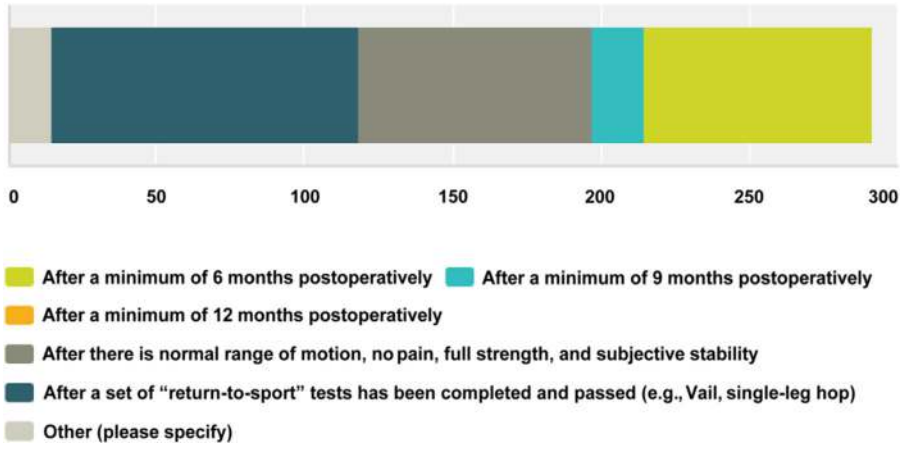

Fig 4. Chart showing response to the question: After ACL reconstruction in your starting running back, what criteria do you use to permit return to sports in a regular season competitive game–type setting? (Note, responders were instructed to select all answers that were applicable.)

that, although a similar percentage of survey participants use autografts versus allografts in the starting NFL running back and the 25-year-old recreational athlete, the type of autograft the surgeons choose to use in each group are different. Eighty-six percent use BPTB autografts for their elite-level running backs and 11% using 4-strand semitendinosus-gracilis autografts. However, 50% and 42% use BPTB and 4-strand semitendinosus-gracilis autografts in their 25-year-old recreational athletes, respectively.

There have been complications with BPTB autografts, mostly revolving around anterior knee pain donor-site morbidity.[16] Early biological graft healing with autograft bone-to-bone supersedes the risk of anterior knee pain in this population.[17] The risk of patellar fracture is extremely low after BPTB harvest and thus does not play a significant role in decision making. Recent data suggest that there may be an increase in infection rate with hamstring autografts compared with BPTB autografts and allografts.[18] Although the overall rate of infection was less than 1%, an 8.2 times higher risk of surgical site infection was found with hamstring autografts compared with BPTB autografts. These data may prove to be relevant because 11%, 42%, and 45% of team physicians said they would use hamstring autografts in the treatment of their elite, 25-year-old recreational, and 35-year-old recreational athletes, respectively.

This survey showed that 67% of surgeons drilled their femoral tunnel through an anteromedial approach, whereas 25% used the transtibial technique. There have been many recent studies examining the 2 techniques, both alone and in comparison.[19-21] Some studies have found improved rotational and anterior stability of the knee using an anteromedial approach, although these findings do not seem to be clinically or functionally significant.[20] Other studies have found the anteromedial approach to be correlated with an extension loss in the late stance phase of gait, whereas the transtibial approach was correlated with inferior anterior-posterior stability during the stance phase of gait.[21] Although many studies have examined these 2 techniques, there does not appear to be a clear functional or clinically relevant advantage to either technique.[19]

Kraeutler et al.[16] showed, through a meta-analysis of more than 5,000 patients who received BPTB autografts versus allografts, that BPTB autografts outperformed allografts in several knee scores, including Tegner and Lysholm scores, and had a lower rate of repeated rupture (4.3% *v* 12.7%).[16] Several systematic reviews analyzing ACL reconstruction are summarized in Table 2. With this being said, the graft choice still cannot overcome surgeon error with misplacement of the tunnels when drilling.[22,23] As such, it seems that BPTB autografts remain the gold standard for ACL reconstruction for a multitude of reasons, including low failure rates and decreased costs, among others.[22,24]

Finally, because there is no definitive evidence to support bracing versus not bracing athletes on return to sport from an ACL reconstruction, 65% of team orthopaedic surgeons recommended against bracing. A recent prospective randomized study of bracing versus not bracing in the initial 6-week postoperative period after ACL reconstruction in 64 patients showed no difference in all subjective or objective outcomes, except pain scores, which were better in the nonbraced group, at 4-year follow-up.[25] Based on this study, it can be concluded that BPTB autografts are a reasonable choice for an athlete of any age, but specifically in an elite-level running back, and that the approach to the femoral tunnel should be performed through whatever method the treating surgeon is most comfortable with, because the survey and review of the literature did not unanimously favor the transtibial or anteromedial approach.

Limitations

This study has several limitations. First, it is Level V evidence of only one position in one sport of team physicians. Although some of these team physicians also take care of athletes in other sports, this survey was specifically targeted at answering questions about football running backs. This study did not address all ages or both sexes, which is significant because there is a higher rate of ACL tears in female athletes. In relation to sex, all running backs are men, and there was a high rate of BPTB grafts chosen by surgeons. However, the recreational athlete can be of either male or female sex, and the fact that some surgeons would choose a hamstring graft in a female athlete for cosmetic reasons must not be overlooked. The survey response rate was 51%, although this was one of the largest surveys of team physicians to date. There have been studies that have reported similar response rates in relation to ACL practices,[26] and recent literature has validated that lower response rates in surveys does not alter the results.[27,28] This percentage could be falsely low if some of the e-mail addresses were inaccurate. There is also the possibility that a survey respondent clicked on the wrong answer choice accidentally (as may have been the case with the allograft answer for graft choice in a starting running back—survey question 3). This response rate also offers the possibility of selection bias, because surgeons who may routinely use allografts in their athlete population did not want to admit this. This study does not claim to report how all NFL running back ACL injuries have been treated; rather, the surgeons who were surveyed are those who are taking care of these athletes and the responses are how these particular surgeons would address ACL tears in their elite-level running backs. There is the possibility that

Table 2. Summary of Current Systematic Reviews Examining Various Graft Types in ACL Reconstruction[29-34]

Author	Study Type	Level of Evidence	Grafts Compared	Single or Double Bundle	Outcomes	Complications	Pearls
Carey et al.[29]	Systematic review	III	Autograft *v* allograft of both BPTB and hamstring	Not specified	No difference in patient reported outcomes, physical examination, or instrumented laxity between autograft and allograft; Lysholm score averaged 1.5 better in autografts	No difference in arthrofibrosis, reoperation rates, or infection between autografts/allografts; increase in kneeling pain in autograft group	All patients in included studies had at least 2 years of follow-up
Lewis et al.[30]	Systematic review	II	BPTB and hamstring (autograft *v* allograft unspecified)	Single	Purpose was to report outcomes in single-bundle reconstruction—showed 80% negative postoperative pivot shift test; 90% of patients had less than a 5° difference in extension between operative and nonoperative knees; 74% IKDC A or B; 93% patient satisfaction;	3.5% graft repeated rupture (no difference between hamstring and BPTB grafts)	All patients in included studies had at least 2 years of follow-up
Poolman et al.[32]	Systematic review	II	BPTB autograft *v* hamstring autograft	Not specified	BPTB grafts were favored by more studies for stability compared with hamstring grafts; hamstring grafts were favored for anterior knee pain; more studies favored hamstring grafts over BPTB grafts for range of motion	Not reported	
Spindler et al.[33]	Systematic review	II	BPTB autograft *v* hamstring autograft	Not specified	Increased range of motion with hamstring grafts; weakness in hamstring muscles with hamstring grafts; no difference in anterior knee pain, IKDC, Lysholm, or patient satisfaction, but increased pain with kneeling with BPTB grafts	3.6% incidence of graft failure (no difference between BPTB and hamstring grafts)	
Samuelsson et al.[31]	Systematic review	II	BPTB autograft *v* hamstring autograft	Single *v* double	No difference in laxity, clinical outcome, or return to sport between hamstring and BPTB grafts; initially more anterior knee pain and pain with kneeling with BPTB grafts, but this decreases with time		No differences between clinical outcomes in single *v* double bundle
Krych et al.[34]	Meta-analysis	III	BPTB autograft *v* allograft	Not specified	Allografts had a higher rate of repeated rupture than did autografts; autografts performed betteron hop test		All patients in included studies had at least 2 years of follow-up

ACL, anterior cruciate ligament; BPTB, bone–patellar tendon–bone; IKDC, International Knee Documentation.

some NFL running backs were treated by surgeons who were not surveyed in this study. This survey did not address concomitant pathologic conditions of the knee (posterior cruciate ligament, medial/lateral collateral ligaments, or medial/lateral meniscal damage) nor did it discuss all possible technique variables (metal versus bioabsorable interference screws, aperture versus suspensory fixation, method of fixation, degrees of knee flexion, and amount of axial load at time of graft fixation, notchplasty versus no notchplasty, use of platelet-

rich plasma or not, graft diameter, use of a continuous passive motion machine postoperatively, degrees of motion allowed postoperatively, and postoperative rehabilitation protocol). In reference to professional football players, this study addressed only running backs, so the results may have differed if a different position was chosen. Finally, because several team doctors serve both the NCAA and NFL, and because we desired to keep responses blinded, we could not compare results between NFL and NCAA team doctors.

Conclusions

BPTB autografts are the most frequently used grafts for ACL reconstruction by NFL and NCAA Division I team physicians in their elite-level running backs. Nearly all surgeons always use a single-bundle technique, and most do not recommend a brace on return to sport in running backs. Return to sport most commonly occurs at least 6 months postoperatively, with some surgeons requiring a normal examination and normal return-to-sport testing (single leg hop).

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