



Current practice: postoperative and return to play trends after ACL reconstruction by fellowship-trained sports surgeons

N. E. Marshall¹ · R. A. Keller¹ · J. Dines² · C. Bush-Joseph³ · O. Limpisvasti¹

Received: 27 December 2017 / Accepted: 19 October 2018 / Published online: 25 October 2018
© Istituto Ortopedico Rizzoli 2018

Abstract

Purpose Advances in anterior cruciate ligament (ACL) reconstruction have allowed for many progressions in postoperative management. However, there is no standardized protocol for immediate postoperative management or return to play. Our objective was to evaluate current trends in immediate postoperative and return to sport practices after ACL reconstruction.

Level of evidence Cross sectional study, Level IV.

Methods Surveys were obtained from four large sports fellowship alumni networks. Demographics included years of practice and ACLs performed per year. Postoperative questions included weight bearing status, brace use and continuous passive motion (CPM) use. Return to play included time for return, brace use and metrics used for clearance to sport.

Results A total of 143 surveys were completed (32% response rate). Average years in practice were 15.1 years. Average ACL reconstructions performed per year was 20–50 in 44% and 50–100 in 29%. 26% used CPM in all patients, 8% if concomitant meniscal repair and 66% never. Bracing after surgery was used in 84% and 48% after return to play. Return to play was allowed at 6–9 months in 67% and overall 94% from 6 to 12 months. No consensus on return to play metrics was used, with the hop test being most important followed by specific time point after surgery.

Conclusion Immediate weight bearing after surgery is commonplace with intermittent CPM use. Bracing is common postoperatively and half the time with return to play. Return to play is typically allowed after at least 6 months with no consensus on return to sport metrics. Years after fellowship and ACLs performed yearly had no correlation with postoperative practices.

Keywords Anterior cruciate ligament reconstruction · ACL reconstruction · Return to sport · Postoperative management

Introduction

Anterior cruciate ligament (ACL) reconstruction has been shown to be a reliable procedure to return all levels of athletes to sport and performance [1–5]. It is estimated that approximately 250,000 ACL injuries occur per year in the USA [6]. With the high rate of injury, ACL reconstruction is a common procedure performed in a relatively young, athletic population. Advances in reconstruction and fixation techniques have allowed for many adaptations in the

postoperative management of ACL reconstructions allowing for a more accelerated rehabilitation as well as early range of motion and weight bearing [7–9]. Although some general trends for postoperative management after reconstruction have been accepted in the orthopedic community, there is not a standardized protocol for immediate postoperative management as well as return to play metrics.

In the early or immediate postoperative period, consideration of the patient's immobilization, weight bearing status and range of motion must be made. Historically, patients underwent strict immobilization after ACL reconstruction with casting and non-weight bearing for 12 weeks [10]. The benefits of range of motion and early weight bearing after reconstruction have largely led to abandonment of immobilization in favor of advanced mobilization. Shelbourne et al. [7, 8, 11] showed low incidence of arthrofibrosis and overall significant increased range of motion with immediate range of motion and weight bearing compared to traditional strict immobilization. As the benefits of immediate motion

✉ N. E. Marshall
natemarshall10@gmail.com

¹ Kerlan Jobe Orthopaedic Clinic, 6801 Park Terrace Dr., Los Angeles, CA 90045, USA

² The Hospital for Special Surgery, 541 E 71st St., New York, NY 10021, USA

³ Midwest Orthopedics at Rush, 1611 W Harrison St., Chicago, IL 60612, USA

were realized, the advantages and disadvantages of continuous passive motion (CPM) were also evaluated. A study by McCarthy previously showed a possible decreased need for pain medication with CPM use and no change with anterior laxity [12, 13]. A number of other studies showed no change in knee range of motion or other outcome measures with using or not using CPM after reconstruction [14, 15]. Bracing postoperatively is also meant to provide early protection after reconstruction until the patient can regain control of the knee with quadriceps function, and even maintained longer in some instances. Kruse et al. [16] showed no benefit to bracing postoperatively and stated it is neither necessary nor beneficial and adds to the cost of the procedure.

Another difficult decision that is required after ACL reconstruction is when a player can return to his or her sport. Decision for return to sport is often multifactorial, encompassing a number of variables including time from surgery, physical therapy goals, clinical examination, advanced strength testing and also sport played and sports-specific metrics. The literature on return to sport varies greatly. For example, Muller et al. [17] evaluated patients at 7 months and found the single hop test to be the strongest predictor of return to sport compared to strength testing and outcome scores. Another study evaluated functional tests for return to sport including the hop test and found that 4 months was appropriate for return to light activity with 3 months too short a time frame and 6 months a more appropriate time for return to sport [18]. Finally, a study by Mayer et al. [19] evaluated 98 ACL reconstructions at 6 months that were either cleared or not for sport based on clinical measures by the surgeon. They concluded that clinical impairment measures are not related to measured functional ability, as they found no correlation with those cleared clinically against those not cleared, based on functional testing.

With several postoperative decisions after ACL reconstruction to take into consideration and with no consensus in the literature on optimal postoperative management, it is important to evaluate and understand the current practices being employed by fellowship-trained sports surgeons. The purpose of this current study was to elucidate current trends in immediate postoperative treatments and return to play after ACL reconstruction. We hypothesized that the majority of respondents would allow full weight bearing, would not use CPM, and would brace and allow return to sport at a specific time point with clearance of specific physical therapy goals.

Methods

Following approval from our institutional review board, an online, anonymous survey was developed and e-mailed to the alumni networks of four large ACGME-accredited sports

medicine fellowship programs (Kerlan-Jobe Orthopaedic Clinic, the Hospital for Special Surgery, Cleveland Clinic and Rush University). These four alumni networks were chosen because of their long institutional history, large alumni networks and their geographic diversity with one west coast (California), one east coast (New York) and two Midwest (Illinois and Ohio) program locations. E-mails were directly sent to the alumni of each program between November and December 2016. To evaluate the survey in its entirety, please refer to [Appendix](#).

Questions included initial physician demographic data including number of years in practice and training, Certification of Added Qualifications (CAQ) in sports medicine and the number of ACL reconstructions performed each year.

Respondents were then asked about immediate postoperative practices. They were asked if a brace was used after surgery, and if so which type of brace. Also asked if a continuous passive motion (CPM) device was commonly used after reconstruction. Respondents were asked about final rehabilitation clearance. This specifically included if a brace is used when returning to sport. They were also asked about when patients are allowed to return to sport. Finally, assessment of which metric is used when deciding whether athletes are able to return to sport including a specific time frame, patient clinical appearance, physical therapy clearance, one-legged squat test, hop test or Biodex testing.

All answers were collected for analysis. Microsoft Excel (Microsoft, Redmond, Washington) was used to record survey data and to perform statistical analysis. Averages were determined for each categorical response. Trends and correlations were determined and used correlation coefficients for each category. Significance was set as $p < 0.05$.

Results

Surveys were sent to 444 surgeons. The survey was completed by a total of 143 surgeons for a response rate of 32%. Of the respondents, 58% (82/143) responded to having sports medicine fellowship training with a certificate of advanced qualification (CAQ) and 40% (56/143) with no CAQ. Average years of training after fellowship were 15.1 years with a range of 0.5–46 years (SD 10.6 years). The average number of ACL reconstructions performed per year was 0–20 in 14% (20/143), 20–50 in 44% (63/143), 50–100 in 29% (41/143) and > 100 in 13% (19/143) (Table 1).

In evaluation of immediate postoperative protocol trends, the majority of respondents allowed full weight bearing after ACL reconstruction if no meniscus repair was performed. A total of 55% (78/143) allowed weight bearing as tolerated, 36% (52/143) allowed weight bearing as tolerated locked in extension, 8% (12/143) allowed partial weight bearing and 1% (1/143) made non-weight bearing. Overall, 91%

Table 1 Demographic data of respondents

Variable	Value or average (%) (n = 143)
Sports fellowship, CAQ	82 (58%)
Sports fellowship, no CAQ	56 (40%)
Years practicing post-fellowship (years)	15.1 (range 0.5–46, SD 10.6)
ACLs performed per year	
0–20	20 (14%)
20–50	63 (44%)
50–100	41 (29%)
> 100	19 (13%)

CAQ certificate of added qualifications

Table 2 Postoperative ACL protocols

Variable	Value (%) (n = 143)
Weight bearing	
Full weight bearing	130 (91%)
Without brace	78 (55%)
With brace	52 (36%)
Partial weight bearing	12 (8%)
Non-weight bearing	1 (1%)
CPM	
Yes, all patients	37 (26%)
Yes, only with meniscus repair	12 (8%)
No	94 (66%)
Brace post-op	
Yes	120 (84%)
No	23 (16%)
Type of brace	
Locked hinged	91 (64%)
Unlocked hinged	14 (10%)
Knee immobilizer	19 (13%)
Compression sleeve	0 (0%)
N/A	18 (13%)

CPM continuous passive motion

(130/143) of respondents allowed full weight bearing. A small number used CPM after surgery with 26% (37/143) using a CPM in all patients, 8% (12/143) using if concomitant meniscal or cartilage repair and 66% (94/143) not using CPM at all. Almost all used a postoperative brace of some sort after surgery with 84% (120/143) using a brace. The most common brace used was a locked hinged knee brace with 64% (91/142) using this brace. A total of 10% (14/142) used a hinged knee brace unlocked and 13% (19/142) used a knee immobilizer (Table 2).

When asked about final clearance for when to return athletes to sport, the majority allowed return to play at 6–9 months with 67% (96/143) allowing play at this

time point, 27% (39/143) at 9–12 months, 5% (7/143) at 3–6 months and 1% (1/143) at over a year (Fig. 1). The majority did not require an ACL brace for return to sports with 52% (74/143) not requiring a brace. A large proportion did require an ACL brace with 42% (60/143) requiring bracing during the first year back to sport and 6% (9/143) for specific sports only, with none requiring for the rest of the playing career (Table 3). There was no majority consensus for specific metric used to clear athletes to sport as the highest percentage of use in one metric was about one-third. The most common metric used for return to sport was the hop test, with specific time point after surgery as the next most common. The hop test was listed as most important in 33% (44/135), with specific time point after surgery in 32% (45/139), one-legged squat test at 25% (34/136), clearance by physical therapy at 24% (34/140) and general clinical appearance at 22% (30/138). The Biodex testing was listed as the least important metric in 31% (41/132) and listed as most important in only 9% (12/132) (Table 4). Overall, the weighted average of importance from 1 to 5, with 5 being most important, for return to sport was the hop test at 3.65, specific time point at 3.57, one-legged squat test at 3.52, clinical appearance at 3.47, clearance by physical therapy at 3.38 and Biodex testing at 2.38.

There were no significant correlations between years in practice after fellowship training and postoperative ACL trends. There was also no significant correlation with number of ACLs performed per year and specific postoperative ACL trends. The greatest correlation was with increasing number of years after training to increased importance on clinical appearance as a metric for return to sport, which still showed no linear correlation with a correlation coefficient of 0.252. There was also no significant correlation between years after training and number of ACLs performed per year (correlation coefficient 0.110).

Discussion

ACL reconstructions have shown successful outcomes with returning athletes of all levels back to competitive play [1–5]. A variety of postoperative protocols as well as return to play standards can be employed, as there is no standardized protocol. A survey of fellowship-trained sports medicine surgeons from different regions of the country showed some current trends to be consistent with postoperative decisions and return to play; however, there are several decisions and practices that are still less defined.

Immediate postoperative practices in our cohort were fairly consistent. Over 90% of our respondents allowed immediate full weight bearing provided no meniscal or cartilage repair was required, with the majority of the remaining surgeons allowing partial weight bearing. This is consistent

Fig. 1 Timing after surgery for return to play after ACL reconstruction

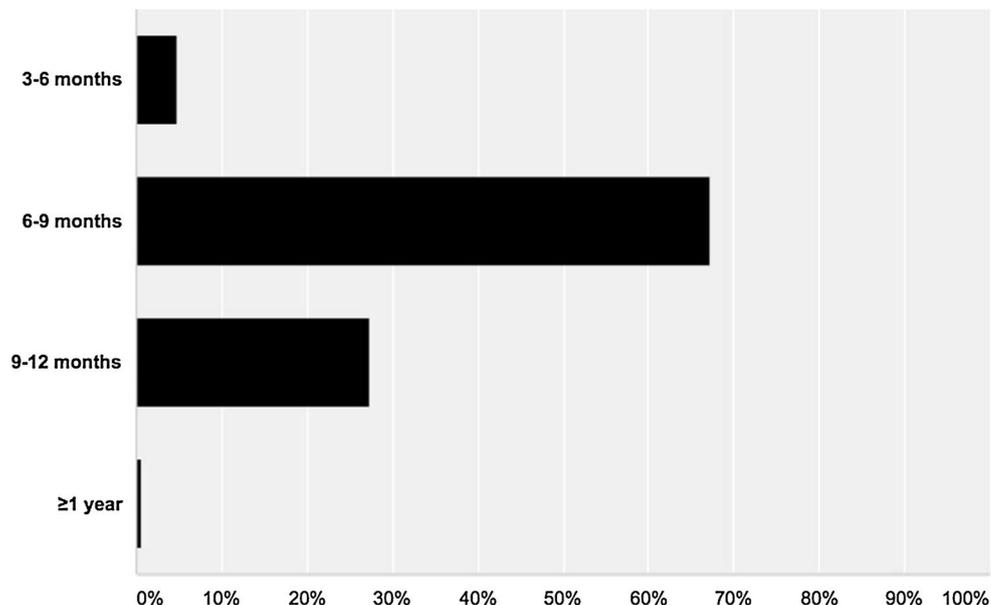


Table 3 Timing to return to sport and bracing for sport

Variable	Value or average (%) (n = 143)
Return to play	
3–6 months	7 (5%)
6–9 months	96 (67%)
9–12 months	39 (27%)
> 1 year	1 (1%)
ACL brace for sport	
Yes, 1st year back	60 (42%)
Yes, specific sports	9 (6%)
Yes, rest of career	0 (0%)
No	74 (52%)

with the previous literature that has shown the benefit of early weight bearing on overall outcomes as well as general chondrocyte health [8, 10, 20]. One inconsistency in postoperative treatment is that the majority of respondents choose

not to use CPM postoperatively with approximately a quarter using it every time and a small number using CPM with meniscus treatment. The inconsistent use of CPM postoperatively is likely due conflicting studies with some showing a possible pain benefit, but most studies showing no change in the range of motion or overall outcomes [12–16, 20]. It was also quite common for our respondents to use a brace postoperatively with over 80% employing a brace and slightly under half requiring a brace with return to sport. This is in contrast to the recommendation from Kruse et al. [16] and Wright et al. [21] that performed a systematic review, finding that without brace use there was no increase in postoperative injuries, pain, loss of range of motion or increased laxity. They recommended against brace use postoperatively.

Return to sport and activity after ACL reconstruction has been evaluated in the literature, and there appears to be no consistent protocol with regard to clearance to play. Graft healing principles can give indications to a time frame for healing, but appropriate muscle strengthens and knee stability to allow for safe return with low risk of re-injury can be more difficult to determine. The majority of our respondents

Table 4 Metrics used for return to play and level of importance of each metric

Variable	1—least important	2	3	4	5—most important	N/A	Weighted average
Specific time point after surgery (n = 139)	16 (12%)	14 (10%)	27 (19%)	33 (24%)	45 (32%)	4 (3%)	3.57
Clinical appearance (n = 138)	16 (12%)	14 (10%)	27 (20%)	50 (36%)	30 (22%)	1 (1%)	3.47
Clearance by physical therapy (n = 140)	16 (11%)	19 (14%)	30 (21%)	33 (24%)	34 (24%)	8 (6%)	3.38
One-legged squat test (n = 136)	14 (10%)	15 (11%)	22 (16%)	41 (30%)	34 (25%)	10 (7%)	3.52
Hop test (n = 135)	16 (12%)	10 (7%)	19 (14%)	34 (25%)	44 (33%)	12 (9%)	3.65
Biodex testing (n = 132)	41 (31%)	17 (13%)	11 (8%)	15 (11%)	12 (9%)	36 (27%)	2.38

returned athletes to sport with 94% returning from 6 to 12 months, of which approximately two-thirds returned at 6–9 months. Some authors have recommended for accelerated rehabilitation with return to sport much earlier than our respondents and suggest return between 4 and 6 months [8, 10, 11]. Whereas some may base return on healing principles with full ligamentization of the graft taking up to 12 months, other studies have recommended for functional evaluations with studies showing typical functional clearance to be past 6 months [17, 19, 22]. The respondents in our study appeared to favor a delay in return after 6 months, rather than an accelerated rehabilitation.

Time point after surgery is not the only metric for evaluating return to play. The clinical appearance of the patient including effusion, range of motion, knee stability and strength are common metrics used for return. Previous studies evaluating functional performance have shown that patients cleared based on clinical appearance by their surgeon may not be the best metric. In a study evaluating 98 ACL reconstructions at 6 months, it was found that there was no difference in functional testing between a group cleared for play and a group not cleared for play based on clinical evaluation. It was also found that the typical patient in each group was also at risk of re-injury based on functional testing [19]. In evaluation of current trends in clearance, there was very little consistency in the metrics used and appears to be no standard for clearance to sport. The most highly weighted metric for clearance was the hop test followed by specific time point from surgery and one-legged squat test, each of which only represented about 30% of respondents listing as most important. The least important to our respondents was Biodex testing, which was rated as least important in 30%. Overall the majority of our respondents weighted multiple returns to sport metrics as important besides Biodex testing. There seems to be an importance placed a specific function testing, with the hop test rated highest in our group, with also consideration of time point after surgery and clinical appearance. Using some measure of function appears important to our respondents, which the previous literature has shown the benefit of with the hop test being one of the best predictors for return to sport and other functional testing giving a better indication rather than strength testing [17–19]. Our respondents showed an importance in some functional clearance as well as a specific time point from surgery; however, no standard for return was used and there appears to be no consistent consensus for appropriate return.

There are multiple limitations to the study. One limitation was the low response rate with our survey with a response rate at 32%. Although a higher response rate gives a more complete representation of those surveyed, this rate is similar to other previously published literature on survey studies,

with a recent study of ASES members responding at 29.9% and another shoulder arthroplasty survey at around the same response rate [23, 24]. Secondly, although we chose to send surveys to alumni networks from large, geographically diverse fellowship programs, this is only a small sample size of sports medicine fellowship-trained surgeons in the USA, thus creating the potential for selection bias. Thirdly, as with most survey studies, the data reflect opinions or perceptions of respondents, but do give specific information to the current trends for all orthopedic sports surgeons. The strengths of this study are that the surveys were distributed to different geographic alumni networks throughout the country as well as to historically well-defined sports fellowship programs, which gives a good representation of current trends. This is also one of the first studies to evaluate the opinions and current practice in response to changes in the literature for postoperative ACL protocols and return to play metrics.

Conclusion

There are a variety of postoperative protocols and return to play modalities that can be employed. Immediate weight bearing after surgery is commonplace in most surgeons with intermittent CPM use. Bracing is still quite common immediately postoperatively as well as half the time with return to play although not recommend with some recent literature. Finally, return to play is allowed after at least 6 months with some form of functional testing and timing from surgery being most important metrics for allowing return to play; however, the variety of metrics used for clearance show no standard exists. These decisions also show no significant correlation with surgeon experience or number of ACLs performed per year.

Compliance with ethical standards

Conflict of interest N. E. Marshall and R. A. Keller declare that they have no conflict of interest. J. Dines served in editorial or governing board of American Journal of Orthopedics, as board or committee member in American Shoulder and Elbow Surgeons, as paid consultant, paid presenter or speaker and research support in Arthrex, Inc., as paid consultant in CONMED Linvatec, in editorial or governing board of Journal of Shoulder and Elbow Surgery, and as paid consultant in Trice, received IP royalties from Linvatec, and received publishing royalties, financial or material support from Wolters Kluwer Health—Lippincott Williams & Wilkins. C. Bush-Joseph served in editorial or governing board of American Journal of Sports Medicine, as board or committee member in American Orthopaedic Society for Sports Medicine, and gave stock or stock options to Cresco Lab. O. Limpisvasti served as paid consultant in Arthrex, Inc. and received IP royalties from CONMED Linvatec.

Ethical approval IRB approval was obtained from our institutional review board.

Appendix

Are you a sports medicine fellowship-trained orthopaedic surgeon?

- Yes, CAQ
- Yes, no CAQ
- No

How long have you been practicing orthopedics (post training)?

Approximately how many ACL reconstructions do you perform a year?

- 0–20
- 20–50
- 50–100
- > 100

What is your weight bearing status after an uneventful ACL reconstruction assuming no cartilage or meniscal repair was performed?

- Weight bearing as tolerated
- Weight bearing as tolerated locked in extension
- Partial weight bearing
- Non-weight bearing

Do your patients use a Continuous Passive Motion (CPM) machine post-operatively after ACL reconstruction?

- Yes
- Yes, if there was a concomitant meniscal or cartilage repair
- No

Is it your practice to have patients wear a knee brace immediately post-operatively after ACL reconstruction?

- Yes
- No

If your patients wear a knee brace immediately post-operatively, what type of brace do you use?

- Knee immobilizer
- Hinged knee brace, locked
- Hinged knee brace, unlocked
- Compression sleeve
- N/A

Is it your practice to require patients to wear an ACL brace for sports participation after return to sport?

- Yes, for the first year back to sport
- Yes, for the rest of their playing career
- Yes, but only for specific sports
- No

What do you use for deciding when a player is able to return to sport after ACL reconstruction? (Check all that apply) (For each selection, rate from 1 to 5 with 1 being least important and 5 being most important)

- Specific time point after surgery (ex: 9 months after ACL reconstruction)
- General clinical appearance during office visit
- Clearance by their physical therapist
- One-legged squat test
- Hop test
- Biodex testing

References

1. Brophy RH, Schmitz L, Wright RW, Dunn WR, Parker RD, Andrich JT, McCarty ED, Spindler KP (2012) Return to play and future ACL injury risk after ACL reconstruction in soccer athletes from the Multicenter Orthopaedic Outcomes Network (MOON) group. *Am J Sports Med* 40(11):2517–2522
2. Erickson BJ, Harris JD, Cole BJ, Frank RM, Fillingham YA, Ellman MB, Verma NN, Bach BR Jr (2014) Performance and return to sport after anterior cruciate ligament reconstruction in national hockey players. *Orthop J Sports Med* 2(9):2325967114548831
3. Erickson BJ, Harris JD, Cvetanovich GL, Bach BR, Bush-Joseph CA, Abrams GD, Gupta AK, McCormick FM, Cole BJ (2013) Performance and return to sport after anterior cruciate ligament reconstruction in male major league soccer players. *Orthop J Sports Med* 1(2):2325967113497189
4. Lefevre N, Klouche S, Milrouse G, Herman S, Gerometta A, Bohu Y (2017) Return to sport after primary and revision anterior cruciate ligament reconstruction. *Am J Sports Med* 45(1):34–41
5. Spindler KP, Huston LJ, Wright RW, Kaeding CC, Marx RG, Amendola A, Parker RD, Andrich JT, Reinke EK, Harrell FE Jr, MOON Group, Dunn WR (2011) The prognosis and predictors of sports function and activity at minimum 6 years after anterior cruciate ligament reconstruction: a population cohort study. *Am J Sports Med* 39(2):348–359
6. Barrera Oro F, Sikka RS, Wolters B, Graver R, Boyd JL, Nelson B, Swiontkowski MF (2011) Autograft versus allograft: an economic cost comparison of anterior cruciate ligament reconstruction. *Arthroscopy* 27(9):1219–1225
7. Shelbourne KD, Gray T (1997) Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation. A two- to nine-year followup. *Am J Sports Med* 25(6):786–795
8. Shelbourne KD, Klootwyk TE, Decarlo MS (1992) Update on accelerated rehabilitation after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther* 15(6):303–308

9. Shelbourne KD, Klotz C (2006) What I have learned about the ACL: utilizing a progressive rehabilitation scheme to achieve total knee symmetry after anterior cruciate ligament reconstruction. *J Orthop Sci* 11(3):318–325
10. De Carlo MS, McDivitt R (2006) Rehabilitation of patients following autogenic bone–patellar tendon–bone ACL reconstruction: a 20-year perspective. *N Am J Sports Phys Ther* 1(3):108–123
11. Shelbourne KD, Nitz P (1990) Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med* 18(3):292–299
12. McCarthy MR, Buxton BP, Yates CK (1993) Effects of continuous passive motion on anterior laxity following ACL reconstruction with autogenous patellar tendon grafts. *J Sport Rehabil* 2:171–178
13. McCarthy MR, Yates CK, Anderson MA, Yates-McCarthy JL (1993) The effects of immediate continuous passive motion on pain during the inflammatory phase of soft tissue healing following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther* 17(2):96–101
14. Engstrom B, Sperber A, Wredmark T (1995) Continuous passive motion in rehabilitation after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 3(1):18–20
15. Witherow GE, Bollen SR, Pinczewski LA (1993) The use of continuous passive motion after arthroscopically assisted anterior cruciate ligament reconstruction: help or hindrance? *Knee Surg Sports Traumatol Arthrosc* 1(2):68–70
16. Kruse LM, Gray B, Wright RW (2012) Rehabilitation after anterior cruciate ligament reconstruction: a systematic review. *J Bone Joint Surg Am* 94(19):1737–1748
17. Muller U, Kruger-Franke M, Schmidt M, Rosemeyer B (2015) Predictive parameters for return to pre-injury level of sport 6 months following anterior cruciate ligament reconstruction surgery. *Knee Surg Sports Traumatol Arthrosc* 23(12):3623–3631
18. Rambaud A, Samozino P, Edouard P (2016) Functional tests can they help in the decision to return to sports after anterior cruciate ligament? Example with Hop tests. *Ann Phys Rehabil Med* 59S:e119–e120
19. Mayer SW, Queen RM, Taylor D, Moorman CT 3rd, Toth AP, Garrett WE Jr, Butler RJ (2015) Functional testing differences in anterior cruciate ligament reconstruction patients released versus not released to return to sport. *Am J Sports Med* 43(7):1648–1655
20. Huang HS, Ao YF, Wang YJ, Li X (2008) The effects of continuous passive motion on tendon–bone healing of the tendon autograft used for anterior cruciate ligament reconstruction in a rabbit model. *Zhonghua Wai Ke Za Zhi* 46(14):1088–1091
21. Wright RW, Preston E, Fleming BC et al (2008) ACL reconstruction rehabilitation: a systematic review part I. *J Knee Surg* 21(3):217–224
22. Falconiero RP, DiStefano VJ, Cook TM (1998) Revascularization and ligamentization of autogenous anterior cruciate ligament grafts in humans. *Arthroscopy* 14:197–205
23. Garcia GH, Taylor SA, Fabricant PD, Dines JS (2016) Shoulder instability management: a survey of the American Shoulder and Elbow Surgeons. *Am J Orthop (Belle Mead NJ)* 45:E91
24. Savin DD, Zamfirova I, Iannotti J, Goldberg BA, Youderian AR (2014) Survey study suggests that reverse total shoulder arthroplasty is becoming the treatment of choice for four-part fractures of the humeral head in the elderly. *Int Orthop* 40(9):1919–1925