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Web-based survey results: surgeon practice patterns in Italy regarding anterior cruciate ligament reconstruction and rehabilitation

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Abstract
Purpose The aim of this study was to report Italian orthopaedic surgeons' management of choice for ACL reconstruction and rehabilitation, and to compare surgical applications and rehabilitation approaches of Italian surgeons to the current approaches of "ACL Study Group". A secondary purpose was to compare the preferences of subgroup based on graft choice, surgical techniques and experience.
Methods A web-based survey was developed to investigate the attitudes of members of a national association specialized in sports traumatology and knee surgery (SIGASCOT) regarding surgical techniques, routine postoperative applications, rehabilitation approaches and starting time of specific activities and exercises following ACL reconstruction.
Results The response rate was 17 % (131 questionnaires). The most popular graft type was hamstring tendon (81 % in male patients, and 91 % in female patients). The rate of continuous passive motion use was 55 %. Half surgeons routinely used a brace (49 %), usually a hinged brace. In total, 33.0 % of surgeons allowed patients to load the operated knee as much as tolerated within the first 2 weeks. Fifty-nine per cent of surgeons did not limit full flexion within the first 2 weeks. Most surgeons advise to wait until 4 months or more (97 %) for return to sports not requiring contact, and 6 months or more for full-contact sport (86 %).
Conclusions This survey demonstrates clear trends in the practice of ACL reconstruction and rehabilitation in Italy. The data obtained from the SIGASCOT members revealed a more conservative approach when compared to the current approaches of "ACL Study Group".
Level of evidence Cross-sectional survey, Level III.

Keywords Anterior cruciate ligament · Rehabilitation · Italy · Survey

Introduction

Examination of practice patterns over time can reveal changes in surgical decision-making and technique [29]. Over the past decades, there has been significant modification both in surgical technique and in methods of rehabilitation of anterior cruciate ligament reconstruction (ACL). This trend can be aided by a number of factors, including geography, level of experience, refinement of surgical technique, instrumentation, and implant devices, and better understanding of ACL anatomy. Although the data from a systematic review of randomized controlled trials suggested that graft choice may not be the primary determinant of successful results after ACL surgery [34], there is still some debate regarding the type of graft used, its positioning and fixation method. In recent years, there has been a significant shift in the graft choice from patellar tendon (PT) autograft to hamstring (semitendinosus/gracilis) tendon (HT) autograft due to lower donor-site morbidity rates [2, 3, 16]. Similarly, rehabilitation following ACL

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reconstruction has undergone considerable changes. Attributes of graft material, graft fixation and specific morbidities are important factors in determining the rehabilitation protocol. Accelerated rehabilitation programmes that suggest early restoring of the range of motion and early loading are widely accepted today [21], but were designed according to PT use [32]. Soft tissue recovery of HT grafts requires at least 8–12 weeks, and accelerated rehabilitation protocols may improve graft-tunnel movement during this period [17]. Yet, it is not clear what kind of changes is required to be made in rehabilitation protocols.

Although several surveys of current practice of ACL reconstruction exist, there is no available study on the graft type, surgical method and rehabilitation approach preferred by orthopaedic surgeons in Italy. Surveys have been frequently used to collect data on beliefs, attitudes and behaviours of physicians [19]. A web-based survey was developed to investigate the attitudes of a large community of orthopaedic surgeons (members of the SIGASCOT, Società Italiana del Ginocchio Artroscopia Sport Cartilagine Tecnologie Ortopediche) in terms of graft type, surgical method and post-operative care in ACL reconstruction. The expansion of the Internet and the diffusion of web-based tools have made online surveys a simple and reasonable technology for collecting preferences and opinions about several topics and hence for contributing to medical knowledge and clinical practice [4, 28]. There is compelling evidence that electronic and paper-and-pencil surveys deliver equivalent measures [14], and sometimes electronic ones are more reliable [7]. The aim of this paper was to report the preferences of Italian surgeons relating to ACL reconstruction and rehabilitation, and to compare surgical applications and rehabilitation approaches of Italian surgeons to the current approaches of "ACL Study Group" that represents a worldwide society of ACL experts. A secondary purpose of this study was to compare the preferences of subgroups based on graft choice, surgical techniques and number of ACL reconstruction operations performed per year.

Materials and methods

Questionnaire design

The questionnaire ("Appendix") consisted of 15 questions covering the following topics: the type and number of ACL reconstruction operations performed; graft type used; post-operative rehabilitation programmes; whether patients were braced or not; full loading duration; and starting time for specific exercises and activities. In questions on duration of loading, full flexion limitation, and the starting time of specific activities and exercises, choices were categorized to provide a standard and to facilitate the completion of questionnaire forms. The survey was prepared by four orthopaedic surgeons and one physiatrist involved in the research team; the drafting process included several iterations within the research team. An open-source platform (https://drive.google.com) was configured to collect the responses anonymously.

Study sample

A national association specialized in sports traumatology and knee surgery (SIGASCOT) was contacted. This association has more than 850 members, with 88 % of the members being orthopaedic surgeons. All people in the official mailing list of the SIGASCOT association were considered eligible, and authorization was gained to contact them without prior consent. On the basis of the mailing list, 778 personalized invitations were sent (target population). Members of the SIGASCOT association were contacted by email twice: the first time to present the research initiative and to invite each member to participate in the initiative by completing the online questionnaire; the second time to send a reminder to join the initiative. The survey was kept open for 30 days, from 30 June to 30 July 2015; on 13 July, the reminder email was sent and this produced further 53 (71 %) responses.

Statistical analysis

Data obtained from the completed questionnaires were entered into a comprehensive database developed using the Microsoft Excel Package Office 2013. The final data were analysed using summary statistics available within the database and the Microsoft Excel package. Response rates are summarized in terms of proportions of respondents. The Pearson Chi-square test and Fisher's exact test were used to study the association between number of reconstruction operations performed, graft type used, type of surgery and selection of treatments. A p value lower than 0.05 ($p < 0.05$) was considered statistically significant. Statistical analysis was performed using PSPP software (Free Software Foundation, Inc.) for windows.

Results

At the end of the survey, 131 completed questionnaires (17 % of the target population) were collected. The survey results are summarized in "Appendix".

The most popular graft type was HT (81.1 % in male patients and 91.2 % in female patients). When ACL reconstruction in professional athletes was considered, 49.6 % of the surgeons used PT graft, while 44.8 % used HT graft.

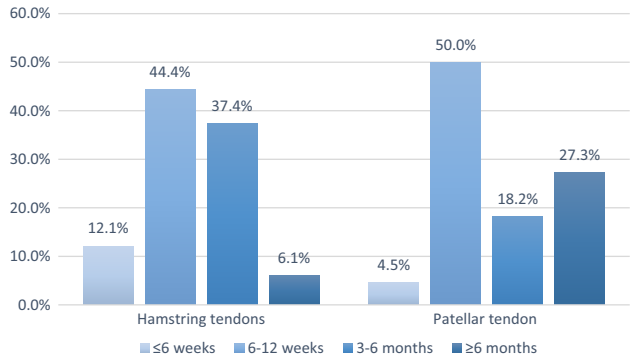

Fig. 1 Correlation between graft utilized in the reconstruction of the anterior cruciate ligament in male patients and time to allow strengthening open kinetic chain quadriceps between 90° and 40°. The data reveal a Chi-square statistic of 11.207 ($p = 0.011$)

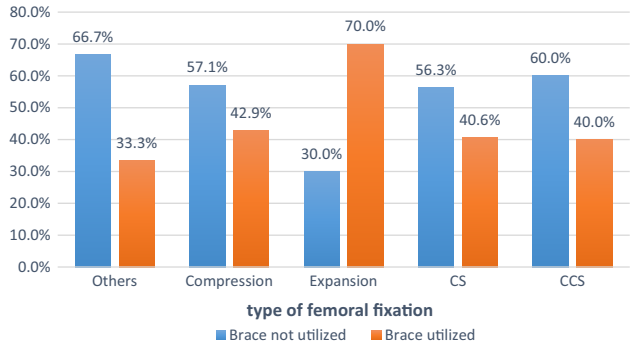

Fig. 2 Correlation between type of femoral fixation and brace utilization. The data reveal a Chi-square statistic of 6.699 ($p = 0.035$). *CS* cortical suspension, *CCS* cortico-cancellous suspension

In total, 56.0 % of the surgeons use the same graft regardless of the sport practiced. Among the surgeons who chose PT graft in male patients, a significantly higher rate of responders preferred to start quadriceps strengthening open kinetic chain exercises between 90° and 40° after 6 months (Fig. 1, $p = 0.011$). There was no statistically significant difference in any of the other answers between the starting times of specific activities determined for two most popular graft types.

Regarding the surgical technique used, the best ranked technique to perform the femoral tunnel was transtibial (60.5 %); a single-band technique was preferred to a double-band technique. The most popular femoral fixation technique was found to be cortical suspension (51.2 %). Among the surgeons choosing expansion for femoral fixation, a significantly higher rate of responders used to brace patients (Fig. 2, $p = 0.035$). A significantly higher rate of surgeons who chose compression for femoral fixation preferred to start quadriceps strengthening open kinetic chain exercises between 90° and 40° after 6 months (Fig. 3,

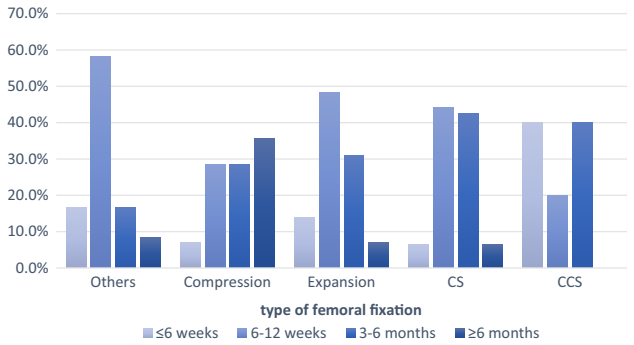

Fig. 3 Correlation between type of femoral fixation and time to allow strengthening open kinetic chain quadriceps between 90° and 40°. The data reveal a Chi-square statistic of 12.828 ($p = 0.046$). *CS* cortical suspension, *CCS* cortico-cancellous suspension

$p = 0.046$). There were no other significant association between response rates considering post-operative applications and surgical technique.

Considering post-operative routine applications, half surgeons routinely used a brace (49.2 %). The rate of continuous passive motion (CPM) use was 55.1 %. There was a significant reverse association between the CPM use and the number of reconstruction operations performed per year (Fig. 4, $p = 0.003$). Starting times for specific activities/exercises are given in "Appendix".

Discussion

The most important finding of the present study consists in the possibility to delineate trends between the SIGASCOT members regarding ACL reconstruction and rehabilitation. In the current survey, preference rate for the HT graft was observed to be very high, although a recent meta-analysis has concluded that the current evidence is insufficient to recommend whether a PT graft or a HT graft is better for ACL reconstruction [27]. The lower donor-site morbidity seen in the literature in case of HT graft could be a factor driving surgeons' preferences [2, 3, 16]. In ACL study group, preference rate for HT grafts was 56 %. Middleton et al. [26] reported a preference rate for HT grafts of 53 % among orthopaedic surgeons participating at five panels of the 2011 Panther Global Summit on anatomic ACL reconstruction held in Pittsburgh, Pennsylvania. PT autografts were used 23 % of the time, allografts were used 13 % of the time, and quadriceps tendon autograft reconstructions were performed 11 % of the time [26]. When ACL reconstruction in professional athletes was considered, the preferences of respondents to the survey were distributed evenly between PT and HT graft. This finding is supported by a recent systematic review reporting no

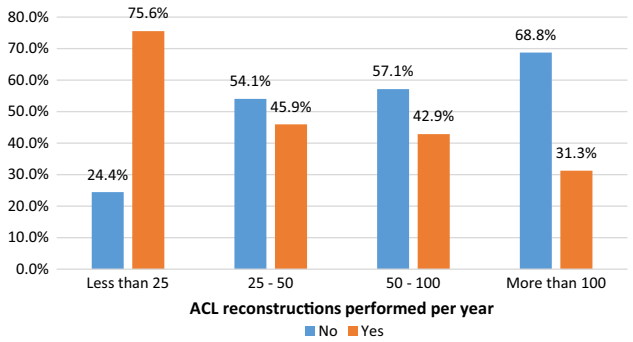

Fig. 4 Correlation between number of ACL reconstruction performed per year and continuous passive motion utilization. The data reveal a Chi-square statistic of 14.115 ($p = 0.003$)

noticeable differences in time to return to sport based on the type of graft, with most of the studies reporting values of 6–9 months [1, 40].

Another important finding of the present study was that Italian surgeons seemed to embrace a more conservative approach in terms of starting times for full range of motion, weight-bearing, stationary cycling and cutting sports, post-operative brace and CPM use if compared to the current trends of the "ACL Study Group". According to the results obtained from our questionnaire, the use of post-operative brace was more common in comparison with "ACL Study Group". Brace use was preferred at a rate of 35 % in "ACL Study Group", while this rate rises to 49 % in our country. However, the "ACL Study Group" reported an increase in number of brace prescribers when compared to previous surveys. Similar studies made in Australia [9], Turkey [5], and UK [11] revealed a post-operative brace user rate of 58, 54.3 % for HT and 60 % for PT graft, and 30 %, respectively. With regard to the brace use, there is no evidence in the literature to support the preferences of the respondents. Post-operative bracing has not been found to improve ACL recovery and rehabilitation. Two systematic reviews and a recent update of a systematic review of level 1 and level 2 studies regarding ACL reconstruction rehabilitation investigated the efficiency of brace use [20, 33, 37] and reported that bracing did not protect against post-operative injury, decrease pain, alter range of knee motion, or improve knee stability. Lindström et al. [22, 23] found that a 3-week post-operative brace after HT ACL reconstruction does not affect laxity, range of motion, subjective and functional test results or muscular cross-sectional area 1 year after surgery, as well as the presence of joint effusion three months after surgery. Conversely, Vadalà et al. [36] reported that full extension brace utilization for 2 weeks after HT ACL reconstruction might reduce bone tunnel expansion.

CPM use was preferred at a rate of 39 % in "ACL Study Group", while this rate was 55 % according to the results obtained from our questionnaire. Interestingly, there was significant reverse association between the CPM use and the experience of respondents. This result is not surprising, given the results of six randomized trials evaluating CPM for the rehabilitation of the ACL-reconstructed knee [8, 24, 25, 30, 31, 39]. No long-term benefits were determined for CPM. Given these studies, post-operative CPM was not included as part of the original or revised MOON protocol for rehabilitation after ACL reconstruction [37].

With regard to home-based ACL rehabilitation, the preference observed was slight. In a randomized clinical trial, it was found that patients who participate in a predominantly home-based rehabilitation programme in the first 3 months after ACL reconstruction have similar short- and long-term outcomes compared with those patients who participate in a more clinically supervised programme [12, 13].

With reference to the starting time for specific activities and exercises, SIGASCOT members were more conservative than the ACL Study Group. Whereas three-quarters (77 %) of the ACL Study Group allowed full range of motion after ACL reconstruction, 41 % of SIGASCOT members limited the flexion at different durations and degrees within the first 2 weeks. In a randomized controlled trial, Ito et al. [18] reported no increased subsequent laxity associated with ROM exercises immediately after ACL reconstruction with hamstring autograft.

While a third of surgeons allowed patients to load the operated knee as much as tolerated within the first 2 weeks, other surgeons limited the loading at different durations. One randomized trial compared the efficacy of immediate weight-bearing versus a delay of 2 weeks following autograft PT ACL reconstruction [35] and found no deleterious effects of early weight-bearing on stability or function and that anterior knee pain may be decreased by earlier recruitment of the vastus medialis oblique when weight-bearing.

Only 33 % of SIGASCOT members allowed stationary cycling by 4 weeks, and only 16 % allowed jogging by 8 weeks compared to 79 % and 39 % of the ACL Study Group members, respectively. Dauty et al. [6] compared patients in a 2-month running retraining programme with controls after ACL reconstruction. Running retraining occurred between the fourth and sixth weeks after surgery. There were no differences in KT1000, Lysholm and Tegner scores between the groups after 2 months of training. The PT group had weaker isokinetic strength in extension, and the HT group had weaker isokinetic strength in flexion.

The majority of orthopaedic surgeons (88 %) preferred to start quadriceps strengthening open kinetic chain exercises between 90 and 40° after 6 weeks. The literature supports this finding by showing that open-chain activities after 6 weeks may improve strength without adversely affecting

the graft and/or increasing graft laxity [10, 15]. There is currently insufficient evidence on the safety of open-chain knee exercises before 6 weeks post-surgery [38].

In accordance with the literature, almost three-quarters (70 %) of the respondents preferred to start isokinetic exercises for strengthening after 2 months. Vadalà et al. [36] randomized forty-five patients after ACL reconstruction with HT to either accelerated rehabilitation (immediate knee motion and isometric and isotonic exercises), or standard rehabilitation (active knee motion after 2 weeks, isotonic and isokinetic exercises after 6 weeks). The authors reported increased tibial and femoral tunnel diameters and at 10 months of follow-up in the accelerated rehabilitation group.

While cutting sports by 6 months in ACL study group was permitted by 66 %, 14 % of SIGASCOT members allowed return to sports requiring contact between months 4 and 6, and 73 % between months 6 and 8. These differences are interesting, but difficult to explain. Given some of the concerns raised about accelerated rehabilitation of HS ACL reconstruction, and the high preference rate for the HT graft observed in the current survey, one might anticipate a more conservative approach among SIGASCOT members. However, no statistically significant difference was found between the surgeons' rehabilitation approaches after HT and PT use.

The main limitation of this study concerns the low response rate with respect to the generic population of orthopaedic surgeons as this affects the risk of a heavy non-response bias. This could be due to a high number of surgeons not involved in knee surgery, residents and non-orthopaedic members and no-active members. The members that really support the society are about the 60 %. Moreover, this was the real first example of a survey sent by the society to the members; the low rate of answer can be explained by the novelty of such approach for SIGASCOT members. Furthermore, many of SIGASCOT members are not involved in academic hospital as they work in a private setting, and probably, these members are not interested on research or scientific papers. Despite the fact that this issue could have lowered the reliability of the results, it should be, however, highlighted the high number of responders. In fact, one of the most influential survey on orthopaedic practice [4, 28] performed on European scale by the ESSKA involved 412 responders that represents only about the threefold of the 131 responders of the present National survey. Other survey of Turkish [5], British [11] and Australian [9] societies involved even a widely lower number of responders (39, 101 and 38 responders, respectively).

Another limitation of this study is that thirty-seven per cent of the respondents annually performed less than 25 ACL reconstructions. However, the number of reconstruction operations performed per year was related only to CPM use, and there were no other significant association between response rates and experience of responders considering post-operative applications.

The main clinical relevance of this study is that information on collective agreement could be used by surgeons when counselling patients on the post-operative treatments that are available after ACL reconstruction. For variables on which agreement is poor or moderate, surgeons may advise patients about the variability of choice among SIGASCOT members. Conversely, for variables on which a good agreement is achieved, surgeons may confidently advise patients that there is consensus about the treatment that should be chosen in cases similar to the one under discussion.

Conclusions

The present study is the first conducted in Italy to report the preferences of Italian surgeons regarding ACL reconstruction and rehabilitation. The results obtained from the study revealed a more conservative approach among SIGASCOT members when compared to the current approaches of "ACL Study Group", in terms of starting times for full range of motion, weight-bearing, stationary cycling and cutting sports, and post-operative brace and CPM use.

Acknowledgments We would like to thank to all orthopaedists who participated in our questionnaire.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Appendix: Study questionnaire with summarized results

(1) How many ACL reconstructions are you performing per year?

<25	25–50	50–100	More than 100
37.2 %	28.7 %	22.5 %	11.6 %

(2) What type of graft you use preferably in the reconstruction of the anterior cruciate ligament in male patients?

Patellar tendon	Hamstring (semitendinosus/gracilis) tendons	Quadriceps tendon	Allograft	Artificial ligament
16.5 %	81.1 %	0 %	1.6 %	0.8 %

(3) What type of graft you use preferably in the reconstruction of the anterior cruciate ligament in female patients?

Patellar tendon	Hamstring (semitendinosus/gracilis) tendons	Quadriceps tendon	Allograft	Artificial ligament
6.4 %	91.2 %	0 %	1.6 %	0.8 %

(4) What type of graft you use preferably in the reconstruction of the anterior cruciate ligament in professional athletes?

Patellar tendon	Hamstring (semitendinosus/gracilis) tendons	Quadriceps tendon	Allograft	Artificial ligament
49.6 %	44.8 %	0 %	4.8 %	0.8 %

(5) Do you use the same graft regardless of the sport practiced?	Yes	No
	56.0 %	44.0 %

(6) What type of surgery you use preferably?	Double bundle	Single bundle
	7.0 %	93.0 %

(7) What type of surgery you use preferably to perform the femoral tunnel?	Transtibial	Anteromedial portal	Out-in technique
	60.5 %	29.0 %	10.5 %

(8) What type of femoral fixation you use preferably?

Compression	Expansion	Cortical suspension	Cortico-cancellous suspension	Others
11.2 %	24.0 %	51.2 %	4.0 %	9.6 %

(9) Do you routinely brace your patients post-operatively?	Yes	No
	49.19 %	50.8 %

If yes. What type of brace?	Mouldable	Hinged	Rigid	
	5.5 %	64.4 %	30.1 %	
If yes. How long?	≤2 weeks	2–4 weeks	4–6 weeks	≥6 weeks
	19.2 %	69.8 %	11.0 %	0.0 %

(10) What is the duration of loading post-operatively?	≤2 weeks	2–4 weeks	4–6 weeks	≥6 weeks
As much as it is tolerated	33.0 %	44.4 %	20.9 %	1.7 %
Limited loading	72.2 %	26.9 %	0.9 %	0.0 %

(11) Do your patients routinely use continuous passive motion post-operatively?	Yes	No
	55.12 %	44.88 %

(12) Do you limit full flexion at the knee?	≤2 weeks	2–4 weeks	4–6 weeks	≥6 weeks
No	58.6 %	9.9 %	22.5 %	9.0 %
0°–90°	61.9 %	30.5 %	7.6 %	0.0 %
0°–45°	87.8 %	12.2 %	0.0 %	0.0 %
0°–20°	97.6 %	2.4 %	0.0 %	0.0 %

(13) Which of the below do you prefer following ACL reconstruction?

Home exercise programmes	Professional rehabilitation programmes
10.2 %	89.8 %

(14) Do you have standard rehabilitation programme?	Yes	No
	84.3 %	15.7 %

(15) When do you start below specific activities/exercises?

	≤2 weeks	2–4 weeks	4–6 weeks	≥6 weeks
Proprioceptive exercise	14.4 %	21.6 %	45.6 %	18.4 %
Exercise bicycle	2.4 %	30.4 %	50.4 %	16.8 %
	≤4 weeks	4–6 weeks	6–8 weeks	≥8 weeks
Running in treadmill	1.6 %	9.6 %	37.60 %	51.20 %
Running in outside	0.8 %	2.5 %	12.3 %	84.4 %
	≤6 weeks	6–12 weeks	3–6 months	≥6 months
Strengthening open kinetic chain quadriceps between 90° and 40°	12.0 %	44.8 %	34.4 %	8.8 %
	≤2 months	2–4 months	≥4 months	never
Isokinetic exercises for strengthening	29.8 %	44.4 %	21.8 %	4.0 %

	≤2 months	2–4 months	4–6 months	6–8 months	8–10 months	10–12 months	>12 months
Sport-specific rehabilitation	3.2 %	29.8 %	56.5 %	9.7 %	0.8 %	0.0 %	0.0 %
Skills on sports not requiring contact	0.8 %	21.8 %	64.5 %	12.1 %	0.8 %	0.0 %	0.0 %
Skills on sports requiring contact	0.8 %	1.6 %	41.6 %	48.0 %	6.4 %	0.8 %	0.8 %
Return to sports not requiring contact	0.0 %	3.3 %	44.7 %	43.9 %	7.3 %	0.8 %	0.0 %
Return to sports requiring contact	0.0 %	0.8 %	13.6 %	58.4 %	20.8 %	6.4 %	0.0 %

References

1. Barber-Westin SD, Noyes FR (2011) Factors used to determine return to unrestricted sports activities after anterior cruciate ligament reconstruction. Arthroscopy 27:1697–1705
2. Beard DJ, Anderson JL, Davies S, Price AJ, Dodd CAF (2001) Hamstring versus patella tendon for anterior cruciate ligament reconstruction: a randomised controlled trial. Knee 8:45–50
3. Biau DJ, Tournoux C, Katsahian S, Schranz PJ, Nizard RS (2006) Bone-patellar tendon-bone autografts versus hamstring autografts for reconstruction of anterior cruciate ligament: meta-analysis. BMJ 332(7548):995–1001
4. Cabitza F, Ragone V, Arrigoni P, Karlsson J, Randelli P (2013) Management of knee injuries: consensus-based indications from a large community of orthopaedic surgeons. Knee Surg Sports Traumatol Arthrosc 21(3):708–719
5. Campbell J (2010) Treatment trends with ACL, PCL, MCL and cartilage problems. ACL Study Group Meeting, 20–26 February 2010, Phuket
6. Dauty M, Menu P, Dubois C (2010) Effects of running retraining after knee anterior cruciate ligament reconstruction. Ann Phys Rehabil Med 53(3):150–161
7. Duracinsky M, Lalanne C, Goujard C, Herrmann S, Cheung-Lung C, Brosseau JP, Schwartz Y, Chassany O (2014) Electronic versus paper-based assessment of health-related quality of life specific to HIV disease: reliability study of the PROQOL-HIV questionnaire. J Med Internet Res 16(4):e115
8. Engstrom B, Sperber A, Wredmark T (1995) Continuous passive motion in rehabilitation after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 3:18–20
9. Feller JA, Cooper R, Webster KE (2002) Current Australian trends in rehabilitation following anterior cruciate ligament reconstruction. Knee 9:121–126
10. Fleming BC, Oksendahl H, Beynnon BD (2005) Open- or closed-kinetic chain exercises after anterior cruciate ligament reconstruction? Exerc Sport Sci Rev 33:134–140
11. Francis A, Thomas RD, McGregor A (2001) Anterior cruciate ligament rupture: reconstruction surgery and rehabilitation. A nation-wide survey of current practice. Knee 8:13–18
12. Grant JA, Mohtadi NG (2010) Two- to 4-year follow-up to a comparison of home versus physical therapy-supervised rehabilitation programs after anterior cruciate ligament reconstruction. Am J Sports Med 38:1389–1394
13. Grant JA, Mohtadi NG, Maitland ME, Zernicke RF (2005) Comparison of home versus physical therapy-supervised rehabilitation programs after anterior cruciate ligament reconstruction: a randomized clinical trial. Am J Sports Med 33:1288–1297
14. Gwaltney CJ, Shields AL, Shiffman S (2008) Equivalence of electronic and paper-and-pencil administration of patient-reported outcome measures: a meta-analytic review. Value Health 11:322–333
15. Heijne A, Fleming BC, Renstrom PA, Peura GD, Beynnon BD, Werner S (2004) Strain on the anterior cruciate ligament during closed kinetic chain exercises. Med Sci Sports Exerc 36:935–941
16. Herrington L, Wrapson C, Matthews M, Matthews H (2005) Anterior cruciate ligament reconstruction. Hamstring versus bone-patellar tendon-bone grafts: a systematic literature review of outcome from the surgery. Knee 12:41–50
17. Höher J, Möller HD, Fu FH (1998) Bone tunnel enlargement after anterior cruciate ligament reconstruction: fact or fiction? Knee Surg Sports Traumatol Arthrosc 6:231–240
18. Ito Y, Deie M, Adachi N, Kobayashi K, Kanaya A, Miyamoto A, Nakasa T, Ochi M (2007) A prospective study of 3-day versus 2-week immobilization period after anterior cruciate ligament reconstruction. Knee 14(1):34–38
19. Kellerman SE, Herold J (2001) Physician response to surveys. A review of the literature. Am J Prev Med 20(1):61–67
20. Kruse LM, Gray B, Wright RW (2012) Rehabilitation after anterior cruciate ligament reconstruction: a systematic review. J Bone Joint Surg Am 94:1737–1748
21. Kvist J (2004) Rehabilitation after anterior cruciate ligament injury: current recommendations for sports participation. Sports Med 34:269–280
22. Lindström M, Strandberg S, Wredmark T, Felländer-Tsai L, Henriksson M (2013) Functional and muscle morphometric effects of ACL reconstruction. A prospective CT study with 1 year follow-up. Scand J Med Sci Sports 23(4):431–442
23. Lindström M, Wredmark T, Wretling ML, Henriksson M, Felländer-Tsai L (2015) Post-operative bracing after ACL reconstruction has no effect on knee joint effusion. A prospective, randomized study. Knee. doi:10.1016/j.knee.2015.04.015
24. 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
25. 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 17:96–101
26. Middleton KK, Hamilton T, Irrgang JJ, Karlsson J, Harner CD, Fu FH (2014) Anatomic anterior cruciate ligament (ACL) reconstruction: a global perspective. Part 1. Knee Surg Sports Traumatol Arthrosc 22:1467–1482
27. Mohtadi NG, Chan DS, Dainty KN, Whelan DB (2011) Patellar tendon versus hamstring tendon autograft for anterior

cruciate ligament rupture in adults. Cochrane Database Syst Rev 9:CD005960
28. Randelli P, Arrigoni P, Cabitza F, Ragone V, Cabitza P (2012) Current practice in shoulder pathology: results of a web-based survey among a community of 1084 orthopedic surgeons. Knee Surg Sports Traumatol Arthrosc 20(5):803–815
29. Redfern J, Burks R (2009) 2009 survey results: surgeon practice patterns regarding arthroscopic surgery. Arthroscopy 25(12):1447–1452
30. Richmond JC, Gladstone J, MacGillivray J (1991) Continuous passive motion after arthroscopically assisted anterior cruciate ligament reconstruction: comparison of short-versus long-term use. Arthroscopy 7:39–44
31. Rosen MA, Jackson DW, Atwell EA (1992) The efficacy of continuous passive motion in the rehabilitation of anterior cruciate ligament reconstructions. Am J Sports Med 20:122–127
32. Shelbourne KD, Gray T (1997) Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation. A two- to nine-year follow up. Am J Sports Med 25:786–795
33. Smith TO, Davies L (2008) A systematic review of bracing following reconstruction of the anterior cruciate ligament. Physiotherapy 94:1–10
34. Spindler KP, Kuhn JE, Freedman KB, Matthews CE, Dittus RS, Harrell FE Jr (2004) Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring: does it really matter? A systematic review. Am J Sports Med 32(8):1986–1995
35. Tyler TF, McHugh MP, Gleim GW, Nicholas SJ (1998) The effect of immediate weightbearing after anterior cruciate ligament reconstruction. Clin Orthop 357:141–148
36. Vadalà A, Iorio R, De Carli A, Argento G, Di Sanzo V, Conteduca F, Ferretti A (2007) The effect of accelerated, brace free, rehabilitation on bone tunnel enlargement after ACL reconstruction using hamstring tendons: a CT study. Knee Surg Sports Traumatol Arthrosc 15:365–371
37. Wright RW, Haas AK, Anderson J, Calabrese G, Cavanaugh J, Hewett TE, Lorring D, McKenzie C, Preston E, Williams G (2015) Anterior cruciate ligament reconstruction rehabilitation: MOON guidelines. Sports Health 7(3):239–243
38. Wright RW, Fetzer GB (2007) Bracing after ACL reconstruction: a systematic review. Clin Orthop Relat Res 455:162–168
39. Yates CK, McCarthy MR, Hirsch HS, Pascale MS (1992) Effects of continuous passive motion following ACL reconstruction with autogenous patellar tendon grafts. J Sport Rehabil 1:121–131
40. Zaffagnini S, Grassi A, Serra M, Marcacci M (2015) Return to sport after ACL reconstruction: how, when and why? A narrative review of current evidence. Joints 8(3):25–30