Return to Sport After ACL Reconstruction

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abstract

Full article available online at Healio.com/Orthopedics. Search: 20140124-10

Objective guidelines permitting safe return to sport following anterior cruciate ligament (ACL) reconstruction are infrequently used. The purpose of this study was to determine the published return to sport guidelines following ACL reconstruction in Level I randomized controlled trials. A systematic review was performed using Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. Level I randomized controlled trials were included if they reported a minimum 2-year follow-up after ACL reconstruction and return to sport criteria. Outcomes analyzed were the timing of initiation of return to sport, follow-up duration, and use of quantitative/qualitative criteria to determine return to sport. Forty-nine studies were included (N=4178; 68% male; mean patient age, 27.5±3.2 years; mean follow-up, 3.0±1.9 years; mean time from injury to reconstruction, 379±321 days). Ninety-six percent of reconstructions used autograft and 87% were single-bundle reconstructions. Lysholm score, single-leg hop, isokinetic strength, and KT-1000 or KT-2000 arthrometer (MEDmetric, San Diego, California) testing were performed in 67%, 31%, 31%, and 82% of studies, respectively. Only 5 studies reported whether patients were able to successfully return to sport. Ninety percent and 65% of studies failed to use objective criteria or any criteria, respectively, to permit return to sport. Description of permission/allowance to return to sport was highly variable and poor. Twenty-four percent of studies failed to report when patients were allowed return to sport without restrictions. Overall, 39%, 45%, and 51% of studies permitted running at 3 months, return to cutting/pivoting sports at 6 months, and return to sport without restrictions at 6 months, respectively. Further research into validated return to sport guidelines is necessary to fill the existing void in contemporary literature and to guide clinical practice.

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The authors have no relevant financial relationships to disclose.

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Received: May 28, 2013; Accepted: August 20, 2013; Posted: February 7, 2014.
doi: 10.3928/01477447-20140124-10

Rehabilitation following anterior cruciate ligament (ACL) reconstruction plays a significant role in the ability to achieve a successful clinical outcome. Although variations in rehabilitation programs exist, most follow an accelerated protocol that encourages early motion, strength recovery, and return of function.[1] Up to 250,000 ACL reconstructions are performed each year in the United States.[2] Given the frequency with which this surgical intervention is performed globally, the ACL has become one of the most studied topics in orthopedics and sports medicine. Multiple textbooks[3-5] and systematic reviews of systematic reviews[6,7] are devoted exclusively to the ACL. Patients undergoing ACL reconstruction may vary across a wide athletic spectrum, from the occasional recreational weekend warrior to the high-level elite professional athlete. Numerous publications discuss return to sport following ACL reconstruction.[8-10] However, no formal subjective or objective guidelines that permit safe return to play currently exist.

The purpose of this systematic review was to determine the published return to sport guidelines (subjective and objective) following ACL reconstruction in Level I randomized controlled trials. The study hypothesis was that patients were permitted to return to sport at 6 months postoperatively, with fewer than 50% of the studies using objective criteria to permit return to sport.

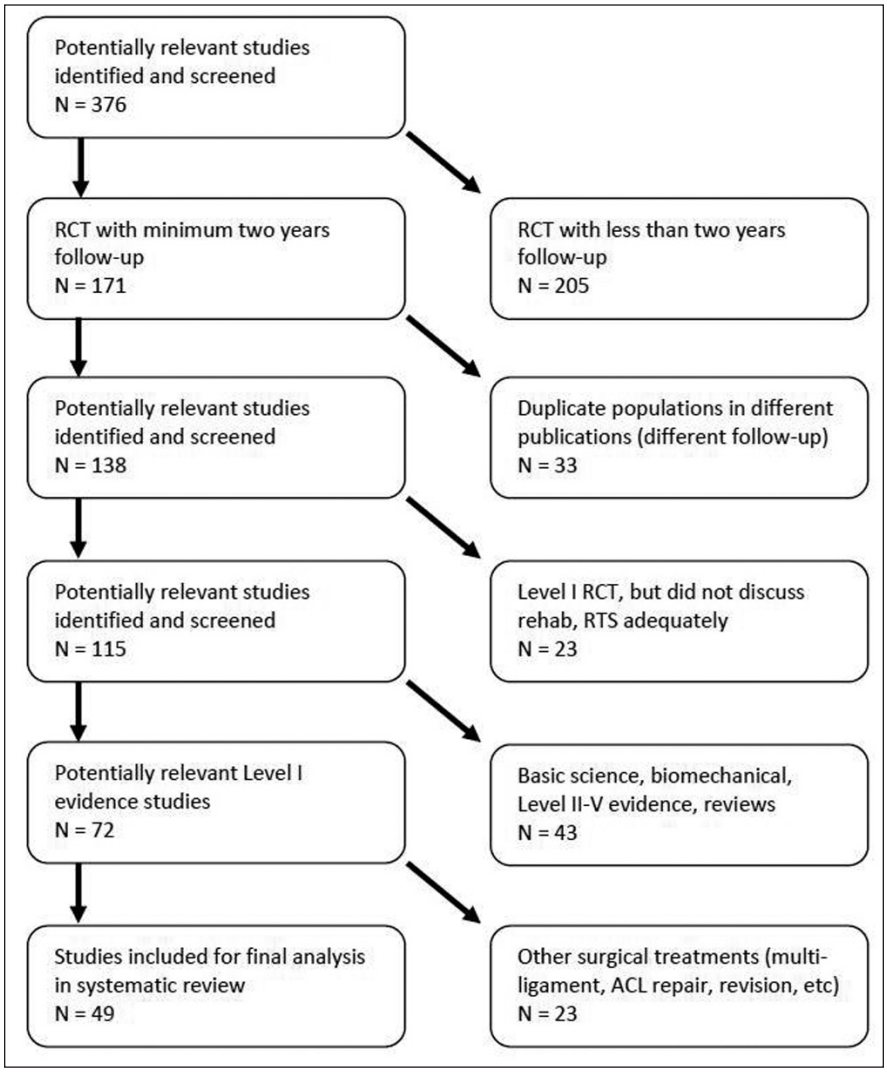

Figure: Flow chart illustrating application of exclusion criteria to determine the final number of studies analyzed in this systematic review. ACL (anterior cruciate ligament); RCT (randomized controlled trial); RTS (return to sport).

Materials and Methods

A systematic review of the available literature was conducted according to the guidelines recommended by Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) using a PRISMA checklist.[11] No formal protocol or registration number was established for the purposes of this investigation. Two independent reviewers (J.D.H., G.D.A.) conducted the search separately on November 16 and November 18, 2012, using the following databases: Medline (1950–November 16, 2012), SciVerse Scopus (1960–November 16, 2012), SportDiscus (1975–November 16, 2012), and Cochrane Central Register of Controlled Trials (1994–3rd quarter, 2012). The electronic search citation algorithm used was: (acl[Title/Abstract] OR (anterior[Title/Abstract] AND cruciate[Title/Abstract])) AND reconstruction[Title/Abstract] AND ((“1950/01/01”[PDAT] : “2012/11/18”[PDAT]) AND Randomized Controlled Trial[ptyp] ND English[lang]). Only Level I randomized controlled trials, as defined by the Oxford Centre for Evidence-based Medicine,[12] were included and analyzed. Given the depth and breadth of contemporary ACL research, only these article types were included to further investigate and answer the study’s clinical question. Both print journal and electronically published articles were eligible for inclusion. Medical conference abstracts were ineligible for inclusion. All references within included studies were cross-reference assessed for potential inclusion if missed by the initial search. Duplicate subject publications within separate unique studies were not reported twice. In the event of the latter, the study

with the longer duration follow-up, greater number of patients, or more explicit reporting of return to sport criteria was retained for inclusion and analysis. Studies on multiligament knee reconstruction, ACL repair, pediatric ACL reconstruction, posterior cruciate ligament reconstruction, and revision ACL reconstruction were excluded. The **Figure** illustrates the application of exclusion criteria to determine the final studies included in this systematic review.

The patients of interest in this systematic review were male and female patients enrolled in an appropriately randomized controlled trial with a minimum 2-year clinical follow-up after the intervention of primary unilateral ACL reconstruction using autograft or allograft of any graft type. A requirement of inclusion was that studies reported either subjective or objective return to sport criteria (qualitative and quantitative). Specific outcomes of interest were the timing of initiation of unrestricted return to sport, timing of initiation of return to cutting/pivoting sports, timing of return to sport-specific training, timing of return to running, duration of follow-up, use of isokinetic strength testing, use of functional performance testing (eg, single-leg hop test for distance, stair-hop test, 6-meter 1-legged hop test for time, triple jump test), use of KT-1000 or KT-2000 arthrometer (MEDmetric, San Diego, California) testing, and use of quantitative/qualitative criteria to determine return to sport. Demographic parameters analyzed included sex, age, graft type (ie, autograft, allograft; bone-patellar tendon-bone, hamstring, quadriceps tendon), reconstruction technique (ie, single bundle, double bundle), timing of injury to ACL reconstruction, country of study publication, and presence of study financial conflict of interest.

Study descriptive statistics were calculated. Continuous variable data were reported as mean±SD. Categorical variable data were reported as frequency with percentages. For all statistical analyses either measured and calculated from study data extraction or directly reported from the individual studies, a *P* value less than .05 was considered statistically significant.

Results

Forty-nine studies were included for analysis (**Table 1**). Within these studies, 59% (29/49) reported no presence of a financial conflict of interest. Seventy-six percent (37/49) of studies were published in 3 journals (*Am J Sports Med*, *Knee Surg Sports Traumatol Arthrosc*, and *Arthroscopy*). Twenty-seven (55%) studies were from Europe, 10 (20%) were from North America, 9 (18%) were from Asia, and 3 (6%) were from Australia. On average, the duration of time from ACL injury to ACL reconstruction was geographically unique. Depending on the method of reporting, the time from injury to surgery was fastest in the United States (42% [390/927] and 58% [538/927] of US patients underwent surgery within 3 and 6 months from date of injury, respectively). In Australia, Europe, and Asia, mean time from injury to surgery was 268, 418, and 279 days, respectively. Overall, more patients were male (68%) and young (mean age, 27.5±3.2 years), with a mean clinical follow-up of 3.0±1.9 years. Most patients underwent single-bundle (87%), autograft (96%) ACL reconstruction using semitendinosus and gracilis tendons (62% of all autografts).

Following ACL reconstruction, 67%, 53%, and

Table 1

Study Data

Data	No. (%)
Total studies	49
Financial conflict of interest	
Absent	29
Not reported	10
Present: private	7
Present: public/government	5
Country of study origin	
US	9
Sweden	8
Japan	5
Italy	5
Australia	3
Germany	3
Other[a]	16
Journal of publication	
Am J Sports Med	22
Knee Surg Sports Traumatol Arthrosc	8
Arthroscopy	7
J Bone Joint Surg Br	4
Other[b]	8
Total patients	4178
Male[c]	2612 (68)
Female	1253 (32)
Total knees	4178
Mean patient age, y	27.5±3.2
Mean time from injury to ACL reconstruction, d	379±321
Mean follow-up, y	3.0±1.9
ACL reconstructions analyzed	4075
Autograft	3911
Bone-patellar tendon-bone	1484
Hamstring	2427
Allograft	164
Bone-patellar tendon-bone	132
Achilles	32
Single-bundle reconstruction	3564
Double-bundle reconstruction	511

Abbreviation: ACL, anterior cruciate ligament.
[a]*Slovenia, Finland, South Korea, India, Norway, Spain, Kuwait, China, Czech Republic, Turkey, Canada.*
[b]J Bone Joint Surg Am, Scand J Med Sci Sports, Injury, N Engl J Med, Knee, J Int Med Res, J Zheijang Unv Sci B.
[c]*Sex reported for 3865 patients.*

Table 2

Post-ACL Reconstruction Assessment Methods Used

Assessment Method	No. of Studies
Clinical outcome score	
Lysholm score	33
Tegner activity score	26
IKDC subjective score	16
KOOS Sport and Recreation Function subscore	5
Marx activity score	1
KT-1000 or KT-2000 arthrometer	40
Functional test	
Single-leg hop test for distance	15
Triple jump test	3
Stair-hop test	2
6-meter 1-legged hop test for time	1
Knee walking test	2
Harner's vertical jump test	1
Isokinetic strength test	16
Used to permit return to sport	5
Not used to permit return to sport	11

Abbreviations: ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score.

33% of studies used the Lysholm, Tegner, and International Knee Documentation Committee (IKDC) subjective scores, respectively (**Table 2**). Although 31% of studies used a single-leg hop test for distance to assess functional outcome postoperatively, no other functional test was used in any more than 3 studies. Although isokinetic quadriceps and hamstring strength testing was performed in 31% of studies, only 10% of studies used this evaluation as a criterion to permit return to sport. Although 40 (82%) studies used KT-1000 or KT-2000 arthrometer testing, none used it as a criterion to permit return to sport.

Five (10%) studies reported the ability of patients (n=532) to successfully return to sport at preinjury level (**Table 3**). Nevertheless, 90% (n=479) of patients were able to return to sport at preinjury level. Overall, the description of permission/allowance to return to sport was highly variable and poor. Sixty-five percent of studies did not report whether criteria were used to allow a patient to return to sport. In the remaining studies, there were several different requirements, including strength testing, absence of thigh atrophy, range of motion, stability, absence of effusion, proprioception, and functional testing. When reported, 39% of studies permitted running in a straight line at 3 months postoperatively. When reported, 45% of studies permitted return to cutting and pivoting sports at 6 months postoperatively. Six (12%) studies permitted return to cutting and pivoting sports before 6 months postoperatively. When reported, 51% of studies permitted unrestricted return to sport at 6 months postoperatively. Two (4%) studies permitted return to sport without restrictions prior to 6 months postoperatively. Twelve (24%) studies did not report when patients were allowed to return to sports without restrictions.

Discussion

The purpose of this systematic review of Level I randomized controlled trials was to determine the published return to sport guidelines (subjective and objective) following ACL reconstruction. The authors hypothesized that description of return to sport guidelines is infrequently and variably reported. Further, it was hypothesized that patients are permitted to return to sport at 6 months following ACL reconstruction, with fewer than 50% of the studies using objective criteria to permit return to sport.

The study hypotheses were confirmed. Sixty-five percent of studies did not report whether criteria were used to allow a patient to return to sport. Twenty-four percent of studies did not report when patients were allowed to return to sport without restrictions. Only 10% of studies reported whether patients were able to return to sport at preinjury level. Nevertheless, rate of return to sport at preinjury level was 90%. Overall, 39%, 45%, and 51% of studies permitted running at 3 months, return to cutting/pivoting sports at 6 months, and return to sports without restrictions at 6 months, respectively.

Despite the wealth of peer-reviewed information published in the medical literature, no conclusive guidelines exist to permit safe return to unrestricted sport. There are 139 randomized controlled trials published on ACL reconstruction alone (9.2% of all ACL literature).[13] Return to sport following ACL reconstruction is dependent on several different patient-, knee-, and ligament-specific variables. Validated, reliable, and responsive subjective and clinical outcome scores are frequently reported in these studies. However, the ability to return to sport is broadly and variably defined based on the preinjury competitive level played, the goals of the patient postinjury, and the post-ACL reconstruction level of sport achieved. One question that remains is the definition of success following surgical reconstruction. Although scores may be high on validated clinical measures, the ability to return to sport and performance on return to sport may not be up to the patient's expectations, thus making the surgery unsuccessful in the patient's opinion. This fact has been exemplified in a recent meta-analysis of nearly 6000 patients after ACL reconstruction.[14] The study showed that only 44% of patients were able to return to competitive sport, despite 90% of patients having normal or nearly normal knee function using vali-

dated outcome scores. Similarly, a patient with a painful knee with poor clinical outcome scores may be able to return to play at the same (or higher) competitive sport level, thus deeming surgery successful in the patient's opinion.

The current study highlighted that a significant need exists to better define the outcome of return to sport following ACL reconstruction. This is represented in the fact that only 5 (10%) studies reported whether patients were able to return to sport. In efforts to achieve return to sport as quickly as possible, the surgical results may be compromised, putting the graft and knee at risk. Thus, several ACL reconstruction experts have lengthened the time of rehabilitation prior to return to sport and individualized permission to return to sport based on objective findings (eg, magnetic resonance imaging, biomarkers).[15] The current systematic review showed that, in the highest level of evidence of ACL literature, despite the lack of use of objective criteria, most surgeons permit return to cutting/pivoting sports by 6 (67% of studies, when reported) or 9 (90% of studies, when reported) months and return to sport without restrictions by 6 (57% of studies, when reported) or 9 (86% of studies, when reported) months.

Conclusion

This systematic review of Level I evidence is not without limitations. As with all reviews, the quality of the review, despite the nature of Level I evidence, is based on the quality of the studies analyzed. The strict criteria used for inclusion introduces selection bias. Samuelsson et al[13] performed a recent review of levels of evidence in ACL reconstruction and identified 1510 therapeutic studies. Thus, the current investigation represents only 3.2% of the ACL treatment literature, leaving out clinical therapeutic studies of Levels 2, 3, 4, and 5 evidence, in addition to diagnostic, prognostic, and economic studies. Despite this, the authors intentionally chose only the highest quality, Level I randomized con-

Table 3

Return to Sport Timing Parameters

Variable	No. (%)
Studies reporting rate of return to sport at preinjury level	5
Total patients	532
Patients returning to sport at preinjury level	479 (90)
When allowed to return to unrestricted sports, mo[a]	
Not reported	12
4-5	1
5-6	1
6	19
6-7	1
6-9	4
6-10	1
9	5
10-12	1
12	4
When allowed to return to cutting/pivoting sports, mo[a]	
Not reported	7
3	1
3-4	1
4-5	1
4-6	1
5	1
5-6	1
6	22
6-7	1
6-9	4
6-10	1
9	4
10-12	1
12	3
When allowed to return to running, mo[a]	
Not reported	15
<3	11
3	15
3-6	6
>6	2
Caveats to permission to return to sport[a]	
Not reported	32
Full functional rehabilitation/stability achieved	6
Full motion, full strength, no effusion, normal stability	2
Strength >90% vs contralateral knee	2
Isokinetic strength <10% difference, <1-cm thigh atrophy, single-legged hop >90%, normal Lachman's test	1
Isokinetic quadriceps strength >90% after monitored coordination, balance, and agility training	1
Knee function normal	1
Strength >85% and controlled functional training without difficulty	1
Normal knee motion, torque, and proprioception	1
Normal strength, balance, coordination, and functional performance	1
No problematic symptoms, sufficient muscle recovery	1

[a]*Reported as number of studies.*

trolled trials because these trials represent the outcomes on which clinical decisions should be made about an intervention of interest. The purpose of this review was not to analyze different surgical technique details; thus, performance bias is minimized. Most patients will have attempted a return to sport by 3 years (mean clinical follow-up in this study); therefore, transfer bias was also minimized. The significant heterogeneity in defining return to sport variables introduces detection bias.

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