Original Article

Factors Related to Return to Sport at One Year after Anterior Cruciate Ligament Reconstruction

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ABSTRACT

Objectives: To investigate rates of return to pre-injury sport (RTS) level at around one year after anterior cruciate ligament reconstruction (ACLR) and completing a rehabilitation program for post-ACLR and related factors.
Study design: Retrospective case control study.
Setting: Department Rehabilitation Medicine, Suratthani Hospital.
Subjects: Patients who underwent ACLR and completed the rehabilitation program, had a pre-injury Tegner Activity Scale (TAS) level 5 or higher, had normal Lachman test, and 4 single leg hop tests done.
Methods: Demographic data and results of 4 single leg hop tests were extracted from the recruited patients' medical records. Limb symmetry index (LSI) was calculated from the 4 single leg hop tests. The recruited patients were divided into two groups, the RTS and the non-RTS groups, and data were compared between the two groups.
Results: There were 40 patients in the RTS group and 31 in the non-RTS group. The RTS rates were 56.3% in average, 57.4% for football, 62.5% for running, and 16.7% for basketball. The RTS group had younger age (mean age of 23.5 and 29.0 years, p = 0.01), more athletes (37.5% and 12.9%, p = 0.03), higher percentage of LSI > 90% of all 4 single leg hop tests (77.5% and 29.0%, p = 0.00) than the non-RTS group. Mean duration from operation to the last 4 single leg hop tests was 10.4 months for the RTS group. One reason of being unable to RTS was fear of re-injury (67.7%).
Conclusion: The overall rate of return to pre-injury sport level was 56.3%. Younger age and achieving LSI more than 90% of all 4 single leg hop tests were factors related to RTS at around one year after ACLR and receiving postoperative rehabilitation. Fear of re-injury was a major reason for not returning to pre-injury sports activity.

Keywords: anterior cruciate ligament reconstruction, rehabilitation, return to sport, single leg hop test

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Introduction

The anterior cruciate ligament (ACL) tears are the most common, complete ligamentous injuries that occur in the knee joint.[1] In the United States, it is thought that over 200,000 ACL injuries occur annually, contributing to in excess of 100,000 ACL reconstruction (ACLR) surgeries.[2] The ACLR is the current standard for those with an ACL tear and considered to be at a high risk of knee instability such as young age, high-level athletes in a contact sport.[3] The primary goals of ACLR are to stabilize the knee to ensure minimized morbidity and allow a safe return to previous level of activity.[4] About 98% of the orthopedic surgeons recommend surgery if patients wish to return to sport (RTS).[5] Unfortunately, ACLR does not guarantee that they are able to achieve RTS.[5] Edwards et al. reported 63% of the patients could return to their pre-injury level of sport at 12 months after surgery.[6] The meta-analysis by Ardern et al. recorded a mean return to pre-injury sports rate of 65%.[7] The narrative review by Doyle recorded average RTS for competitive athletes was slightly lower than recreational athletes (60% vs 64%).[4] Different literatures led to improved understanding of variables influencing patients' ability to achieve RTS such as under 25 years of age, normal body mass index (BMI), professional athletes, short duration of injury, absence of co-commitment injury, grafts type, complete rehabilitation program, less 10% deficit quadriceps and hamstring trength, absence knee pain, more than 90% of limb symmetry index (LSI) and positive psychological factor.[1,4,6-10]

After ACLR, a rehabilitation program is provided to patients so that they could to return to a painless and fully functional daily life.[11] The program consists of neuromuscular control, lower limb muscular strength and sport specific exercise. Before returning to sport, functional tests such as a series of single leg hop tests are recommended for evaluating a lower extremity performance, physical function and readiness to RTS after ACLR.[7,12-14] In patients undergoing rehabilitation following ACLR, the 4 single leg hop tests are reliable measure

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of limb symmetry (intraclass correlation coefficient, ICC = 0.82-0.93)[15] as these tests assess the combinations of muscle strength and power, neuromuscular control, confidence in the repaired knee, and ability to tolerate loads related to sport specific activities.[13] The results of individual tests are frequently reported as LSI.[16] Recent ACLR studies have demonstrated an increased re-injury risk in patients not meeting a minimum 90% LSI on functional and strength tests.[10,17]

At Suratthani Hospital, there are about 80 cases of ACLR per year. All 4 orthopedists have utilized a similar arthroscopic ACLR with hamstring tendon autografts surgical technique consisting of anteromedial portal drilling, tibial screw fixation and femoral endobutton fixation.[18] The reason for hamstring tendon autografts choice was most patients were amateur or low division athlete.[18] Furthermore, the long term study of Webster et al. reported 15 years follow up for comparing patellar tendon and hamstring tendon ACLR. There were no differences in knee laxity and degree of osteoarthritis between both groups that supported this graft choice.[19]

In this present study, we aimed to investigate rates of return to pre-injury sport (RTS) level after ACLR and completing the seven-stage rehabilitation program, and factors related to successful RTS. We hypothesized that 1) age, BMI, meniscus injury, sport activity pre-injury status, duration from injury to ACLR and achievement in the functional tests might be related to RTS, and 2) based on the 4 single leg hop tests, those who could RTS would demonstrate better functional tests than those who failed to RTS.

Methods

Ethical approval was obtained from the Suratthani Hospital Human Research Committee (approval ethical number/RF 33/2563) before starting this retrospective study.

Participants

A total 255 of patients who had undergone an arthroscopic ACLR with hamstring tendon autografts during April 2016 - May 2019 were recruited into this study. Inclusion criteria were age between 15 and 50 years, unilateral ACL injury, and a pre-injury Tegner activity scale[20] (TAS) level 5 or higher. Exclusion criteria were bilateral knee injury, prior knee ligament injury and/or surgery, incomplete rehabilitation program, a history of heart condition and pregnant women. The flow diagram (Figure 1) describes how patients were tracked throughout the study.

Following the operation, 194 patients entered our post-operative rehabilitation program[21] (Appendix) starting in the first post-operative week, and duration of the whole program lasted at least six months after surgery. Before advancing to the next stage, the goals of the present stage were evaluated. However, we had only 71 patients who completed program and met all inclusion criteria. After completing the rehabilitation program, having full knee range of motion (ROM) and having normal knee stability (Lachman test with an end point grade 0 to 1+) evaluated by orthopedists, the patients then performed a series of 4 single leg hop tests which indicated knee joint stability function. According to our protocol, if the patients failed the first-time tests, approximately 8 months after ACLR, they were asked to have the second tests two months later; if they still failed the second-time tests, the third tests were repeated in the next two months. For those who passed the first-time tests, they were asked to repeat the tests at approximate one year after surgery.

According to a previous study by Edwards et al. (2018),[6] a sample size of at least 26 members for each group should be recruited.

Data collection

Medical records of eligible patients were identified and relevant demographic and clinical data were extracted. Demographic data were age, gender, body mass index (BMI); clinical data were meniscus injury, date of injury, date of operation, date of rehabilitation program ended, knee ROM, the Lachman test, the pre-injury and the post-operation sport activity status, results and date of performing the 4 single hop tests after completing the rehabilitation program, and reasons of not RTS.

The 4 single leg hop tests measured 1) single hop distance, 2) crossover hop distance, 3) triple hop distance, and 4) time utilized for a 6-meter hop distance with maximum effort.[14] Base on the tests, a LSI is calculated as a percentage of performance on the operated and the non-operated limb (% = operated limb/non-operated limb × 100). Using the last data achieved approximately one year post- operation, the LSI of each 4 single leg hop tests was calculated.[14] From this study of patients with ACLR, the tests were done between 8 and 14 months after operation.

According to previous study by Edwards et al. (2018)[6] to "pass" the tests in this study, one required to achieve LSI > 90% on the operated limb in all 4 tests, and to "fail" when on one or more of the 4 tests showed LSI < 90%.

Statistical analysis

For statistical analysis, the data were divided into two groups based on patients' report: the "RTS" of those who were able to return to their pre-injury sport levels and the "non-RTS" of those who failed. The levels were classified based on TAS.[20] Using STATA version 12.0 (Stata Corp, College Station, TX), descriptive statistics such as means, standard deviations, proportions, percentage, were calculated for all demographic, physical and functional data of each group. Independent t test was used to assess between-group differences of continuous data, and Fisher exact test for categorical data such as gender, age groups, BMI groups, the pre-injury sport level and the functional tests based on LSI mentioned above. A *p*-value of less than 0.05 was considered statistically significant.

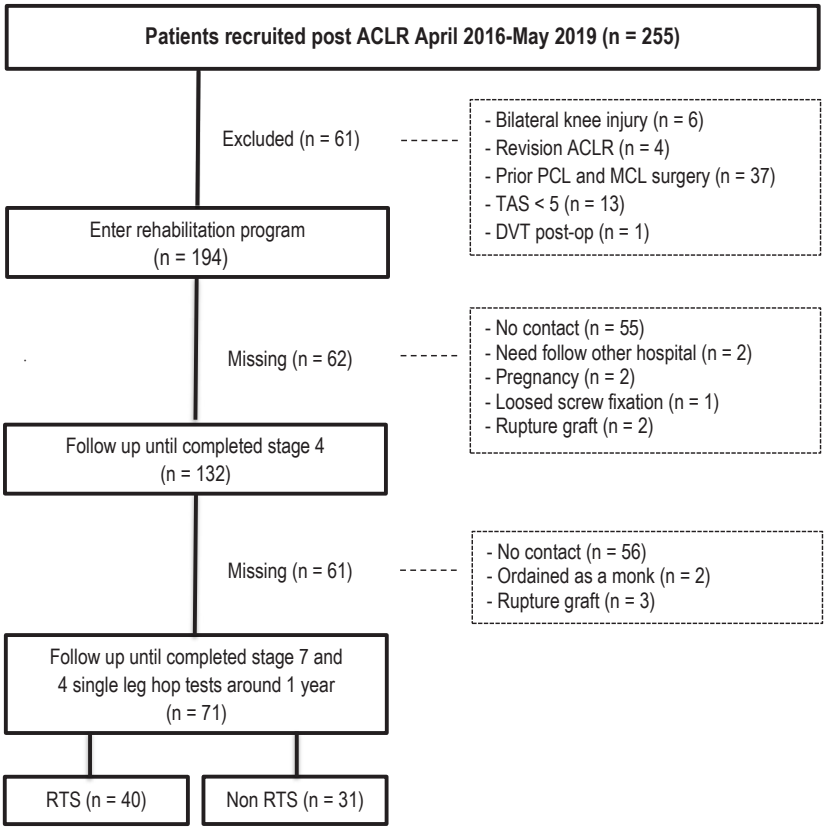

Figure 1. Flow chart diagram for patients recruited post ACLR
ACLR, anterior cruciate ligament reconstruction; PCL, posterior cruciate ligament; MCL, medial collateral ligament; RTS, return to pre-injury sport; DVT, deep vein thrombosis; TAS, Tegner activity scale

Results

A total of 71 patients were included in the study. The rates of return to pre-injury sport level were highest in those below 18 years old (87.5%), followed by those between 26 and 32 years old (62.5%), in those between 18 to 25 years old (50%), and lowest in those over 32 years old (26.7%). The most common sports participants played before their ACL injury were football (76.1%), running (11.3%), and basketball (8.5%); and the rates of RTS were 57.4% for football, 62.5% for running, and 16.7% for basketball. Other sports were volleyball (n = 2) and taekwondo (n = 1), and all could RTS.

Demographic data are shown in Table 1. The RTS group was significantly younger than non-RTS group (mean age of 23.5 and 29.0 years, respectively, p = 0.01). When dividing into four distinct age groups, there was a statistically significant difference between the RTS and the non-RTS groups (p = 0.05). Gender, mean BMI, meniscus injury, and obesity were not different between the two groups. However, the pre-injury sport status was significantly different between the two groups (p = 0.03). Regarding the TAS, the pre-injury level was no difference but the post-injury level was significantly different (p = 0.00), the mean post-operative TAS level was higher in the RTS group than in the non-RTS group. The RTS group had a shorter duration from injury to ACLR but the difference between groups did reach statistical significance (7.0 and 9.9 months, p = 0.24). Mean duration from operation to the last 4 single leg hop tests was similar at 10.4 months for the RTS group and 10.7 months for the non-RTS group (p = 0.61).

There were 31 patients in the RTS group (77.5%) and 9 patients in the non-RTS group (29.0%) who could pass all 4 single leg hop tests with LSI > 90%, and there was statistically significant difference between the two groups (p = 0.00) as showed in Table 2 In addition, the LSI for each 4 single leg hop test and all 4 combined in the RTS group were more than non-RTS group and there were significant differences between the two groups (p = 0.00, 0.05, 0.00, 0.01 and 0.00).

In the non-RTS group, 21 patients (67.7%) reported fear of re-injury or lack of confidence as a primary reason for not returning to pre-injury levels of sports participation, and 10 patients (32.3%) had knee joint symptoms (pain, swelling, and muscle weakness). Muscle weakness was reported by 6 patients (19.4%), knee pain was reported by 3 patients (9.7%) and swelling knee was reported by 1 patient (3.2%). Muscle weakness was the most frequently reported knee joint symptoms.

Discussion

This study investigated the rate of return to pre-injury sport level approximately one year after surgery, 56.3% of

Table 1. Comparison of demographic data between the return to pre-injury sport level (RTS) and the non-RTS groups

Demographic data	RTS (n = 40)	Non-RTS (n = 31)	*p*-value
Age[1] (years)	23.5 (7.4) [16-46]	29.0 (9.6) [17-49]	0.01[a]
Age groups[2] (years)			
< 18	14 (87.5)	2 (12.5)	0.05[b]
18-25	12 (50.0)	12 (50.0)	
26-32	10 (62.5)	6 (37.5)	
> 32	4 (26.7)	11 (73.3)	
Gender[2]			
Male	36 (90.0)	30 (96.8)	0.38[b]
Female	4 (10.0)	1 (3.0)	
BMI[1] (kg/m^2)	23.4 (3.3)	24.8 (4.1)	0.11[a]
BMI groups[2] (kg/m^2)			
< 25	30 (63.8)	17 (36.2)	0.08[b]
> 25	10 (41.7)	14 (58.3)	
Meniscus injury[2]	32 (79.5)	22 (71.0)	0.38[a]
Duration from injury to ACLR[1] (months)	7.0 (6.1) [1-24]	9.9 (13.4) [2-60]	0.24[a]
Duration from ACLR to the 4 single leg hop tests[1] (months)	10.4 (2.1) [8-14]	10.7 (2.3) [8-14]	0.61[a]
TAS[1]			
Pre-injury	7.5 (1.3) [5-9]	7.2 (0.8) [6-9]	0.17[a]
Post operation	7.5 (1.3) [5-9]	5.1 (0.7) [4-7]	0.00[a]
Pre-injury sport status[2]			
Amateur	25 (48.1)	27 (51.9)	0.03[b]
Athlete	15 (79.0)	4 (21.1)	

[1]Mean (SD) [range], [2]number (%)

[a]Independent t test; [b]Fisher exact test

BMI, body mass index; TAS, Tegner activity scale; ACLR, anterior cruciate ligament reconstruction

Table 2. Comparison of means limb symmetry index (LSI) calculated from the 4 single leg hop tests between the return to pre-injury sport level (RTS) and the non-RTS groups

LSI	RTS (n = 40)	Non-RTS (n = 31)	*p*-value
Single hop LSI[1]	95.2 (0.8)	89.6 (1.5)	0.00[a]
Triple hop LSI[1]	95.7 (0.7)	92.6 (1.5)	0.05[a]
Crossover hop LSI[1]	97.0 (0.8)	90.7 (1.6)	0.00[a]
Timed hop LSI[1]	93.8 (1.0)	88.6 (1.8)	0.01[a]
Combined LSI[1]	95.4 (0.7)	90.4 (1.3)	0.00[a]
Pass/Fail[2]	31 (77.5)/9 (22.5)	9 (29)/22 (71.0)	0.00[b]

Pass means achieving LSI > 90% in all 4 tests; Fail means having one or more of the 4 tests with LSI < 90%

[1]Mean (SD), [2]number (%)

[a]Independent t test; [b]Fisher exact test

the patients had returned to their pre-injury level of sport participant, which is in line with the previous research reporting 63% and 65% of patients resumed participation at their pre-injury level of activity by 12 months after surgery.[6,7] Those who participated in running had higher rate of RTS (62.5%) than those who participated in football (57.4%) and basketball (16.7%). One reason of having higher rate of RTS in runners might be due to less injury as running is a non-contact sport. On contrary, basketball had the lowest rate of RTS as basketball is a contact-sport. Similar with Seto et al. reported that athletes who participated in sports involving cutting and twisting motions were less successful in returning to pre-injury activity level after ACLR.[22]

In this study, one factor related to RTS around one-year post ACLR was younger age. Ardern et al. reported that younger age certainly appeared to significantly influence return to pre-injury sport rates, as the RTS rates in their 280 patients divided into four distinct age groups were as follows: 49% in age < 18 years, 57% in age 18-25 years, 44% in age 25-32 years and 33% in age > 32 years; highest in the 18-25 years group and lowest return in the > 32 years group.[23] In our current study, the highest rate (87.5%) was recorded in those < 18 years, while the lowest rate (26.7%) was same in those > 32 years. It has been suggested that people under 18 years of age have a greater opportunity to participate in sports because they are often school athlete and had free

time for recreation activity, whereas those over 32 years of age have more barrier including employment, family commitments and less opportunity to take part in sport.

Ballal et al. displayed that obesity within two years post-operation did not adversely affect functional outcomes as measured by the KOOS and Lysholm scores.[8] However in our study, the percentage of obese patients (BMI > 25 kg/m^2) was less in the RTS group less than non-RTS group (25.00% and 45.16%) and the difference between groups was closely statistically significant (p = 0.08). Hence, we suggest that the obese patients should control their body weight after ACLR and through rehabilitation program as they may fail to RTS.

Another factor concerned was being an athlete. In our study, there was a higher number of athletes in the RTS group than the non-RTS group (37.5% and 12.9%) with statistically significant difference (p = 0.03). Smith et al. displayed the competitive athletes RTS more successfully than recreational athletes.[24] Competitive athletes might be expected to have greater success rates in returning to pre-injury levels of sport than amateur considering that they have a more satisfactory physical status preoperatively, good cooperated with the rehabilitation program, and mental prepare to RTS.

The last but important factor related to RTS found in this current study was the functional tests i.e., the 4 single leg hop tests. There were 22.5% of our patients who had returned to sports even but failed the functional test, and they were at high risk of graft ruptures. According to Kyritsis, et al. athletes who did not meet the required clearance criteria before returning to sport had a 4-fold greater risk of sustaining an ACL graft rupture compared with those who had met the discharge criteria e.g., single leg hop had LSI > 90%, agility running T test < 11 seconds and quadriceps deficit < 10%.[10]In this current study, younger age was a significant predictor of return to sport, with 65% of patients aged < 25 years having already returned to sports at the time of the clinical evaluation but younger age was a significant risk factor for secondary injuries after ACLR as Paterno et al. reported 29.5% of athletes who under 25 years of age suffered a second ACL injury within 24 months of RTS, with 20.5% sustaining a contralateral injury and 9.0% suffering a graft re-injuring.[25] In a systematic review, Wiggins, et al. identified younger patients (< 25 years) and those who returned to a high level of activity, especially in high-risk sports, to be at an increased risk to the secondary ACL injury rate was 23%.[26] The reasons for the increased risk are likely to be younger patients and returning to high-risk sports that involve cutting, jumping, and pivoting movements.[14] We observed 6 of the patients aged < 25 years and who were back playing sport with failed functional tests, potentially putting them at risk of the secondary ACL injury. Patient education seems very important to younger athletes. Rehabilitation physicians (physiatrists) should closely observe and evaluate them through all seven stages of rehabilitation program, and perform follow-up functional tests closely until they achieve all discharge criteria to reduce the re-injury risk.

When exploring the reason why, the patients in this current study who had passed the functional tests but not return to pre-injury sport level fear of re-injury and lack of confidence were the dominant psychological factors. According to the systematic review by Ardern et al. positive psychological responses including motivation, confidence and low fear were associated with a greater likelihood of returning to the pre-injury level of participation and returning to sport.[27] Rehabilitation physicians should encourage positive psychological responses during post-operative rehabilitation program when setting goal for RTS.

This current study had some limitations as it was a retrospective study. The number of patients recruited into the study was rather small when comparing with the number of cases per year which indicated that many patients were missing from the rehabilitation program. We expected causes that 1) some patients had a problem of travelling long distance to Suratthani Hospital because they lived in other provinces e.g., Chumphon, Ranong and Phuket and Samui Island, 2) after operation 2-3 months, patients returned to work or school they found it was difficult to take day off for coming to hospital, and 3) some patients did exercise by themselves after they sought technique from online media and asked their friends.

In conclusion, after ACLR and completing the seven stages out-patient rehabilitation program at Suratthani Hospital, the overall rate of returning to pre-injury sport level at approximately one year after surgery was 56.3% in patients having pre-injury level 5 or higher of Tegner activity scale. Younger patients and achieving a limb symmetry index more than 90% in all 4 single legged hop tests were good predictive factors of RTS at approximately one year after ACLR and completing post-operative rehabilitation program. Fear of re-injury was a psychological barrier of returning to sport.

Disclosure

No potential conflicts of interest relevant to this article were reported.

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Appendix

Home based post ACLR rehabilitation program[21]

Time frame	Rehabilitation goal	Activities
Stage 1 Week 0-2	ROM: full extension Good quadriceps contraction Weight bearing as tolerated with crutches Except repaired meniscus group non weight bearing first 6 weeks	On knee brace full extension all times Isometric quadriceps exercise Ankle pump SLR (flex, abduct, extend) Stretching hamstring and gastrocnemius muscle Prone hang, pillow under heel Gait training Patellar mobilization
Stage 2 Week 2-4	ROM: 0°-90° Closed chain quadriceps exercise Walk without crutches	Knee brace 0°-90° PROM 0°-90° Heel slide Prone hamstring exercise Wall slide knee flex 45°
Stage 3 Week 4-6	ROM: 0°-120° Increased muscle strength and endurance Enhance proprioception, balance, neuromuscular control	Unlocked knee brace PROM 0°-120 stationary bike Step up 4-step forward and lateral Toe rises Wall slide knee flex 90° Shift weight, standing single leg
Stage 4 Week 6-8	ROM: 0°-140° Normal gait pattern Increased muscle strength and endurance With meniscus repaired titrate weight bearing	Off knee brace PROM 0°-140° Step up 8-step forward and lateral Wall slide knee flex 90° with weight and ball Wall slide single leg 45°-90° Backward walking Leg press exercise (0°-60°)
Stage 5 Week 8-12	Full ROM Enhance propriception, balance, neuromuscular control Good single leg squat test	Treadmill walking (flat only) Forward lunge exercise Wobble board balance two legs Single leg squat
Stage 6 Week 12-18	Full ROM Restore functional capability and confidence Good single leg squat test	Reverse lunge exercise Jogging and light running Knee extension exercise Agility exercise Outdoor bike on flat road
Stage 7 Week 18-24	Maintained muscle strength and endurance neuromuscular control Return to sport	Running, jumping, hoping Agility exercise Sport specific exercise

ROM, range of motion; SLR, straight leg raising; PROM, passive range of motion

Reference: Janewanitsataporn S. The functional tests after ACL reconstruction with and without meniscal repair. J Health Sci Med Res. 2020;2:73-9. (with permission)