Knee Surgery, Sports Traumatology, Arthroscopy (2019) 27:2511–2519
https://doi.org/10.1007/s00167-018-5258-y

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Nearly 90% participation in sports activity 12 years after non-surgical management for anterior cruciate ligament injury relates to physical outcome measures

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Received: 21 June 2018 / Accepted: 23 October 2018 / Published online: 1 November 2018

Abstract

Purpose Traditionally reconstructive surgery is recommended for patients planning to return to sport (RTS), especially to pivoting sports after anterior cruciate (ACL) rupture. Recent trends focus on delaying or avoiding surgery as some studies have found similar rates of RTS following both surgical and conservative management. This study aimed to establish long-term RTS levels in ACL-ruptured individuals treated conservatively, and to investigate the relationship between outcome measures and RTS, in particular, pivoting sports.

Method Fifty-five patients from a cohort of 132 ACL-deficient patients were followed-up for 12 (IQR 8,19) years post injury. Mean-aged 42 years, 22 patients were females and 33 males, 35 had meniscal injuries. Patients were treated with physiotherapy focussing on strength and dynamic stability training and not reconstructive surgery. Return to sport was measured on a 6-point scale. Outcome measures included: objective stability, subjective stability, quadriceps and hamstring strength. Spearman's rho and Chi-square tests were used to assess the relationship between RTS and outcome measures.

Results Eighty-nine percent of ACL-deficient patients were currently participating in sport despite a 38% increase in anterior translation ($p < 0.001$) and a 7.5% loss of quadriceps strength ($p = 0.004$) compared to the contralateral side. Six patients (11%) did not RTS, ten (18%) returned to safe sports, five (9%) returned to running and 16 (29%) to non-strenuous sports involving limited twisting. Eighteen patients (33%) returned to pivoting sports, 12(22%) at recreational level and six (11%) at competitive level. The level of RTS was related to subjective stability ($p = 0.002$), and to quadriceps and hamstring strength of the injured leg ($p < 0.001$). Patients able to return to pivoting sports differed significantly from those not doing so in outcome measures including objective ($p = 0.022$) and subjective stability ($p = 0.035$), and quadriceps strength ($p = 0.044$).

Conclusions Eighty-nine percent of ACL-ruptured individuals treated conservatively lead an active sporting life. One-third returned to pivoting sports. Overall RTS was related to subjective and objective stability and quadriceps and to a lesser extent hamstring strength. This finding reinforced the importance of dynamic stability training as an initial treatment option in most cases.

Level of evidence III.

Keywords Anterior cruciate ligament · Return to sport · Conservative management · Pivoting sports · Outcome measures

Abbreviations

ACL	Anterior cruciate ligament
RTS	Return to sport
AP	Anterio-posterior

Introduction

It is generally considered that if patients wish to return to sport (RTS) following an anterior cruciate ligament (ACL) injury, the treatment of choice is surgery [25]. This applies especially to patients wishing to return to pivoting sports

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[17]. Reconstructive surgery, usually using a bone–patellar tendon–bone or a semitendinosus/gracilis graft aims to restore joint stability, to reduce the likelihood of developing osteoarthritis (OA) and to allow for successful RTS [22, 34]. Reports have shown a high level of return to sport following surgery with an 83% return rate in elite athletes [24], up to 85.7% in children and adolescents [35] and 76% in younger sportspeople [42]. Following surgery in non-elite athletes, some studies report a much lower 55–63% RTS in adults [4, 6, 7, 36] similar to that achieved in conservatively treated sportspeople. In addition, surgically managed patients have been shown to have reduced quadriceps and hamstring strength and high levels of OA [37]. In some cases considerable dissatisfaction [14] was recorded, thus questioning the superiority of surgery.

Whereas many studies have reported RTS following ACL reconstruction (Table 1, studies 1–10) fewer have specifically reported RTS following non-surgical treatment, especially long-term outcomes [19, 23, 39]. A growing number of recent studies (Table 1, studies 14–24) have compared RTS between surgical and non-surgical groups. No study was found that investigated the relationship between injury outcome measures and the ability to RTS, in particular to pivoting sports, following conservative treatment. However, following ACL surgery, correlations were found between RTS and several outcome measures [10, 27]. Relating injury outcome measures with RTS can provide valuable information and direction for rehabilitation strategies.

At this time when conservative management is gaining favour over surgery [44], it is important to assess the long-term sporting outcome of patients who have not had surgery. Traditionally, with surgery considered the primary option for treatment, the selection of those best suited for reconstruction has been challenging, as some patients return to their pre-injury sporting level without surgery. Such individuals, recognised by Noyes et al. [32] and described as 'copers' [34, 38] have been treated conservatively with stability training programs, more so in some countries. The current recommendation is that non-surgical management with comprehensive rehabilitation, should be the primary treatment choice for all, including high-demand individuals with ACL injuries [16, 43]. The KANON study [16] has shown in a randomised control trial (RCT) that only 51% of non-surgically treated patients in an RCT followed over 5 years, required surgery.

This retrospective study was planned to gain better insights into patients able to successfully RTS long-term without surgery, in particular to pivoting sports. The aim was to assess the level of RTS following conservatively managed ACL-deficient (ACLD) individuals injured on average 12 years previously. A second aim was to investigate the relationship between RTS level and the following outcome measures: objective stability, subjective stability, quadriceps and hamstring strength. Further, we aimed to assess whether those returning to pivot sports differed from those who did not in measures of stability and strength.

Materials and methods

Patients were recruited from a cohort of 132 ACLD patients who had been referred to physiotherapy for conservative management by one of five knee surgeons (Fig. 1). These patients did not have surgery either due to age, lower activity demand, financial restrictions, work issues or because they were functionally stable and surgery had not been advised by the surgeon. Patients were recalled 12 (IQR 8, 19) years post-injury. They were included if on initial orthopaedic assessment they had a complete ACL tear confirmed on clinical testing, MRI or arthroscopy, if they were less than 60 years old and had no reconstructive surgery. Seventy-seven patients were excluded including 22 (17%) diagnosed as partial injuries, in keeping with reports that 10–27% of ACL injuries are partial [41]. Fifty-five patients who met the inclusion criteria physically attended the clinic for assessment. There were 33 males and 22 females. The average patient age was 41.6 (±9.1) years. The average age at the time of injury was 28 years (±9.7). Twenty-seven patients were in the acute and 28 in the chronic phase post-injury at the time of referral to physiotherapy.

Initial orthopaedic assessment reported varying levels of stability: 11 patients with a clear-cut pivot shift had an unstable knee and it was indicated that surgery would become necessary; 31 had an equivocal pivot shift test with positive anteroposterior instability and were recommended physiotherapy in a 'wait and see' attempt to avoid surgery; 13 patients had a negative pivot shift test with no signs of functional instability despite a complete tear on MRI and were recommended physiotherapy only. Thirty-five patients had meniscal injuries on the injured side, 31 were diagnosed at the initial assessment, four occurred subsequently. Of these 24 had arthroscopies/meniscectomies. Two patients had ligament injuries on the injured side with one having had a lateral ligament repair. Two patients had arthroscopies on the contralateral side. Three patients, all males, had bilateral ACL injuries. One contralateral ACLD knee had been reconstructed and was stable and fully functional.

Physiotherapy

Patients had followed a rehabilitation program detailed previously [20]. This program, focussed on strength and dynamic stability training (Fig. 1). In addition, range of motion, balance, and safe movement planning were incorporated. Some agility training was included but generally, patients were discouraged from partaking in pivoting sports.

Table 1 Literature summary showing studies assessing RTS following surgical (1–10) and non-surgical treatment (11–13) and those comparing both approaches (14–24)

No.	References	Group	Time frame post injury or surgery	No surgery	Surgery	Measure
1	Dekker et al. [12]	Paediatric 6–17 years	48 months		91% 84%	Overall RTS Return to same sport
2	Nwachukwu et al. [33]	Active athletes mean age 26 years	10 months		87% 67%	Overall RTS Return to preinjury level
3	Lai et al. [24]	Elite athletes	6–11 months		83%	Return to preinjury level
4	McGrath et al. [26]	Adults aged 18–40 years	12 months 24 months		81% 83%	Tegner score Tegner score
5	Adhern et al. [4]	Meta-analysis over 7000 participants	40 months		81% 65% 55%	RTS Return to preinjury sport Return to competition
6	Webster et al. [42]	Aged < 20 years	5 years		76% 65%	Preinjury sport Preinjury level
7	Cinque et al. [9]	National football league linesmen	10.7 months		64.3%	Played at least one game
8	Ardern et al. [6]	Young active adults	41 months meta-analysis		63% 44%	Return to preinjury Return to competition
9	Ardern et al. [7]	Competitive sport-speople Football, netball basketball, soccer	12 months		33%	Return to preinjury level
10	Filbay et al. [14]	Patients with knee difficulties	5–20 years		39% 28%	Return to competition Return to lower level
11	Sommerlath et al. [39]	Adults mean aged 28 years	9–16 years	39%		Returned to preinjury level
12	Kostogiannis et al. [23]	ACL deficient adults	3 years	44%		Returned to preinjury level
13	Buss et al. [8]	Selected low demand, sedentary, > 30 years	46 months	70%		Moderate-demand sport Recreational
14	Dunn [13]	Paediatric	38 months	43.75%	92%	Ability to return to sport
15	Ramski et al. [35]	Children and adolescents	Reporting results of 2 studies	0%	85.7%	Return to previous level
16	Andersonn et al. [3]	Competitive athletes	41–80 months	27%	63% Surgery with augmentation	
17	Fink et al. [15]	Mean aged 32	13 years	70% decline compared to preinjury	44% decline compared to preinjury	Innsbruck Knee Sports Rating Scale. Return to pivoting sport
18	Ardern et al. [5]	Groups matched	1 year 2 years	54.5 55.9	66.9 64.4	KOOS sport Score
19	Grindem et al. [17]	Aged 13–60 years, pair matched	1 year	68.1% 54.8%	68.1% 61.9%	RTS Return to level 1 sport
20	Kessler et al. [22]	Patients with isolated ACL ruptures	11 years	4.9	5.3	Tegner score
21	Frobell et al. KANON study [16]	Active young adults, not professional An RCT	5 years	23%	20% Half of this group had delayed surgery	Active at preinjury Tegner score
22	Meuffels et al. [28]	Pair matched High level athletes	> 10 years	7	8	Tegner score

Table 1 (continued)

No.	References	Group	Time frame post injury or surgery	No surgery	Surgery	Measure
23	Streich et al. [40]	Matched for age, gender BMI, concomitant injuries	15 years	5.1	4.7	Tegner score
24	Myklebust et al. [31]	Competition handball players	7.8 years	82%	58%	Returned to preinjury level

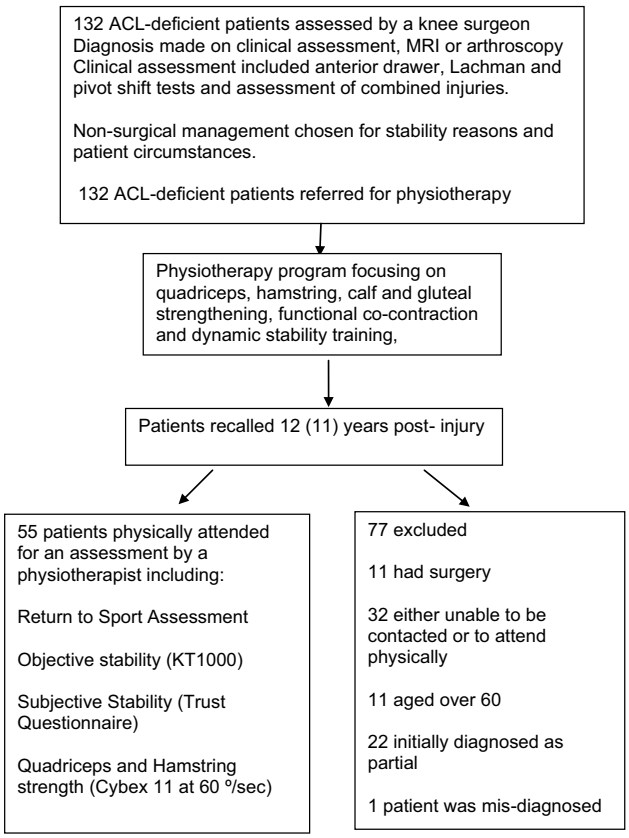

Fig. 1 Flow diagram showing recruitment of participants

Patients were educated regarding the prevention of reinjury, realistic outcomes and ongoing self-management.

All except five patients were treated in the same physiotherapy clinic but not always in the early stages post-injury.

Outcome measures

This assessment was conducted 12 years post-injury by a physiotherapist.

Return to sport (RTS)

The highest current return to sport ability was assessed according to six levels: The RTS score was: 0 if not playing any sport; 1 if actively involved in safe solo sports, for example hiking, cycling, rowing, gym work; 2 if actively jogging/running; 3 if involved in sports with restricted twisting like golf, surfing, skiing and tennis; 4 if partaking in vigorous pivoting team sports at a recreational level for example touch, netball, hockey, basketball; 5 if partaking in vigorous pivoting team sports at a competitive level.

Passive stability

Antero-posterior (AP) stability was assessed using the KT1000 arthrometer (MEDmetric, San Diego, California). The AP translation was recorded during a manual maximum test (MMT). This was expressed as the difference in millimetres, between the injured and uninjured sides.

Subjective instability

This was assessed on the Trust Questionnaire which assesses progressively demanding tasks challenging anterolateral stability. This questionnaire has been previously described [20].

Isokinetic quadriceps and hamstring strength

This was assessed using the Cybex II dynamometer (Lumex Inc. Ronkonkoma, New York) at 60°/s following a 3-min warm up on an exercise bike and two stretches for the quadriceps and hamstring muscles. The seating position, stabilizing of the trunk and verbal encouragement was strictly standardised for each participant. The patients performed five maximal cycles of extension/flexion and the highest quadriceps and hamstring torque of five contractions were recorded. The strength of the injured leg, as well as the strength index which compared the injured as a percentage of the uninjured side were used in the calculations.

Ethical clearance to conduct this study was granted by the Medical Research Ethics Committee of The University of Queensland, Australia. Approval number 2008000964. All patients signed a consent to take part in the study.

Statistical analysis

The number of patients achieving different sporting levels was calculated. Analyses compared stability and strength between the injured and uninjured sides. In addition, using Spearman's rho, RTS was correlated with stability and strength of the injured side as well as side-to-side indices and Trust scores. Further analysis, using Chi-square and *t* tests compared stability and strength index measures between those returning to pivoting sports with those who did not do so. The three patients with bilateral injuries were excluded from the statistical analysis.

A power analysis under the parameters of an expected large effect size difference between the two groups, $\alpha = 0.05$, and power = 0.08 was conducted. Based on these parameters, a full sample size of 34 (17 in each group) would be required to maintain a type I error at 0.05.

Results

Return to sport

Of the 55 patients taking part in this study, 49 (89%) were currently involved in sport, with 18 (33%) involved in pivoting sports. Table 2 shows the level of RTS achieved.

Outcome measures

There was a significant 38% increase in anterior tibial translation comparing the MMT between the injured and uninjured sides ($p < 0.001$). For the Trust score, the average was 10.3 representing a 69% level of trust compared to healthy knees. Our results showed a 7.5% loss ($p < 0.005$) of quadriceps strength and a non-significant 2% loss of hamstring strength compared to the uninjured side (Table 3).

Correlation between measures and RTS levels

There was a significant relationship between the level of sport played and (i) the Trust score ($p = 0.004$), (ii) quadriceps strength on the injured side ($p < 0.001$), (iii) hamstring strength on the injured side ($p < 0.001$) (Table 4). Return to sport level did not correlate with the MMT on the injured side but came close to correlating with the side-to-side differences between injured and uninjured knees (n.s).

Differences in measures comparing pivot and non-pivot sports

Comparison between measures for the pivot and non-pivot sports showed that those engaged in pivoting sport had significantly greater MMT side-to-side difference ($p = 0.022$), Trust scores ($p = 0.035$) and quadriceps strength index ($p = 0.044$) (Table 5).

Table 2 Current levels of return to sport achieved, $N = 55$

Sport	Examples and Tegner level	Number/percentage of 55 returning to sport
No sport	Able to walk on even ground (Tegner level 1)	6 (11%)
Safe solo sports	Walking varied surfaces, cycling (Tegner level 2–4)	10 (18%)
Running	Running on level and slightly uneven surfaces (Tegner level 4–5)	5 (9%)
Non-strenuous sport involving twisting	Tennis, skiing, surfing, golf (Tegner level 6, surfing and golf added)	16 (29%)
Pivoting team sport recreational	Soccer, touch rugby, cricket, netball, hockey (Tegner level 7, touch rugby, cricket, netball, hockey added)	12 (22%)
Pivoting team sport competitive	Soccer, touch rugby, cricket, netball, hockey (Tegner level 8–9, touch rugby, cricket, netball, hockey added)	6 (11%)
Total returning to sport		49 (89%)

Table 3 Long-term strength and stability deficits following non-surgical management for anterior cruciate ligament rupture

Measure	Injured side, mean (SD)	Uninjured side, mean (SD)	% deficit (%)	*p* value, $N = 52$
KT 1000 (mm) MMT	11.7 (2.5)	7.2 (1.9)	38	< 0.001**
Trust questionnaire	10.3 (3.2)	15 (0)	31	
Quadriceps strength (ft lbs)	99 (40)	107.(39)	7.5	0.005**
Hamstring strength (ft lbs)	66 (26)	67 (23)	2	n.s.

$N = 52$ excludes three patients with bilateral injuries

Table 4 Correlation between measures for strength and stability and level of return to sport

Measure	Correlation Spearman's rho	*p* value
Injured side KT1000 MMT	− 0.152	(n.s)
Trust score	0.404**	0.004
Injured side quadriceps strength	0.644**	< 0.001
Injured side hamstring strength	0.701**	< 0.001
Side-to-side KT MMT index	− 0.250	(n.s.)
Quadriceps side-to-side index	0.235	(n.s.)
Hamstring side-to-side index	0.262	(n.s.)

N = 52 excludes three patients with bilateral ruptures

*Correlation significant at the 0.05 level (two-tailed)

**Correlation significant at the 0.01 level (two-tailed)

Discussion

The most important finding of the present study was that 89% of conservatively treated patients in this study were currently still involved in sport. One-third of patients were involved in pivoting sports, 11% at a competitive level. Most patients had changed or modified their sporting activity and they reported that they now planned their movement, in particular, their foot placement.

RTS relates to strength and stability 12 years post injury

The strongest correlation between RTS and objective measures was found between level of RTS and quadriceps and hamstring strength of the injured side (Table 4). The level of RTS also correlated, as expected, with subjective stability as measured using the Trust Questionnaire, but less so with objective passive stability. Several researchers, including McGrath et al. [27] also found a relationship between RTS and hamstring strength post ACL reconstruction but not between RTS and KT 1000 measures [26].

Most importantly, our findings showed significant differences in strength and stability in individuals able to return to pivoting sports compared to those not able to do so. The most significant difference was in objective stability (Table 5) as expected, but those returning to pivoting sport also had significantly greater Trust scores and quadriceps strength.

This current study provides support for investing in a comprehensive rehabilitation program focussing on strength, especially quadriceps strength, and stability training to facilitate a return to sport, in particular, pivoting sports.

Confirmation of a select stable subgroup of patients

As anticipated we found a wide range of RTS ability. This was not surprising since our cohort included patients with clear-cut instability who were advised to have surgery as well as those with complete tears but a negative pivot shift test who were functionally stable. That is, our cohort included 'copers', 'potential copers' and 'non-copers'. This study identified a select subset of six patients, who, without a functioning ACL, were able to return to pivoting sports at a competitive level. While there are several explanations for this including the presence of the intercruciate band [30] or the stabilizing properties of the menisci [1], it is possible that active neuromuscular system responses [18] and physiotherapy training, maximize dynamic stability, and enable the return to competitive pivoting sports. There is a growing body of evidence that this is the case [2, 16].

Surgery versus non-surgical treatment

This study found that 89% of conservatively managed ACLD patients returned to sport ranging from safe solo sports to

Table 5 Comparison in outcome measures between patients participating in pivoting (*N* = 18) and non-pivoting or no sport (*N* = 37)

Outcome measures	Sport	Mean (SD) (*N* = 52)	*P* value *N* = 52 excluding bilateral injuries
Side-to-side_KT1000	Non-pivot sports	5.2 (2.2)	0.022*
	Pivot sports	3.7 (2.3)	
Trust score	Non-pivot sports	9.8 (3.1)	0.035*
	Pivot sports	11.8 (2.9)	
Quadriceps Index	Non-pivot sports	0.89 (15)	0.044*
	Pivot sports	0.99 (0.21)	
Hamstring Index	Non-pivot sports	0.94 (0.16)	(n.s)
	Pivot sports	1.03 (0.18)	

*Correlation significant at the 0.05 level (two-tailed)

**Correlation significant at the 0.01 level (two-tailed)

competitive pivoting sports. This compares favorably to the study by Buss et al. [8] where 70% of patients returned to moderate demand sport at the recreational level. Most of our patients did not return to their pre-injury sport but as they grew older they were happy with their decision to follow conservative management and modify their sport. Many reached challenging goals including completing triathlons, half marathons and the 800 km Camino Walk. In general, most studies that have compared surgical to non-surgical treatment show a higher RTS in surgical compared to non-surgical treatment [3, 15]. Dunn et al. [13] report a significant difference in RTS in paediatric patients with 43.75% returning to sport following non-operative and 92% following surgical treatment. However, in studies with matched groups [17, 40] or randomized allocation [16], the results between surgical and non-surgical approaches are comparable, leading to a growing emphasis on conservative management. In general. few patients treated conservatively are considered to be able return to pivoting sport [34]. In this current study, 33% of patients returned to pivoting sports compared to 59% [21] in a similar cohort who underwent reconstruction.

A high rate of meniscal injury

While it was encouraging to find a high percentage of well-functioning ACLD patients, it is important to be aware that conservative management in young athletes who demonstrate significant instability, may heighten the risk of meniscal injury which increases the predictability of osteoarthritis [21]. In this current study, 35 of 55 (64%) patients injured their menisci. This would seem to be a higher rate of injury than in surgically managed patients where surgery is recommended not only to improve functional performance but also to reduce the risk of subsequent meniscal damage [22]. Thirty-one of 35 patients presented with meniscal injuries at the time of initial consultation, mostly those with chronic injuries. It has been shown that there is a 12× higher risk of meniscal injury in the ACLD compared to the ACL reconstructed adolescent knee [35]. This may be one drawback of non-surgical treatment. In addition, according to some studies, patients report a superior quality of life and function in sport, comparing surgical to non-surgical treatment [5].

Strengths and weaknesses of this study

Because of the retrospective nature of this study, we did not have the same baseline measures for strength and stability and were unable to assess the effect of the physiotherapy intervention. A further weakness of this study is that the cohort is heterogeneous regarding stability, despite the exclusion of participants suspected of having a partial ACL injury. The wide range of years post-injury is a further weakness as was the inability to contact 32 of the patients. One of the strengths of this study is that a considerable number of ACLD subjects were recruited, in a country [45] where surgery has been the gold standard for ACL management over the last decades.

This clinically relevant study has shown that physiotherapy management of ACLD patients may be a successful alternative to surgery in patients with varying levels of instability. A non-surgical approach can lead an active and satisfying sports life, albeit modified, many years after injury.

Conclusion

It has been shown that 89% of ACLD patients treated conservatively are still active in some form of sport 12 years after injury. Most patients had modified their sport and their sporting goals. Thirty-three percent of these patients were still involved in pivoting team sports with 11% partaking in competition. An important finding of this study is that the ability to return to sport is related to modifiable measures including objective and subjective stability in addition to quadriceps and hamstring strength. This finding reinforces the importance of specifically targeted physiotherapy training programs in maximizing the potential of ACLD individuals to return to sport.

Author contributions SLK conceived of the study, recruited the patients, was responsible for the data collection and the initial manuscript draft. PN assisted with the study design and was responsible for the data analysis and interpretation. ACK assisted with study concept and design and assisted with assessment and manuscript draft. All authors read and approved the final manuscript.

Funding No funding has been received for this study.

Compliance with ethical standards

Conflict of Interest The authors have no conflicts of interest.

Ethical Approval Work has been approved by the Medical Research Ethics Committee of The University of Queensland, Australia.

Informed Consent All subjects signed an informed consent form before data collection took place.

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