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Outcome and knee-related quality of life after anterior cruciate ligament reconstruction: a long-term follow-up

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Abstract The aim of the present investigation was to study patient-reported long-term outcome after anterior cruciate ligament (ACL) reconstruction. On an average 11.5 years after ACL reconstruction with bone-patellar tendon-bone (BPTB) autograft 56 patients were asked to answer four different questionnaires about their knee function and knee-related quality of life. Another aim was to study whether there were any correlations between clinical tests, commonly used for evaluating patients with ACL injuries, which were performed 2 years after ACL reconstruction, and patient-reported outcome in terms of knee function and knee-related quality of life on an average 9.5 years later. All patients who had unilateral BPTB ACL reconstructions were examined at 2 years and on an average 11.5 years after surgery. At 2 years one-leg hop test for distance, isokinetic muscle torque measurement, sagittal knee laxity, Lysholm knee scoring scale and Tegner activity scale were used for clinical evaluation. At the follow-up on an average 9.5 years later the patients were evaluated with knee injury osteoarthritis outcome score (KOOS), short form health survey (SF 36), Lysholm knee scoring scale and Tegner activity scale. The SF-36 showed that the patients had a similar health condition as an age- and gender-matched normal population in Sweden on an average 11.5 years after ACL reconstruction. There was no correlation between the results of one-leg hop test for distance, isokinetic muscle torque measurement, sagittal knee laxity evaluated 2 years after surgery and the result of KOOS (function in sport and recreation, knee-related quality of life) and SF-36 evaluated on an average 11.5 years after surgery. We also compared patients that 2 years after surgery demonstrated a side-to-side difference in anterior–posterior knee laxity of more than 3 mm with those with 3 mm or less and found no significant group differences in terms of knee function as determined with KOOS. We found no correlation between the results of KOOS and SF-36 at the long-term follow-up and the time between injury and surgery, age at surgery or gender, respectively. We conclude that there is no correlation between patient-reported knee function in sport and recreation and knee-related quality of life on an average 11.5 years after BPTP ACL reconstruction and the evaluation methods used 2 years after surgery.

Keywords Anterior cruciate ligament (ACL) reconstruction · Long-term follow-up · KOOS · Outcome · SF-36

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Introduction

Anterior cruciate ligament (ACL) injury is one of the most serious injuries in sports medicine, especially in the so-called pivoting sports. These sports are characterized by sudden stops, change of directions, accelerations, and decelerations that put high demands on knee joint stability. Football, handball, ice hockey, and floor ball belong to these pivoting sports and represent sports with the highest number of ACL injuries. In 1997 following distribution of registered players from the database of the Folksam insurance company was presented for the Stockholm County: football 20,787 players, floor ball 9,360 players,

handball 3,672 players, and ice hockey 6,410 players. During this year 151 of the registered players were reported as having an ACL reconstruction. The distribution between the different sports was football 70 players, floor ball 35 players, handball 34 players, and ice hockey 12 players (Folksam insurance company database in Sweden). For football players, Roos et al. reported a prevalence of 344 ACL injuries among 188,152 players (18 injuries/10,000 players) [32].

In a study where patients who had experienced a rotation trauma to their knee also was assigned to an MRI it was reported an incidence of 8 ACL injuries/10,000 inhabitants in age group 10–64 [11]. In 2005 the Swedish National ACL register was established. Their estimation is that the injury rate is 7,200/year and that 50% of these are surgically treated. This register covers 90% of all clinics in Sweden that perform ACL surgery. In 2006 and 2007 the clinics reported a total of 2,506 and 2,643 ACL reconstructions. Whereof 1,038 respectively 1,071 individuals were injured when playing football.

Most sports orthopedic surgeons suggest that an ACL-injured athlete should undergo an ACL reconstruction in order to stabilize the knee joint and thereby prevent giving way [8]. The modern surgical techniques of today have also enabled the orthopedic surgeons to reconstruct the ACL with fewer traumas to the knee than previous techniques [12]. ACL reconstruction is a commonly performed surgical procedure within sports orthopedics. The actual incidence of ACL injuries is not known, but the Swedish National Register for ACL injuries estimates in their report for year 2005–2006 that the incidence is between 35 and 70 injuries/100,000 habitants. In year 2006, 36 different hospitals in Sweden reported to the register that they made 2,181 primary ACL reconstructions. ACL reconstruction using the bone-patellar tendon-bone (BPTB) graft has been the 'gold standard' for several years, although the use of hamstring tendon as a graft has recently increased. The long-term use of BPTB graft for ACL reconstruction has led to several investigations [3, 4, 16, 26, 35–37] and clinical follow-up studies with both objective and subjective evaluations demonstrate favorable results in 80–90% of the patients [3, 4, 6, 10, 27, 39]. There are also some authors that have evaluated the outcome after a mid- and long-term follow-up and found good clinical results [1, 4, 16, 17, 19, 21, 35, 40]. In a 4–7-year follow-up study, Brandsson et al. [5] reported that 80% of their patients were classified as normal or nearly normal according to the International Knee Documentation Committee (IKDC) [14]. To our knowledge, reports from follow-ups of 10 years or longer are rare.

In sports medicine no consensus exists about the optimal way of evaluating ACL-reconstructed athletes before return to sport should be allowed. In general, there is both objective and subjective evaluation instruments used in the clinic. The most frequently used objective evaluation measures in ACL-injured patients or patients with ACL reconstructions are measurements of knee laxity, range of motion and isokinetic muscle torques combined with functional tests, the one-leg hop test for distance being the most popular one [23]. During the last decade subjective measures, such as different types of functional scores and questionnaires have been suggested. The main reason is to receive information about knee function and quality of life from the patient's point of view. The importance of the clinician's judgement of clinical outcome has been gradually reduced in favor of the patient's own experience of his/her knee function. The optimal evaluation after ACL reconstruction and before returning to sport should, however, be a combination of both. Wilk et al. [49] reported a positive relationship between the results of isokinetic knee extensor measurements, functional tests, and patient-reported outcome questionnaires. Hitherto, there are no convincing studies on possible correlations between objective and subjective evaluation instruments appropriate for patients with ACL-reconstructed knees, though.

The main aim of this investigation was therefore to study the long-term effect, 11.5 years after surgery, of patient-reported knee function and knee-related quality of life after BPTB ACL reconstruction, and to investigate whether commonly used clinical tests, performed 2 years after surgery, could predict the long-term outcome. We also wanted to study if gender, time from injury to surgery and age at surgery influence the patient-reported outcome in terms of knee function and knee-related quality of life on an average 9.5 years later.

Materials and methods

From April 1994 to November 1995, 62 ACL reconstructions were made with BPTB graft. The inclusion criteria were unilateral ACL injury combined with or without associated meniscal injury. Patients with collateral ligament injuries, posterior cruciate ligament injuries or ACL injury in the contralateral knee were excluded. The patients in the present study were included in a prospective randomised study as well [22] with a median follow-up time of 24 months (24–33).

Informed consent was obtained and the study was approved by the ethical committee at the Karolinska Hospital. The demographic data did not differ between the groups.

In the present follow-up investigation, we report the results of the entire patient cohort on a median follow-up time of 11.5 (11–12) years after ACL reconstruction.

All patients were contacted by mail and were asked to fill in the forms that were enclosed. If they did not respond within 2 weeks a reminder was sent and if they did not respond to this reminder they were contacted by phone.

The present study comprised 30 males and 32 females with a mean age of 27.5 (8) years at the time of surgery. The median time from injury to surgery was 6 (2–240) months. At the time of the ACL reconstruction there were also 17 meniscus injuries in 14 patients, and three out of these sustained both a medial and a lateral injury. These meniscus injuries were classified as associated injuries and were included in the study. All associated injuries were treated at the initial ACL surgery. None of the meniscus injuries was sutured.

At the long-term follow-up at 11.5 years after ACL reconstruction we were able to follow-up 56 patients. Six patients were lost to follow-up at 2 years. Two patients had secret addresses, two patients had moved abroad with unknown addresses and two patients did not want to participate due to lack of time.

At the follow-up on an average 11.5 years six patients were lost. One patient was missing from both the short-term (2 years) and the long-term (11.5 years) follow-up and the other five patients had attended the 2-year follow-up but were missing at the long-term follow-up.

Surgery

There were four experienced orthopedic surgeons involved in the study. Two performed an arthroscopic ACL reconstruction using patellar tendon autograft and fixation with interference screws, as described by Rosenberg [34]. The other two used a modified technique by drilling the femoral tunnel from the outside, using the rear entry guide and used interference screws for fixation. This technique is described by De Haven [7] and Rosenberg [33]. All patients received the same postoperative regime, apart from the brace, and followed the same standardized rehabilitation program supervised by a physiotherapist. Between the short-term (2 years) and long-term (11.5 years) follow-ups four patients sustained ACL graft ruptures and three were re-operated with a new graft while one did not want another reconstruction. Three patients had undergone meniscal surgery of the operated knee and one patient had an ACL injury to the contralateral knee.

Part I: Measurements at the 2-year follow-up

Knee laxity test

The Stryker laxity tester (Stryker Kalamazoo, Mich, USA) was used to measure sagittal knee laxity at 20° of knee flexion (90N) as described by Andersson and Gillquist [2]. The following standardized testing procedure was performed: the patient sat with the medial epicondyle of the femur on the level of the hinge between the positioning seat and the leg holder. The measurement device was mounted with the proximal part on the tibial tubercle and the scale pointing at the middle of the patella. Measurements were performed in both the anterior and posterior directions. An anterior load was applied from the medial side to reduce a possible internal rotation of the tibia. The test was continued until the obtained value was stabilized, starting with posterior laxity. The difference in anterior–posterior laxity between injured and uninjured knee was recorded.

Isokinetic muscle torque measurement

Isokinetic concentric peak torques during knee flexion and knee extension were measured at an angular velocity of 90 and 180°/s with a Kintrex® 1000 (Meditronic Instruments, Ecublens, Switzerland). Prior to testing the patient warmed up at a stationary bicycle for approximately 5 min. The seating position was standardized, with fixation of the body and legs. The patient was tested in 90° of hip flexion with the back supported and the arms folded across the chest. The distal pad of the Kintrex was fixed around the ankle just above the lateral malleolus. The lateral femur condyle was defined as the center of knee motion and compensation for gravity forces was automatically made by the equipment. The patients performed five submaximal repetitions to become familiarized with the Kintrex device. Peak torque was recorded from one out of three maximal repetitions. A ratio between injured and uninjured leg was calculated.

One-leg hop for distance

Functional performance was addressed by using the one-leg hop test for distance [23]. This requires the patient to jump off on one leg and land on the same leg without loosing balance or stepping on the other leg. If the patients lose their balance the hop was repeated. The test was carried out with “free arms” and with shoes. The longest one out of three hops was measured in centimeters for each leg, starting with the non-involved side. The ratio between the injured and uninjured leg was calculated.

Lysholm knee scoring scale

To evaluate knee function during daily activities the Lysholm knee scoring scale was used [18, 44]. This scale has been widely used in the orthopedic literature and proven reliable and responsive for athletic patients [20].

Tegner activity scale

Activity level was evaluated with the Tegner activity scale [44]. This activity scale is graded from 0 to 10 points, and the level of activity is determined as follows: 0 = not working secondary to knee problem; 1–4 = no sports, but working; 5–7 = recreational sports; 7–10 = competitive sports. The activity level was evaluated before surgery and 6 and 24 months after surgery.

Part II: Measurements at the 11.5-year follow-up

Lysholm knee scoring scale

The Lysholm knee scoring scale [18] was used to evaluate the patient's knee symptoms and possible functional limitations. Patients who scored greater than 91 points were rated as excellent. Patients with scores between 90 and 77 points were rated as good and scores less than 77 points were rated as fair/poor [26]. We also included the preoperative results of the Lysholm knee scoring scale.

Tegner activity scale

The Tegner activity scale was used to determine the level of physical activity [44]. We also included the preoperative results of the Tegner activity scale.

Knee injury osteoarthritis outcome score

Knee injury osteoarthritis outcome score (KOOS) is an instrument to assess the patients' opinion about their knee and associated problems. The KOOS has been found to be useful when evaluating clinical outcome after ACL reconstruction [29, 30]. It consists of five subscales: pain, other symptoms, function in daily living, function in sport and recreation and knee-related quality of life. The score is calculated for each subscale, where 0 represents extreme knee problems and 100 represents no knee problems. The scores obtained from this group were compared to a control group consisting of 25 individuals below 50 years of age with no radiographic changes of knee osteoarthrosis or previous meniscus or ACL injury. The participation in physical activity of the control group was reported as follows: 48% were active in sports, 32% were doing heavy household work, walking on even ground, while 20% had a sedentary life-style [31].

SF-36 health survey

The SF-36 is a generic, patient-based health assessment tool comprising eight subscales. The score of the subscales ranges from 0 to 100, where 100 indicates the least health-related problems and 0 the worst health-related problems. The different subscales are: physical functioning (PF), role-physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role-emotional (RE) and mental health (MH) [48]. We used the Swedish version of SF-36 [28, 42, 43]. The SF-36 has been recommended to be used to evaluate ACL-injured patients [38]. The three subscales specifically analyzed in this study were PF, RP, and BP which have been reported to be well correlated with the Lysholm knee scoring scale [38].

Gender

All investigated parameters were analyzed separately for males and females at the 11.5-year follow-up in order to detect any gender differences in outcome.

Subjective assessment

Subjective patient satisfaction was evaluated by asking the following question: if you suffered a new ACL injury should you choose to undergo ACL surgery again. The patients were asked to answer with "yes", "no", or "I do not know". They were also asked if they were satisfied with the outcome of the surgery performed on an average 11.5 years ago. If the patients had changed their level of activity from the 2-year follow-up, they were further asked if this change was related to their knee.

Statistical analysis

Non-parametric statistics were used. Median values and ranges were calculated for the KOOS and SF-36. Spearman rank order correlation was used to assess any correlations between the results of KOOS; function in sport and recreation and knee-related quality of life, and the results of SF-36 (PF, RP, BP) and the clinical parameters measured 2 years after surgery; sagittal knee laxity, muscle peak torque, one-leg hop test, Lysholm knee scoring scale, Tegner activity scale, time between injury and surgery, age, and gender. The variables KOOS and SF-36 were considered to be ordered categorical data and thus divided into adequate categories before the logistic regression analyses. Stepwise logistic regression analysis for ordinal and binary responses was used to evaluate the association between the dependent variables KOOS; function in sport and recreation (divided into three categories based on tertiles $\leq$65, >65–90, >90), knee-related quality of life (divided into three categories based on tertiles $\leq$68.75, >68.75–87.5, >87.5), SF-36, PF (divided into two categories based on the first tertile $\leq$90, >90) and SF-36, RP (divided into two categories based on the first tertile $\leq$84, >84) and the independent clinical variables measured 2 years after surgery; sagittal knee laxity, muscle peak torque, one-leg hop test, Lysholm knee scoring

scale, time between injury and surgery, age and gender. We used the Mann–Whitney *U* test to investigate if there was any difference in the KOOS: function in sport and recreation and knee-related quality of life in patients that had ≤3 mm or >3 mm side-to-side difference [13] in sagittal knee laxity at the 2-year follow-up. A *P*-value of ≤0.01 was considered as significant. Missing patients in the follow-up was included according to the intention to treat principle.

Results

Lysholm knee scoring scale

Knee function according to the Lysholm knee scoring scale is presented in median and range.

A significant increase could be seen from the preoperative scores to the 2-year follow-up ($P = 0.001$). A significant decrease was noted at the late follow-up from the 2-year follow-up ($P = 0.001$) (Table 1).

Fourteen patients scored below 77 points. Three out of 14 patients had undergone a new ACL surgery because of a new trauma to the same knee and one patient had new surgery because of insufficient result from the first surgery. Another patient had a new injury but did not want to be re-operated. Four out of 14 patients had associated injuries to the meniscus at the initial ACL surgery and one patient had a new ACL rupture in the contra lateral knee. The remaining 42 patients scored as follows: >91 excellent ($n = 20$) and >77 good ($n = 22$).

Tegner activity scale

The activity level is presented in median and range (Table 1). The decrease in activity level preoperatively to the 11.5-year follow-up was not significant ($P = 0.18$).

Eleven patients reported reduced activity level due to knee problems of their operated knee.

Knee injury osteoarthritis outcome score

The evaluation of knee function according to KOOS for the whole group at the 11.5-year follow-up after surgery compared with a control group is reported in Table 2. Comparisons were also done with a reference group consisting of 89 male soccer players 14 years after ACL reconstruction [47]. These figures are presented in Table 3. According to KOOS, 16 patients (28.5%) scored excellent in terms of function in sport and recreation, and 10 patients (17.8%) scored excellent in terms of knee-related quality of life. The two most severe problems experienced by the patients were the following items. (1) "To what degree of problems with twisting/pivoting of your injured knee have you experienced during the last week?" Eight patients (14.3%) reported severe or extreme problems. (2) "To what degree of problems with kneeling have you experienced during the last week?" Fifteen patients (26.8%) reported severe or extreme problems. (3) In the subscale quality of life the most severe problem was shown in the item "Have you modified your lifestyle to avoid potentially damaging activities to your knee?" Nine patients (16%) out of 56 reported a severely or totally modified lifestyle.

SF-36 health survey

The results concerning the patients' general health condition as determined with the SF-36 are presented in Fig. 1. When compared to an age- and gender-matched normal population in Sweden [43] no significant differences were found between the reference group and the studied patients at their long-term follow-up after ACL reconstruction.

Gender

No significant differences in respect of gender were found in any of the investigated parameters.

Subjective assessment

Seven out of 56 patients reported that they would not undergo another ACL surgery if they sustained a new ACL injury. The data about these patients are presented in Table 4. Patient 1 and 2 had undergone a new ACL reconstruction of the same knee, due to a new trauma, scored below median in KOOS in terms of function in sport

Table 1 Knee function and activity level according to Lysholm knee scoring scale and Tegner activity scale, respectively, throughout the entire study period

	Before injury ($n = 62$)	Preop. ($n = 62$)	2 years ($n = 56$)	11.5 years ($n = 56$)
Knee function		76.5 (40–100)	96 (63–100)	90 (40–100)
Lysholm knee scoring scale				
Activity level	6 (2–9)	2 (0–7)	6 (1–10)	4 (2–9)
Tegner activity scale				

The results are given as median values and range

Table 2 Knee function according to KOOS at the long-term follow-up after ACL reconstruction in comparison with a control group of individuals without knee injuries

	Study group ($n = 56$) Md (range)	Control group ($n = 25$) Md (range)
Pain	94 (67–100)	100 (60–100)
Function, daily life	100 (60–100)	100 (47–100)
Recreation/sport	75 (0–100)	100 (40–100)
Quality of life	81 (0–100)	100 (44–100)

Table 3 Knee function according to KOOS at the long-term follow-up after ACL reconstruction in comparison with a reference group of male soccer players 14 years after ACL reconstruction

	Study group ($n = 56$) Mean	Reference group ($n = 89$) Mean (95% CI)
Pain	90	86 (82.2–89.2)
Symptoms	86	75 (70.4–79.6)
Function, daily life	94	91 (88.5–94.0)
Recreation/sport	71	64 (57.7–70.1)
Quality of life	81	62 (56.6–67.1)

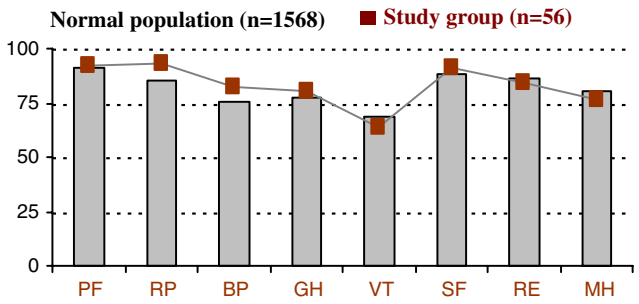

Fig. 1 Swedish SF-36 health survey: a comparison between the study group 11.5 years after ACL reconstruction and an age- and gender-matched normal population in Sweden. Physical functioning (*PF*), role-physical (*RP*), bodily pain (*BP*), general health (*GH*),vitality (*VT*), social functioning (*SF*), role-emotional (*RE*), mental health (*MH*)

and recreation as well as knee-related quality of life compared to the other patients of the study group. Patient 3 with a new injury was not operated on. Patient 7 did not want to undergo another surgical procedure if a new ACL injury occurred. This particular patient showed very low scores in KOOS in terms of function during leisure time and sport and quality of life. This patient had missing data from the 2-year follow-up because he had moved to the USA. However, this patient reported dissatisfaction with the result of the surgery and stated that the low activity level (Tegner 3) was due to the ACL reconstruction that was performed 11.5 years earlier. Two of the three patients that sustained meniscus injuries to the same knee as their ACL reconstructed knee scored between 80 and 100 in terms of knee function according to KOOS. The third patient scored 15 in function in sport and recreation and 50 in knee-related quality of life. One explanation to these low scores could most likely be that this patient sustained an ankle fracture and a new ACL injury of the opposite leg 3 years after the initial ACL surgery. This patient declared satisfaction with the outcome of the first surgery and that this "new" injury did not interfere with his life today. The group of patients with meniscus lesions which was treated at the initial ACL surgery scored 68 (range 5–100) in function in sport and recreation and 69 (range 0–94) in knee-related quality of life, while the whole group ($n = 56$) scored 75 (0–100) in function in sport and recreation and 81 (0–100) in knee-related quality of life.

Correlation between clinical assessment 2 and 11.5 years after surgery

None of the following three postoperative variables were significantly correlated with KOOS in terms of function in sport and recreation, and knee-related quality of life or according to SF-36 in terms of physical functioning and role physical and bodily pain: sagittal knee laxity, muscle peak torques, the one-leg hop test as evaluated 2 years after ACL reconstruction.

In order to analyze possible significant associations between the dependent variables, KOOS in terms of function in sport and recreation, and knee-related quality of life or SF-36 physical functioning, role physical, and the independent clinical variables were measured at the 2-year follow-up. A stepwise regression analysis was used. This analysis did not show any of the clinical variables measured at the 2-year follow-up as a strong predictor of good outcome in terms of KOOS and SF-36. Patients with a side-to-side difference of more than 3 mm in sagittal knee laxity was compared to those with 3 mm or less, and no significant differences were found in terms of knee function according to KOOS. No correlations were found between time of injury and surgery, age at surgery or gender, respectively and knee function according to KOOS or quality of life according to SF-36 at the long-term follow-up 11.5 years after ACL reconstruction.

Discussion

The purpose of this study was to assess the patient-reported long-term results after ACL reconstruction with BPTB graft in patients with unilateral ACL injuries. We also wanted to study if knee joint laxity, muscle torque, one-leg hop test for distance, 2 years after surgery, when the

Table 4 Knee function according to KOOS regarding the subgroups function in sport and recreation and knee-related quality of life in those seven patients that denied to undergo another ACL reconstruction, if injured again

Patient	New ACL injury	New ACL surgery	Other surgery	Sport/Rec	Quality of life
1	Yes	Yes		45	44
2	Yes	Yes		50	44
3	Yes	No		65	63
4	No		Meniscus injury	85	69
5	No			100	81
6	No			95	100
7	No			25	38

patients were considered fully rehabilitated, could predict the long-term result as evaluated with KOOS subscales: knee function in sport and recreation and knee-related quality of life, SF-36 subscales: PF, RP and BP, Lysholm knee scoring scale and Tegner activity scale.

We found good patient-reported long-term results as evaluated by the Lysholm knee scoring scale, which is in agreement with other studies [15, 20]. When analyzing the Tegner activity scale at the same time we conclude that at the 6-month follow-up the patients have rather low activity levels but a good knee function as evaluated with the Lysholm knee scoring scale, indicating that there are no severe problems during daily living [22]. Tegner et al. [44] suggested that an activity scale is a valuable complement to a functional score.

By the 2-year follow-up they reported an even better knee function with Lysholm knee scoring scale, and in addition a higher activity level according to Tegner activity scale, indicating that many patients had returned to the same activity level as before injury without severe problems. When compared with the results we gained in KOOS subscales knee function in sport and recreation and knee-related quality of life, we are inclined to believe that the Lysholm knee scoring scale is not as sensitive to physically active individuals as the KOOS. Therefore, it is important to consider the patients' level of activity when using the Lysholms knee scoring scale. Although in this study we only found a slight decrease in physical activity determined with the Tegner activity scale. This decrease could probably, to some extent, be explained both by the fact that the patients were 11–12-year-old and thereby decreased their activity level because of family and or working situations and spent less time in physical activity. We chose to assess the patients with validated scores at the long-term follow-up. The SF-36 is not a knee-specific score and may therefore have a lower ability than KOOS to discriminate between patients with different knee problems. In the present study, the majority of patients reported a similar degree of general health in the SF-36 different subscales as compared to an age- and gender-matched reference group of normals. This could explain why we did not find any differences in our series that might have been found in a larger patient population. Our results of the KOOS score was in line with previously reported results of the KOOS in a study performed on male soccer players 14 years after surgery [47]. However, we are aware that there is some difficulty in comparing the results of these two groups, as the patient cohort was registered male soccer players, and therefore likely to be more active after ACL surgery than our patient cohort representing both males and females with various activity levels in different sports. It has been reported in other studies [29] that the most discriminative subscales for knee function are function in sport and recreation as well as knee-related quality of life, which was the case in this study too. We consequently found that our group reported more problems with sports, recreation, and quality of life than a control group with no knee injuries [29], but they also reported similar result as the control group in the two other dimensions. This might indicate that the patient who has undergone ACL surgery suffers from reduced knee function when being or wanting to be physically active. Furthermore, our patients were fairly young individuals, which might mean that they had high demands on activity level and lifestyle. When analyzing patients with poor results we found that this can only partly be explained by associated injuries at the initial surgery or new knee injuries during the follow-up period. Our second goal in this study was to assess the prognostic value of various objective and subjective parameters measured when the patients were suggested to be fully rehabilitated after ACL reconstruction. In some previous studies no such correlations have been reported [9, 41]. On the other hand, Wilk et al. [49] found a positive relationship between isokinetic knee extensor torque, functional tests, and patient-reported knee scores. In the present study, we were not able to establish any correlations between objective parameters, such as knee joint stability and peak muscle torque, and the patient's own experience of the long-term outcome measures with self-reported questionnaires. Although we specifically addressed patients that had a side-to-side

difference of sagittal knee laxity of more than 3 mm ($n = 23$) with those with 3 mm or less ($n = 33$), we could not find that the patients with greater laxity had a less-favorable outcome. A plausible explanation might be that there were so few patients with poor results in our patient cohort. A population-based study may be needed to find factors of prognostic value for the long-term results.

It would have been an advantage if all measures that were carried out preoperatively and 2 years postoperatively also had been performed at the long-term follow-up 11.5 years after ACL reconstruction. Due to practical reasons this was, however, not possible. Furthermore, in a recent study [24, 25, 45, 46], it has been suggested that psychological parameters should be considered when deciding which patient that would benefit from surgical intervention.

In the present study we did not evaluate psychological characteristics, which might be seen as a study limitation.

In conclusion, we found that the patients in this study reported a good knee function (KOOS, Lysholm) and a similar degree of health conditions (SF-36) as an age- and gender-matched normal population in Sweden on an average 11.5 years after ACL reconstruction with BPTB graft. Neither objective nor subjective measurements at the 2-year follow-up after ACL reconstruction could predict long-term results in our patient cohort.

Conclusion

The findings in the present study show that there was no predictor of long-term results after ACL reconstruction, among the variables which are addressed 2 years after surgery. However, for professionals, orthopedic surgeons and physiotherapists, it is of interest to receive the answer to the question "what are the most important predictors that enables the ACL-injured and surgically reconstructed individual to be physically active in a long-term perspective without compromising a good quality of life"? The answer of such a question may make it easier to screen those patients that will be able to return to their previous activity level after an ACL reconstruction, and it would also improve our possibility to better help the patients to reach appropriate goals during rehabilitation.

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