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Knee-related quality of life, functional results and osteoarthritis at a minimum of 20 years' follow-up after anterior cruciate ligament reconstruction

Matias Costa-Paz [a,*], Ignacio Garcia-Mansilla [a], Sebastian Marciano [b], Miguel Angel Ayerza [a], D. Luis Muscolo [a]

[a] Department of Orthopedic Surgery, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina
[b] Department of Research and Statistics, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina

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ABSTRACT

Background: Few studies in the literature show results with more than 20 years of follow-up after anterior cruciate ligament reconstruction (ACLR). The main purpose of this retrospective study was to describe knee-specific quality of life, functional results and prevalence of osteoarthritis (OA) of the knee in patients with ACLR using bone–patellar tendon–bone (BPTB) autograft with ultra-long-term follow-up.
Methods: Prospective analyzed data included demographics, meniscus status, radiographic OA, KT-1000 arthrometer measurements and physical examinations. KOOS, Lysholm and IKDC subjective surveys were conducted. Multivariate and univariate logistic models were used to determine the effect of potential predictors of OA and symptomatic knees.
Results: Seventy-two knees were included at a median follow-up of 22 (IQR 21–25) years postoperatively. Radiographic scores were normal in 15%, nearly normal in 57%, abnormal in 18% and severely abnormal in 10%. Multivariate analysis showed that the predictive factor for the presence of OA in the long-term was an associated meniscal lesion; patients with meniscal lesions were 3.9 times as likely to develop OA in comparison with those without meniscal injury. The subjective scores were progressively and significantly lower as the level of OA was greater.
Conclusion: At a median of 22 years of follow-up, this study shows that patellar tendon autograft ACL reconstruction provides good clinical outcomes, with clinically objective knee stability and a 28% prevalence of OA. Additionally, we identified that meniscal injury at time of surgery was an independent predictor of OA.
Level of evidence: Level IV; case series.

1. Introduction

Anterior cruciate ligament (ACL) tears are among the most common injuries in young athletes. ACL injury has been associated with tibiofemoral instability, decreased functional outcomes, and meniscal injury [1–3]. Adolescents and young adults who sustain an ACL reconstruction are at an increased risk for the development of osteoarthritis (OA), with almost 50% of ACL-injured knees showing OA five to 15 years after initial injury [4–10]. ACL reconstruction (ACLR) attempts to re-establish normal joint kinematics and structural integrity, while at the same time decreasing the likelihood of suffering further joint injury or deterioration [2,3,11].

* Corresponding author at: Callao 1175, CABA CP1023, Argentina.
E-mail address: matias.costapaz@gmail.com. (M. Costa-Paz).

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A systematic review presents an overview of health-related quality of life (HRQoL) after ACLR and has shown that these outcomes are associated with several factors [12]. Concomitant or subsequent meniscal injuries, revision ACLR surgery and the presence of severe radiographic OA are associated with poorer HRQoL after ACLR. Gender, graft type, age at surgery, and time from injury to surgery were not significantly associated with HRQoL outcomes.

Long-term follow-up studies that include patients who had undergone an ACLR using bone–patellar tendon–bone (BPTB) graft have been reported. However, the number of patients evaluated beyond 20 years' follow-up is limited; we found only three studies with 80, 100 and 423 patients [13–15]. With some differences in the surgical technique (one with open arthrotomy), the results show progression to osteoarthritis of 20–50%, and subjective International Knee Documentation Committee (IKDC) score between 74 and 86.

The main purpose of this retrospective study was to analyze knee-specific quality of life, functional results and prevalence of OA of the knee in patients with an ACLR using a BPTB autograft and a minimum 20-year follow-up. The secondary objective of this study was to try to identify factors associated with poor functional outcomes (symptomatic patients) and OA. We hypothesized that patients with ACLR would present satisfactory results with regard to function and quality of life after 20 years post-surgery and the meniscal status would be the main factor that influenced OA.

2. Methods

2.1. Patient population

We designed a retrospective cohort study of a series of consecutive patients with an ACLR performed by a unit of three surgeons from November 1986 to January 1996 at a teaching hospital.

The inclusion criteria were patients diagnosed with an isolated ACL rupture with no associated posteromedial or posterolateral laxities and an ACLR with at least 20 years' follow-up. Exclusion criteria included any associated ligament injury requiring surgery and refusal to be involved in a research project.

2.2. Data collection and definitions

All medical care interventions are centrally registered in a computerized data repository, with only one electronic health record per person. Variables included patient's gender, age at surgery and age at the time of follow-up, history of knee surgery, time between injury and surgery (three months to be considered a late reconstruction) and Tegner Activity Score (TAS) [16] both at the time of surgery and at the time of follow-up. The Clinical Research and Bioethics Committee of the aforementioned hospital approved the study, in accordance with the Declaration of Helsinki of 1975, as revised in 2008. The STROBE guidelines were used to structure the article [17].

Patients were identified from a list of all ACLR performed at our institution and were contacted by telephone in order to participate in the study. After informed consent was signed, a complete physical examination was performed including ligament stability and instrumented knee testing. Objective stability was tested with the knee arthrometer test (KT-1000 knee arthrometer, MEDmetric Corp.) and the manual maximum difference between knees (in mm) was used for analysis of reported mean side-to-side differences in stability [18,19]. In patients where the contralateral knee was injured, ligament stability was measured by the Lachman and pivot-shift tests [20]. The Lachman test was graded as 0 (negative), 1 (one to five millimeters laxity), 2 (six to 10 mm laxity), or 3 (>10 mm laxity) and the pivot-shift test as 0 (negative), 1 (glide), 2 (clunk), or 3 (gross). Knee laxity was defined by the presence of any of the following: ≥5 mm difference in KT1000, Lachman ≥2 and pivot shift ≥1. All patients were evaluated by a single orthopedic observer who had six years of experience in Orthopedics (sports medicine fellow) who did not participate in the surgery of enrolled patients.

The subjective assessment included the Knee Injury and Osteoarthritis Outcome score (KOOS) [21], Lysholm knee score [22] and IKDC subjective knee function score [23]. The KOOS was the main outcome measure and was used to identify symptomatic patients and quality of life assessment. It is a knee-specific instrument developed to assess patients' opinion about their knee and associated problems. It was developed for short- and long-term follow-up studies and has been validated on several types of injuries of the knee such as ACL ruptures, meniscal injuries, and post-traumatic OA [24,25]. Because no agreement exists upon cutoff with regard to the definition of a symptomatic knee, we used a previously published definition according to the KOOS [26]. This operational definition aimed at identifying patients symptomatic enough to possibly seek medical care and required that the score for the KOOS subscale Quality of Life (QOL) and two of the four additional subscales should be equal to or less than a specified threshold level (86.1 for pain, 85.7 for symptoms, 86.8 for activities of daily living (ADL), 85.0 for Sport/rec and 87.5 for QOL). It was suggested that eight to 10 points may represent the minimal perceptible clinical improvement (MPCI) of the KOOS [24,27,28].

To evaluate OA, all patients underwent a knee radiographic evaluation. It was performed as a side-to-side comparison using bilateral double-leg posteroanterior weightbearing at 35–45° of flexion, lateral and patellar skyline views [29]. Radiographs were classified according to the IKDC guidelines as follows: A = normal, B = minimal changes and barely detectable joint space narrowing, C = moderate changes and joint space narrowing of up to 50%, and D = severe changes with greater than 50% joint space narrowing. This grading system has been shown to be both reliable and reproducible with longitudinal data [30,31]. An experienced knee surgeon (M.C.-P.) graded all radiographs and we considered grade C or more to define a patient with OA [4].

2.3. Surgical technique

All of the arthroscopically assisted procedures were performed with essentially the same two-incision outside-in technique. Arthroscopic examinations were first performed to confirm the rupture and laxity of the ligament. All meniscal resections were completed before ACL reconstruction. The ipsilateral central third of the patellar tendon was harvested with two bone blocks of patella and tibia. The femoral tunnel was sited approximately seven millimeters anterior to the over-the-top position, aiming for a two-o'clock/10-o'clock position. The tibial tunnel was drilled using a drill guide under arthroscopic view through the middle of the tibial ACL footprint.

During the first years, the proximal bone block was fixed in the femoral tunnel with an AO screw or a button of a lab coat, and the distal bone block was fixed in the tibial tunnel with an AO screw (65 patients). After 1995 we started using metal interference screw (seven patients). The only two technical aspects that changed throughout these nine years were to locate the center of the tibial tunnel just posterior to the anatomic center of the ACL tibial footprint (to avoid anterior impingement) and the graft fixation [32].

2.4. Statistics

Quantitative variables are presented as median and interquartile range (IQR). Categorical variables are presented as absolute numbers and percentages. Comparisons between groups (patients with or without OA, and symptomatic or asymptomatic patients) were performed with chi-squared for categorical data and Mann–Whitney test for quantitative variables. A logistic regression analysis was performed to identify independent factors associated with OA and presence or absence of symptoms. The variables that were included in the multivariate analyses were pre-defined by the investigators, according to the previous knowledge from the literature. Since the sample was expected to be relatively small, a model with two independent variables was pre-defined (including meniscal injury at time of surgery and late reconstruction). A *P*-value lower than 0.05 was considered statistically meaningful. The data was analyzed using STATA software version 13.

3. Results

During the study period, a total of 435 patients underwent an arthroscopically assisted ACLR. After contacting the patients, 97 (22.3%) patients were eligible for 20-year follow-up, 16 patients were excluded because of associated ligament injury requiring surgery and five declined to participate. Finally, 76 patients were included in the study (Figure 1).

Reviews were performed on patients with intact ACL grafts at 20 years; four patients (five percent) sustained ruptures of the ACL graft, had a revision ACLR, and were excluded from the final analysis.

The patients were all male, with a mean age of 51 years and a mean follow-up of 21 years.

Subjects' characteristics are presented in Table 1. Overall, patients were predominantly male, and the right knee was involved in 45 participants (62%). The median age at surgery was 30 years (IQR 22–36). Early ACLR was performed in 31 patients (43%). Four patients (five percent) had previous meniscal surgery at the time of ACL reconstruction. During surgery, 33 patients (46%) had intact menisci, 32 (45%) required partial meniscectomy, and three (four percent) underwent a successful meniscal suture (did not require any further meniscal surgery during the follow-up period). The medial meniscus was injured in 30 patients (42%), the lateral meniscus in nine (12%), and both menisci in four (six percent) patients. The median follow-up from surgery to outcome evaluation was 22 years (IQR 21–25), the shortest follow-up period was 20 years and the longest was 30 years.

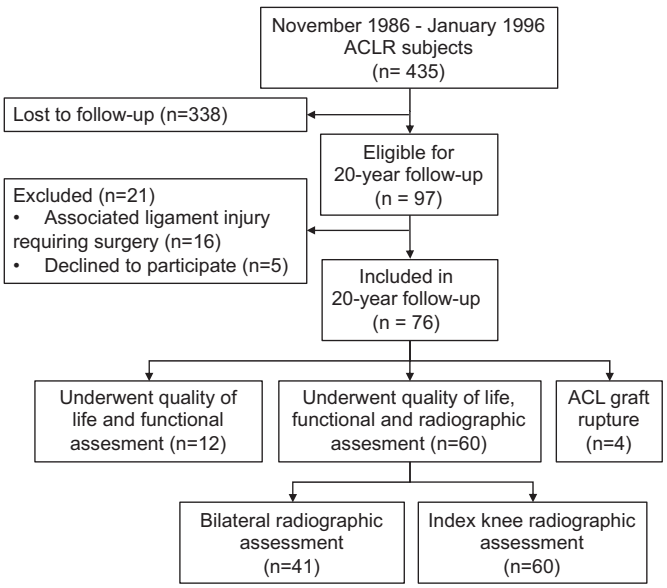

Figure 1. Flow diagram of patients screened and consented. ACLR, anterior cruciate ligament reconstruction.

Table 1
Subject characteristics (n = 72).

Variable[a]	
Age at surgery (years)	30 (22–36)
Age at follow-up (years)	51 (48–59)
Male sex, number (%)	59 (82)
Late ACLR, number (%)	41 (57)
Tegner Activity Scale	4 (0–9)
KOOS score	
Pain	94 (90–100)
Symptoms	93 (86–96)
ADL	100 (99–100)
Sports/Recreation	85 (10–95)
QOL	87 (72–94)
IKDC subjective score	83 (70–95)
Lysholm score	93 (82–99)
IKDC radiological grade, number (%)	
ACLR knee[b]	
A	9 (15)
B	34 (57)
C	11 (18)
D	6 (10)
Contralateral knee[c]	
A	21 (51)
B	17 (42)
C	3 (7)
D	–

ACLR, anterior cruciate ligament reconstruction; ADL, Activity Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome score; QOL: Quality of Life.
[a] Data are reported as median (interquartile range, IQR) unless otherwise indicated.
[b] Available in 60 patients.
[c] Available in 41 patients.

Before ACL injury, 55 patients (76%) performed pivoting contact sports (Tegner eight to 10). At evaluation, most of the patients remained athletic (39% of the patients returned to recreational sports) but switched to activities involving less contact (Figure 2).

Overall, 60 patients (83%) underwent a complete physical examination; nine of them (15%) showed knee laxity. Forty-one patients were evaluated with a KT-1000 arthrometer, the mean manual maximum difference between knees was 2.82 mm, and in patients where the contralateral knee was injured (19), ligament stability was measured by the Lachman and pivot-shift tests.

3.1. Outcome evaluation

3.1.1. Subjective clinical outcome and radiographic findings

The KOOS subscale scores ranged from the highest for the ADL subscale 100 to the lowest for the sport/recreation subscale 85. According to the KOOS score, 22 patients (31%) were considered symptomatic. The median IKDC subjective score was 83 and the

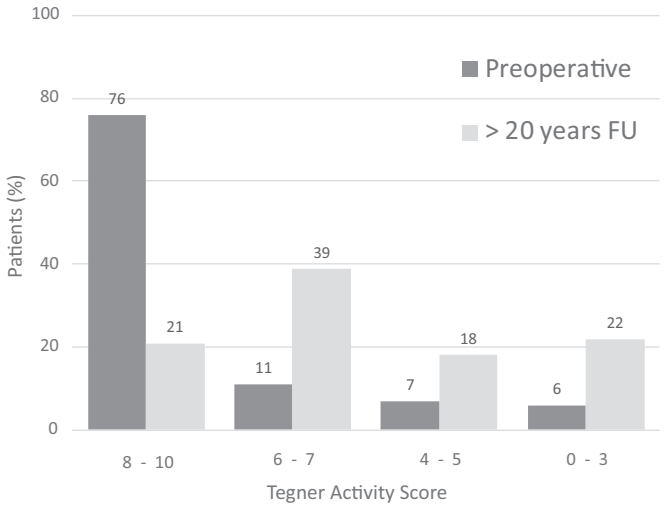

Figure 2. Preoperative Tegner Activity Score and at follow-up (FU).

Table 2
Comparison of KOOS, IKDC and Lysholm results according to radiographic osteoarthritis.

Variables[a]	Radiographic findings	
	IKDC A/B (n = 43)	IKDC C/D (n = 17)
KOOS		
Pain	94 (89–100)	92 (89–97)
Symptoms	93 (89–96)	89 (75–93)
ADL	100 (99–100)	100 (94–100)
Sports/Recreation	85 (70–95)	80 (65–85)
QOL	87 (69–94)	75 (44–81)
IKDC subjective score	84 (72–96)	71 (66–86)
Lysholm score	90 (85–99)	83 (78–94)

KOOS: Knee Injury and Osteoarthritis Outcome score. ADL: Activity Daily Living. QOL: Quality of Life. IKDC: International Knee Documentation Committee.
[a] Data are reported as median (IQR).

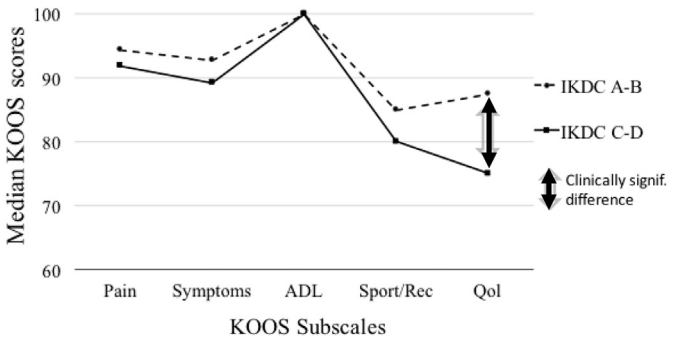

Figure 3. The Knee Injury and Osteoarthritis Outcome score (KOOS) profile related to radiographic osteoarthritis. Median KOOS results are shown for patients without osteoarthritis (OA) (dashed line) compared with patients with OA (solid black line). A difference of eight to 10 points represents the minimal perceptible clinical improvement (MPCI) of the KOOS. ADL, function in activities of daily living; QOL, knee-related quality of life; Sport/Rec, function in sport and recreation.

mean Lysholm score was 93. The KOOS, IKDC subjective and Lysholm scores are presented in Table 1. Almost 45% of patients had kneeling pain according to KOOS and IKDC scores.

Knee radiographs were reviewed in 60 patients (83%). Overall, 17 patients (28%) had OA at follow-up, 11 patients (18%) showed grade C and six patients (10%) grade D findings. Osteoarthritis changes were more frequent in the medial side of the knee. Contralateral uninjured knee radiographs were available in 41 patients (68%); 38 of them (93%) presented IKDC grade A or B (Table 1).

Table 2 describes KOOS, IKDC, and Lysholm results according to the presence or absence of OA. Numerically higher scores are observed in the group of patients without OA. With regard to the KOOS, we found a clinically significant difference in the knee-related Quality of Life subscale between the two groups (a difference of eight to 10 points represents the minimal perceptible clinical improvement of the KOOS) (Figure 3).

3.1.2. Variables associated with osteoarthritis and symptoms at follow-up

The bivariate and multivariate analyses of factors associated with OA are shown in Table 3. In the bivariate analysis, older patients and those with meniscal injury at the time of surgery were more likely to present osteoarthritis at follow-up. In the multivariate analysis, meniscal injury at time of surgery was the only variable independently associated with OA after adjusting for

Table 3
Bivariate and multivariate analysis of factors associated with osteoarthritis.

Variables[a]	IKDC C/D n = 17	IKDC A/B n = 43	OR	*P*	OR adjusted	*P*
Age at follow-up (years)	58 ± 10	52 ± 9	1.06 (1.00–1.13)	0.041	–	–
Male sex, number (%)	16 (94)	33 (77)	4.84 (0.57–41.23)	0.148	–	–
Meniscal injury, number (%)	13 (76)	19 (44)	4.10 (1.15–14.64)	0.030	3.96 (1.07–14.65)	0.039
Follow-up (years)	23 ± 4	23 ± 2	1.07 (0.88–1.31)	0.443	–	–
Late reconstruction, number (%)	11 (65)	23 (53)	1.59 (0.49–5.09)	0.431	1.14 (0.33–3.9)	0.826

IKDC, International Knee Documentation Committee.
[a] Data are reported as median (interquartile range, IQR) unless otherwise indicated.

Table 4
Bivariate and multivariate analysis of factors associated with symptoms at follow-up.

Variables[a]	Symptomatic	Asymptomatic	OR	*P*	OR adjusted	*P*
	n = 22	n = 50				
Age at follow-up, years	55 ± 8	52 ± 10	1.02 (0.97–1.08)	0.306	–	–
Male sex, number (%)	18 (82)	41 (82)	0.98 (0.26–3.63)	0.985	–	–
Meniscal lesion, number (%)	14 (64)	25 (50)	1.75 (0.62–4.90)	0.287	1.76 (0.60–5.13)	0.299
Follow-up (years)	24 ± 3	23 ± 3	1.08 (0.90–1.28)	0.389	–	–
Late reconstruction, number (%)	13 (59)	28 (56)	1.13 (0.41–3.13)	0.807	0.97 (0.33–2.82)	0.963

IKDC: International Knee Documentation Committee.
[a] Data are reported as median (interquartile range, IQR) unless otherwise indicated.

time between injury and surgery. The adjusted odds ratio of meniscal lesion was 3.96 (95% confidence interval 1.07–14.65), meaning that these patients were 3.9 times as likely to develop OA than patients without meniscal injury.

The bivariate and multivariate analyses of factors associated with symptoms at follow-up are shown in Table 4. We did not find any variables associated with symptoms at follow-up in the bivariate analysis or in the multivariate analysis.

4. Discussion

This ACLR study is one of a few with a minimum 20-year follow-up, evaluating knee-specific quality of life, functional results, and prevalence of OA of the knee. Almost 70% of patients were considered asymptomatic according to KOOS and the median IKDC subjective score was 83. A promising 72% of knees in this study had normal or nearly normal radiographs at a median of 22 years after surgery. We identified meniscal injury as a factor associated with poor outcome in the long term.

There are some other papers in the literature showing results with more than 20 years of follow-up. Pernin et al. [13] published in 2010 a series of 100 patients with a 25-year mean follow-up. The procedure was performed through a medial parapatellar arthrotomy; it combined intra-articular reconstruction using a free bone–tendon–bone graft and extra-articular tenodesis. They obtained a subjective IKDC score of 74.7. Meniscal and cartilage lesions were associated with poorer results and suggested the ACLR as a protective effect of structures. Unlike our series, they presented lower clinical results and a higher percentage of radiographic OA, with 54% of patients with grade C or D. Thompson et al. [14] reported the findings of 'isolated' ACL injuries at 20 years' follow-up; they obtained 20% grade C according to the radiographic IKDC classification. Exclusion criteria were previous meniscectomy, chondral injuries, and an abnormal contralateral knee. Therefore, the proportion of OA was less than in other published series. Conversely, clinical results (IKDC subjective score) were similar to our series. Finally, Shelbourne et al. [15] published a series with a minimum of 20-year objective follow-up for 423 knees after ACLR. The prevalence rate of developing moderate to severe OA was 28.6% and mean IKDC score was 74.6. Significant factors predictive of OA in the long-term were older age at surgery, medial meniscectomy and knee extension loss. This study showed similar results to our series.

Beyond the three publications mentioned above, studies reporting long-term OA after an ACL lesion are extremely variable. Trying to explain this fact, Lohmander mentioned different causes: those inherent to the lesion (acute events at the moment of the trauma or surgery), to the individual (level of activity or muscular strength) and methods or criteria used to evaluate OA, which widely vary among studies [2]. In a systematic review published in 2008, seven different radiographic classifications were found, with little clinical–radiographic relations, and values of 0–13% in isolated ACL lesions and 21–48% in combined lesions, in agreement with results in our series [4]. During recent years, new systematic reviews and meta-analysis appeared where OA values lower than those previously published were shown, although they still emphasized the lack of uniformity in studies [7,8,33,34]. In our study, the radiological changes were observed in 85% of patients (IKDC B, C, and D) but the majority of these changes were graded B according to the IKDC classification. The rate of OA (grades C and D) was 28%, which is comparable with other published long-term studies after ACLR.

We evaluated 41 uninjured contralateral knees with radiographs. In these cases, we could see the natural evolution of OA in each particular patient. In our study, 85% of IKDC results were 'A' versus 20% in injured knees, showing meaningful differences between both knees as in other published series [1,9,14].

There is agreement in the literature as regards the fact that meniscal lesions predispose osteoarthritis [4]. In our series, we found that patients with meniscal lesions were 3.9 times as likely to develop OA than patients without meniscal lesion. Based on this information we may consider that saving the meniscus may lead to better results with regard to OA in patients with ACLR.

One way of evaluating the ACLR results is by analyzing the number of patients that could return to their previous sport activity. In our series, 39% of the patients returned to recreational sports. However, a decrease of the sport level was evidenced throughout the follow-up period that might be attributed to the progressive articular wearing in these patients and/or to changes in life styles.

Ultra-long-term retrospective studies have intrinsic limitations. Thus, in the present study, preoperative ratings (IKDC and KOOS) and measurements of laxity were not available. The main weakness of this study was the high rate of patients lost to follow-up (follow-up rate 22.3%). Another limitation was the modification of the graft fixation in our surgical technique over time and the fact that almost all meniscus tears were treated with partial meniscectomy, this has changed in these years because more meniscal injuries are repaired now. Moreover, we did not analyze body mass index, isokinetic strength or graft angle. The strength of this study was that we present a series of patients with ultra-long-term follow-up, surgically treated by the same team, performed with the same graft (BPTB) and evaluated by the same observer.

5. Conclusion

At a median of 22 years' follow-up, this study shows that patellar tendon autograft ACL reconstruction provides good clinical outcomes, with clinically objective knee stability and a 28% prevalence of OA. Additionally, we identified that meniscal injury at time of surgery was an independent predictor of OA.

Conflict of interest

The authors have no conflicts of interest to declare. None of the authors received financial support for this study.

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