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Influence of operative technique on anterior cruciate ligament reconstruction in patients older than 50 years

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ABSTRACT

Background: A consequence of the steady growth in the worldwide population of elderly individuals who remain in good health and continue to engage in sports is an increase in the incidence of anterior cruciate ligament (ACL) rupture occurring after 50 years of age. ACL reconstruction was formerly reserved for young athletes but now seems to produce good outcomes in over 50s. The type of graft and graft fixation method were selected empirically until now, given the absence of investigations into potential relationships of these two parameters with the outcomes. The objective of this study was to assess associations linking the type of graft and the method of femoral graft fixation to outcomes in patients older than 50 years at ACL reconstruction.

Hypothesis: The operative technique is not associated with the clinical outcomes or differential laxity.

Material and methods: A multicentre retrospective cohort of 398 patients operated between 1 January 2011 and 31 December 2015 and a multicentre prospective cohort of 228 patients operated between 1 January 2016 and 30 June 2017 were conducted. Mean follow-up was 42.7 months in the retrospective cohort and 14.2 months in the prospective cohort. The primary evaluation criterion was the clinical outcome as assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Tegner Activity Score (TAS). Differential laxity was the secondary evaluation criterion. The Wilcoxon rank sum test and Kruskal-Wallis test were used to compare groups, and p -values < 0.05 were considered significant.

Results: In the retrospective and prospective cohorts, hamstring tendons were used in 269 (67.6%) and 197 (86.4%) patients and extensor apparatus tendons in 124 (31.2%) and 31 (13.6%) patients. Femoral fixation in the retrospective cohort was cortical in 81 (20.4%) cases, by press-fit in 112 (28.1%) cases, and by interference screw in 205 (51.5%) cases; corresponding figures in the prospective cohort were 135 (59.2%), 17 (7.5%), and 76 (33.3%). The multivariate analysis of the retrospective data identified no significant associations of graft type or femoral fixation type with the KOOS, TAS, or differential laxity values. In the prospective cohort, hamstring grafts were associated with 0.6 mm of additional laxity ($p = 0.007$); compared to cortical fixation, press-fit fixation of patellar tendon grafts was associated with 0.3 mm of additional laxity ($p = 0.029$) and a 0.5-point lower TAS value ($p = 0.033$), with no difference in KOOS values. None of these differences were clinically significant.

Discussion: The various ACL reconstruction techniques used in patients older than 50 years produce similar outcomes. The technique can be chosen based on surgeon preference without regard for patient age.

Level of evidence: IV.

Keywords:

Anterior cruciate ligament
50 years of age
Operative technique
KOOS
Tegner Activity Score
Differential laxity

1. Introduction

The worldwide population of older individuals who remain in good health is engaging in increasingly intense sporting activities until ever older ages. The INSEE has estimated that nearly 39% of the population in France is aged 50 years or over and that 50% of the over 50s engage in sports [1]. Unsurprisingly, the incidence of anterior cruciate ligament (ACL) tears in patients older than 50 years is rising. For many years, traditional thought held that ACL reconstruction should be reserved for young patients or high-level athletes with full-thickness ACL tears. Older patients were not offered reconstruction, as a change in sporting activities was deemed the best course of action [2,3]. This strategy is no longer appropriate to the lifestyle and demands of the current population of over 50s. In recent studies, some of the patients who should have had ACL reconstruction and continued their sports activities exhibited lesions to the menisci and cartilage that were more severe and more difficult to repair [4].

No consensus exists regarding the indications of ACL surgery in patients older than 50 years. Recent studies suggest better clinical outcomes after ACL reconstruction [5–9]. Potential associations linking the operative technique to outcomes in over 50s have not been investigated.

The objective of this study was to assess associations linking the type of graft and method of femoral graft fixation to outcomes in patients older than 50 years at ACL reconstruction. A retrospective cohort and a prospective cohort were investigated. We evaluated whether graft type and femoral fixation method were associated with postoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) and Tegner Activity Score (TAS) values and/or with differential laxity values. The working hypothesis was that the operative technique was not associated with the clinical outcomes or laxity measurement results.

2. Materials and methods

A retrospective cohort and a prospective cohort of patients older than 50 years at primary ACL reconstruction were studied. The data were collected prospectively in the retrospective cohort, which comprised 398 patients with a follow-up of at least 1 year after surgery performed between January 2011 and December 2015 at any of ten centres (Lyon, 3 centres; Bordeaux, 1 centre; Grenoble, 2 centres; Nice, 1 centre; Nancy, 1 centre; Marseille, 1 centre; and Strasbourg, 1 centre). The prospective cohort included 228 patients operated between January 2016 and June 2017 and re-evaluated 1 year later. Mean follow-up was 42.7 months in the retrospective cohort and 14.2 months in the prospective cohort.

Inclusion criteria were as follows: age 50 years or over at surgery; isolated ACL tear documented by physical examination and magnetic resonance imaging (MRI), with or without meniscal injury or cartilage grafting; and primary ACL reconstruction. Exclusion criteria were age younger than 50 years at surgery, tears in more than one ligament, recurrent ACL tear, and surgical procedure on bone such as tibial or femoral osteotomy.

The same standardised follow-up protocol was applied in both cohorts and all centres. All patients were re-evaluated prospectively after 3, 6, and 12 months then as needed. Each follow-up visit included a standardised physical examination and an interview about physical work and sports activities. Patients completed three questionnaires: the ACL-RSI scale assessing patient opinions about the operated knee, the KOOS assessing return to sports, and the TAS on the level of physical activity related to work and sports. The initial radiographic work-up consisted of antero-posterior, lateral, schuss, and skyline view of both knees. In addition, radiographs of both knees with anterior tibial translation were obtained to

measure differential laxity. Detailed information on the operative technique (surgical report) and on the clinical and radiological data collected before and after surgery were recorded prospectively in the medical file of each patient.

The graft techniques used for ACL reconstruction consisted of the Kenneth-Jones technique with a patellar tendon (PT) graft and hamstring tendon techniques including semitendinosus and gracilis tendon graft (ST/G), quadrupled ST graft (ST4), and short ST graft. Femoral fixation varied with surgeon preference: press-fit or interference screw for PT grafts and cortical fixation or interference screw for hamstring grafts. Regardless of the technique, extra-articular reconstruction was performed as needed, with the same indications as in patients younger than 50 years.

Statistical analysis: the Shapiro-Wilk test was applied to assess normality of variable distribution. Quantitative variables were compared using the Wilcoxon rank sum test and Kruskal-Wallis test and qualitative variables using Fisher's exact test and the Chi² test. Values of $p < 0.05$ were considered significant. Univariate and multivariate analyses were performed to identify factors associated with the postoperative values of the scores and differential laxity. For the multivariate analysis, the reference was hamstring graft and cortical femoral fixation. The statistical tests were performed using R version 3.3.2 (<http://www.r-project.org>).

3. Results

3.1. Population

Table 1 reports the main patient features. Mean age was 54.0 years in the retrospective cohort and 54.8 years in the prospective cohort. Table 2 lists the surgical techniques used. The graft was taken from the extensor apparatus or hamstrings, and the femoral fixation methods included cortical fixation, press-fit, and interference screw.

Between the recruitment period for the retrospective and prospective cohorts (2011–2015 vs. 2016–2017), the use of hamstring grafts increased by over 20%, from 71.1 to 92.1%, whereas the use of patellar tendon grafts declined. The proportion of patients who underwent extra-articular reconstruction increased by about 10%, from 7.8 to 16.7%.

3.2. Postoperative outcomes

Table 3 reports the KOOS, TAS, and differential laxity values at last follow-up. KOOS values were not significantly different between the groups managed with PT/quadriceps tendon (QT) grafts and those managed with hamstring grafts, whether in the retrospective cohort ($p = 0.367$) or in the prospective cohort ($p = 0.316$) (Table 4). Neither were any significant differences versus cortical femoral fixation for between press-fit fixation ($p = 0.846$ and $p = 0.324$, respectively) or screw fixation ($p = 0.905$ and $p = 0.489$, respectively).

The TAS was not significantly different between the PT/QT and hamstring groups ($p = 0.080$ and $p = 0.055$, respectively) (Table 5). However, in the prospective cohort, the TAS was 4.6 in the press-fit group and 5.1 in the cortical fixation group ($p = 0.033$). No such difference was found in the retrospective cohort ($p = 0.090$). Femoral fixation using an interference screw was not associated with a significant difference ($p = 0.612$ and $p = 0.557$, respectively).

Differential laxity in the retrospective cohort was not significantly different across graft types ($p = 0.394$) (Table 6). Neither were any differences evidenced for press-fit fixation ($p = 0.410$) or screw fixation ($p = 0.178$). In the prospective cohort, the hamstring group had significantly more differential laxity, with a difference of +0.6 mm ($p = 0.007$). The press-fit group had significantly more

Table 1
Main patient features in the retrospective and prospective cohorts.

	Prospective cohort (n = 228)		Retrospective cohort (n = 398)	
Age at surgery, years, mean ± SD (range)	54.8 ± 4.3	(50.0–71.6)	54.0 ± 4.1	(48.0–70.0)
Follow-up, months, mean ± SD (range)	14.2 ± 3.8	(3.5–30.5)	42.7 ± 19.9	(12.2–98.0)
Males, n (%)	94 (41%)		182 (46%)	
BMI, mean ± SD (range)	24.0 ± 3.6	(16.5–36.1)	24.3 ± 4.0	(17.3–52.6)
Sports level, n (%)				
Professional/Competitive	18 (8%)		39 (10%)	
Recreational	159 (70%)		245 (62%)	
Physically active	33 (14%)		78 (20%)	
Physically inactive	18 (8%)		36 (28%)	
Laxity before surgery, mm, mean ± SD (range)	6.5 ± 3.4	(–2.0–17.5)	6.6 ± 3.4	(–4.5–20.8)

BMI: body mass index; SD: standard deviation.

Table 2
Operative data in the retrospective and prospective cohorts.

	Prospective cohort (n = 228), n (%)		Retrospective cohort (n = 398), n (%)	
Antero-lateral reconstruction				
Yes	37 (16)		31 (8)	
No	191 (84)		367 (92)	
Intra-articular graft				
Hamstring tendon	197 (86)		269 (68)	
Quadriceps/Patellar tendon	31 (14)		129 (32)	
	Prospective cohort (n = 228)		Retrospective cohort (n = 398)	
	Femoral, n (%)	Tibial, n (%)	Femoral, n (%)	Tibial, n (%)
Fixation				
Cortical fixation (Endobutton)	135 (59)	49 (21)	81 (20)	17 (4)
Press-fit	17 (8)	0 (0)	112 (28)	0 (0)
Screw	76 (33)	179 (79)	205 (52)	381 (96)
Meniscal injury				
None	74 (32)		124 (31)	
Medial only	83 (36)		180 (45)	
Lateral only	25 (11)		31 (8)	
Medial and lateral	46 (20)		63 (16)	
	Prospective cohort (n = 228)		Retrospective cohort (n = 398)	
	Medial, n (%)	Lateral, n (%)	Medial, n (%)	Lateral, n (%)
Meniscal procedures				
None	99 (43)	157 (69)	155 (39)	304 (76)
Left in place	17 (7)	29 (13)	33 (8)	32 (8)
Resected	77 (34)	24 (11)	157 (39)	44 (11)
Sutured	25 (11)	16 (7)	30 (8)	16 (4)
Sequela of prior resection	10 (4)	2 (1)	23 (6)	2 (1)
Cartilage damage				
None	55 (24)		114 (29)	
Medial only	30 (13)		85 (21)	
Lateral only	4 (2)		8 (2)	
Patellar	17 (7)		25 (6)	
Multi-compartmental	122 (54)		166 (42)	

Table 3
Postoperative data in the retrospective and prospective cohorts.

	Prospective cohort (n = 228)	Retrospective cohort (n = 398)
Tegner Activity Score, mean (range)	4.9 (1.0–9.0)	5.1 (23.2–100.0)
Graft type: Hamstrings	4.89 (2.0–9.0)	5.12 (1.0–9.0)
PT/QT	5.10 (1.0–9.0)	4.99 (1.0–9.0)
Femoral fixation: Cortical	4.94 (2.0–9.0)	5.10 (1.0–9.0)
Press-fit	4.62 (1.0–6.0)	5.01 (1.0–9.0)
KOOS, mean (min-max)	84.9 (38.0–100.0)	87.4 (23.2–100.0)
Graft type: Hamstrings	85.9 (47.6–100.0)	87.0 (23.2–100.0)
PT/QT	85.2 (41.8–99.4)	84.6 (31.0–100.0)
Femoral fixation: Cortical	85.9 (41.8–100.0)	88.6 (23.2–100.0)
Press-fit	84.9 (49.9–99.4)	84.3 (31.0–100.0)
Differential laxity after surgery, mm, mean (range)	2.2 (–6.0–13.0)	2.2 (–5.5–15.0)
Graft type: Hamstrings	2.32 (–6.0–13.0)	1.94 (–3.0–12.0)
PT/QT	1.72 (–1.0–10.0)	2.78 (–5.5–15.0)
Femoral fixation: Cortical	2.34 (–6.0–13.0)	1.97 (–3–12.0)
Press-fit	2.37 (–1.0–10.0)	2.77 (–5.5–15.0)

PT: patellar tendon; QT: quadriceps tendon; KOOS: Knee injury and Osteoarthritis Outcome Score.

Table 4
Multivariate analysis to identify factors associated with the global KOOS after surgery.

	Prospective cohort				Retrospective cohort			
	n	Regression coefficient	Confidence interval	p-value	n	Regression coefficient	Confidence interval	p-value
Intra-articular graft								
Hamstring	197	REF			269	REF		
PT/QT	31	-4.2	(-12.5-4.1)	0.316	124	-3.87	(-12.31-4.56)	0.367
Femoral fixation								
Cortical fixation (endobutton)	135	REF			81	REF		
Press-fit	17	4.9	(-4.9-14.8)	0.324	112	-0.86	(-9.58-7.86)	0.846
Screw	76	-1.2	(-4.7-2.3)	0.489	205	0.3	(-4.70-5.31)	0.905

PT: patellar tendon; QT: quadriceps tendon.

Table 5
Multivariate analysis to identify factors associated with the change in the Tegner Activity Score from baseline to last follow-up.

	Prospective cohort				Retrospective cohort			
	n	Regression coefficient	Confidence interval	p-value	n	Regression coefficient	Confidence interval	p-value
Intra-articular graft								
Hamstring	197	REF			269	REF		
PT/QT	31	-0.8	(-1.7-0.0)	0.055	124	0.63	(-0.07-1.33)	0.08
Femoral fixation								
Cortical (endobutton)	135	REF			81	REF		
Press-fit	17	1.1	(-0.1-2.1)	0.033	112	-0.63	(-1.35-0.10)	0.09
Screw	76	-0.1	(-0.5-0.3)	0.557	205	0.11	(-0.31-0.52)	0.612

PT: patellar tendon; QT: quadriceps tendon.

Table 6
Multivariate analysis to identify factors associated with differential laxity after surgery.

	Prospective cohort				Retrospective cohort			
	n	Regression coefficient	Confidence interval	p-value	n	Regression coefficient	Confidence interval	p-value
Intra-articular graft								
Hamstring	197	REF			269	REF		
PT/QT	31	-2.4	(-4.1; -0.7)	0.007	124	-0.71	(-2.35-0.93)	0.394
Femoral fixation								
Cortical (endobutton)	135	REF			81	REF		
Press-fit	17	2.3	(0.2-4.4)	0.029	112	0.71	(-0.98-2.40)	0.111
Screw	76	0.3	(-0.4-1.1)	0.348	205	-0.67	(-1.64-0.31)	0.178

PT: patellar tendon; QT: quadriceps tendon.

differential laxity compared to the cortical fixation group, with a difference of +0.3 mm ($p = 0.029$), which was not clinically significant.

4. Discussion

The main finding from this study is that the clinical and laxity outcomes were not significantly influenced by the type of graft or femoral fixation used during ACL reconstruction in patients older than 50 years.

ACL reconstruction has become a common procedure over recent years in young athletes, notably those who play pivot or contact sports. Compared to non-operative management, widely accepted advantages of surgery for partial- or full-thickness ACL tears include a lower risk of complications related to instability, notably meniscal injury; a lower risk of knee osteoarthritis; better clinical scores in the short and long terms; and greater knee stability [11,12]. Several risk factors for the development of knee osteoarthritis have been reported [13]. Although the available studies in patients older than 50 years have small sample sizes, they consistently support an improvement in the clinical scores after surgery. Trojani et al. [14] reported excellent subjective patient satisfaction scores after 30 months. Blyth et al. [8] found a Lysholm score increase from 63 before to 93 after surgery. Dahm et al. [6] retrospectively reviewed the data for 35 knees in 34 patients aged 50 years or over who underwent ACL reconstruction between 2001

and 2006 and found increases in mean values of 39 to 90 for the IKDC score and from 50 to 92 for the Lysholm score.

The first study of patients who had ACL reconstruction after 60 years of age was reported in January 2017 by Toanen et al. [15]. Only 12 patients were included. The ACL-RSI score after 49 months was 76.2%. ACL reconstruction in these physically active patients free of knee osteoarthritis restored good knee stability and usually allowed the return to sports. The results were similar to those in younger patients, with good functional outcomes, no functional loss in the short or medium term and, importantly, no progression to premature osteoarthritis.

Hamstring grafts are currently growing in popularity for ACL reconstruction. Grassi et al. reported that hamstring grafts were used for 68 to 86% of ACL reconstructions [16]. Nonetheless, no evidence exists that one of the two graft types is superior over the other, and the choice remains at the discretion of the surgeon [17]. Each graft type has its own specific complication profile [18].

Laxity measurement on stress radiographs with anterior tibial translation provides an objective assessment of anterior knee laxity after ACL reconstruction. Several studies have compared laxity after ACL reconstruction using PT versus hamstring grafts. A 2015 meta-analysis by Xie et al. [19] comparing PT grafts to quadrupled semi-tendinosus (ST4) grafts showed no significant difference in laxity ($p = 0.06$). In another meta-analysis, reported in 2017 by Samuelsen et al. [20], the results were similar ($p = 0.16$) after a mean follow-up of 5 years. In contrast, a 2002 study by Katabi

et al. [21] found 1.8 mm less residual laxity with PT grafts compared to hamstring grafts 1 year after surgery ($p=0.003$), and Li et al. [22] obtained similar results in a 2011 meta-analysis. In our prospective cohort, residual laxity was 0.6 mm greater with hamstring grafts. However, this difference of less than 1 mm was not clinically relevant and was very probably within the margin of error of the radiographic measurements. Overall, the published data do not provide convincing evidence of a difference in laxity between graft types. PT grafts seem to provide similar or slightly better results. Our findings are consistent with previous reports: no significant difference was apparent in the retrospective cohort and, in the prospective cohort, residual laxity was slightly greater with hamstring grafts. These data on graft types were obtained in young populations and can be extrapolated to populations aged 50 years or over.

Studies have also assessed potential associations between the type of femoral fixation and residual laxity. With hamstring grafts, neither Katabi et al. [21] nor Lubowitz et al. [23] found any significant difference between cortical fixation and interference screw fixation. A 2014 study of hamstring graft outcomes, Ho et al. [24] found no significant differences in residual laxity or clinical scores between femoral knot/press-fit fixation and interference screw fixation. In a study of PT grafts by Sarzaeem et al. [25], residual laxity and the IKDC score were similar between press-fit and interference screw fixation. An evaluation by Widuchowski et al. [26] of 15-year outcomes of PT grafts with press-fit fixation showed that advantages included lower costs, better osseointegration, easier revision surgery, and avoidance of soft-tissue impingement requiring material removal. Similarly, residual laxity did not differ significantly across fixation methods in our retrospective cohort. The 0.3-mm greater laxity with press-fit fixation compared to interference screw fixation in the prospective cohort is not clinically relevant.

Regarding potential associations of graft type with clinical scores, Kim et al. [27] reported in 2018 that the clinical outcomes were dependent on the laxity values irrespective of the type of graft used. A meta-analysis by Xie et al. [19] comparing 931 PT grafts to 999 ST4 grafts showed no significant differences for the clinical outcomes or IKDC scores ($p=0.31$). The return-to-sports rate was significantly higher with PT grafts ($p=0.03$), but these were associated with worse anterior knee pain compared to hamstring grafts ($p=0.01$). A 2005 report by Wagner et al. [28] indicated that Lysholm scores were similar for 72 knees managed with PT grafts and 284 knees managed with hamstring grafts ($p=0.003$). Finally, in a literature review by Mohtadi et al. [29] published in 2011 and including 1597 ACL reconstructions, the PT and hamstring groups were not significantly different regarding the return-to-sports rate, functional scores, subjective scores, TAS, or Lysholm score.

Several studies investigated potential associations between the type of femoral fixation and the clinical scores. Debieux et al. [30] found no difference between bioabsorbable versus metal interference screws for femoral fixation of PT or hamstring grafts. In a study of PT grafts by Biazzo et al. [31], IKDC scores were better with press-fit than with interference screw fixation. We found the opposite in our prospective cohort: the TAS was 4.6 with press-fit fixation and 5.1 with interference screw fixation, a 0.5-point difference. No such difference was apparent in the retrospective cohort. Non-comparative studies showed similar clinical score values with these two fixation methods [23,26,32]. With hamstring grafts, Han et al. [33] and Barth et al. [34] found no differences in clinical outcomes between interference screw fixation and cortical fixation. In a level II study by Lubowitz et al. [23] of hamstring graft ACL reconstruction, the IKDC, KSS, and SF12 values were not significantly different with cortical fixation versus interference screw fixation.

The limitations of our study are inherent in the multicentre design. Nevertheless, only objective and fully validated evaluation criteria were used. The main strength of our study is the large sample size. Of the 10 currently available studies of ACL tears after 50 years of age, 7 were retrospective, 2 prospective, and 1 used registry data. Not counting the registry study, the total number of patients is 259. With 398 patients in the retrospective cohort and 228 in the prospective cohort, our study is the largest published to date.

5. Conclusion

The findings from this study demonstrate that neither the clinical outcomes nor residual laxity values after ACL reconstruction are associated with the type of graft or femoral fixation used in patients aged 50 years or over. The differences found were smaller than 1 mm and therefore not clinically relevant. ACL reconstruction has a role to play in patients aged 50 years or over, and surgeons can use their preferred technique irrespective of patient age.

Disclosure of interest

Q. Ode declares that he has no competing interest.

J.F. Gonzalez is a consultant for CORIN.

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Contributions of each author

Quentin Ode performed the literature review, collected the data, performed the statistical analysis, and drafted the manuscript.

Jean-François Gonzalez, Régis Pailhe, David Dejour and Matthieu Ollivier collected the data and revised the manuscript for important intellectual content.

Jean-Claude Panisset performed the literature review, collected the data, performed the statistical analysis, supervised the study, and revised the manuscript for important intellectual content.

Sébastien Lustig performed the literature review, collected the data, revised the manuscript for important intellectual content, and approved the final version of the manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.otsr.2019.09.010>.

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