Complications After Anterior Cruciate Ligament Reconstruction and Their Relation to the Type of Graft

A Prospective Study of 958 Cases

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Background: Complications and adverse events after anterior cruciate ligament (ACL) reconstruction are well known, but they have been underestimated in previous studies.

Purpose: To describe the complications and adverse events after ACL reconstruction within a 2-year follow-up and analyze them in relation to the type of graft.

Study Design: Cohort study; Level of evidence, 3.

Methods: From 2000 to 2012, 958 patients with an isolated ACL injury underwent surgery by a single knee surgeon. ACL reconstruction was performed with the medial portal technique for the femoral tunnel and the use of bone–patellar tendon–bone (BPTB) or hamstring tendon graft. Patients were reviewed at 6 weeks and 3, 6, 12, and 24 months after surgery with the International Knee Documentation Committee score, plain radiographs, and the KT-1000 arthrometer.

Results: Of 958 patients enrolled, 147 (15%) were lost at last follow-up. The 2 groups (bone–patellar tendon–bone [n = 257] and hamstring [n = 554]) were similar regarding the mean age at the time of surgery and preoperative anterior laxity. The main complications were as follows: anterior knee pain (n = 130 of 811, 16%), stiffness (n = 72, 8.8%), secondary meniscal lesions (n = 59, 7.2%), pain attributed to fixation (n = 79, 9.7%), ACL rerupture (n = 47, 5.7%), contralateral ACL ruptures (n = 24, 3%), patellar fractures (n = 3, 0.3%), infections (n = 9, 1%), and thromboembolic complications (n = 5, 0.6%). There was no significant difference between the grafts with respect to the frequency of joint stiffness, secondary meniscal lesions, or anterior knee pain. During the first 2 postoperative years, the percentage of patients with anterior knee pain was higher in the patellar tendon group (23.3% vs 12.6%, $P < .001$); however, this difference was not significant after the 2-year interval (3.1% vs 2.5%, $P = .63$). The percentage of patients with a rerupture of the graft was significantly lower in the patellar tendon group than in the hamstring group (25 of 811 [3.1%] vs 57 of 811 [7%], $P = .023$). Similar results were recorded regarding the pain related to the hardware material (7 of 811 [0.8%] in the BPTB group vs 113 of 811 [13.9%] in the hamstring group, $P = .001$). The percentage of ACL ruptures contralateral to the repair was higher in the patellar tendon group (41 of 811 [5%] vs 17 of 811 [2%], $P = .016$).

Conclusion: The total rate of complications after an ACL reconstruction was 39%, and the surgical revision rate for any reason was 28%. Problems with the hardware material were more frequent in the hamstring group, leading to an increased rate of surgical revision. Anterior knee pain was initially higher in the patellar tendon group, but there was no significant difference in a 2-year interval. The rerupture rate was statistically higher in the hamstring group.

Keywords: ACL; complications; adverse events

After an isolated rupture of the anterior cruciate ligament (ACL), similar functional results are obtained after reconstruction with patellar tendon (PT), hamstring tendon, quadriceps, or iliotibial band grafts.[1,36,38] The results of this reconstruction have been reportedly satisfactory, since 90% of the patients have normal knee function restored, 80% return to sports, and 55% are able to return to competitive sports activities.[6]

Despite the good outcome, ACL reconstruction has been associated with several complications. Andernord et al[4] reported a 2-year revision rate of 1.8% in a series of 16,930 patients, while in the series of Mohtadi et al,[29] the secondary surgery rate was higher (7.3%). Even though not all complications warrant surgical revision, it is

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essential that they be identified and managed, as they could have a major effect on functional status as well as the patient's quality of life. Several authors have studied the prevalence of revision rates as well as the causes of secondary ACL reconstruction.[13,18,29-31] Others have studied the prevalence and risk factors for a specific complication.[5,7,19,21,36,42] Although the complications after ACL reconstruction have been listed in many studies, an effort has been made in the present study to analyze these complications both separately and in relation to the type of the graft used.

The goal of this prospective study of 958 patients was to record and describe all the complications and adverse events that occurred within 2 years after reconstruction for isolated ruptures of the ACL and to carry out an analysis based on the type of grafts used.

METHODS

Between 2000 and 2012, 958 cases of surgery were recorded as conducted by a single surgeon who specialized in soft tissue knee injuries. Inclusion criteria were rupture of the ACL with or without associated meniscal lesions. Exclusion criteria were associated lesions in a peripheral ligament or the posterior cruciate ligament, an ACL rerupture, and a declination to participate in the study.

Clinical examination included history, anterior drawer, Lachman, and pivot-shift tests. Magnetic resonance imaging, Telos stress dynamic radiographs, KT-1000 arthrometer measurements (pre- and postoperative), and the International Knee Documentation Committee questionnaire were used to diagnose and evaluate these injuries.

The patients were reviewed at 6 weeks and 3, 6, 12, and 24 months by an independent surgeon (R.R.). Adverse events and complications were recorded and analyzed, including anterior knee pain, joint stiffness (lack of extension—flexion deformity $\geq 5°$ in passive motion with 0° as normal; lack of flexion—knee flexion $<120°$ in passive motion), secondary meniscal lesions, pain attributed to hardware devices, ACL reruptures, bone complications (tunnel cysts and patellar fracture), thromboembolic complications, hematomas, and superficial and deep infections.

The choice of graft was based on the age of the patient and the type of sport in which she or he participated. Patients younger than 25 years old, dancers, and patients who participated in competitive pivot/contact sports such as football and handball had PT grafts. Patients younger than 15 years old, patients who did not participate in competitive pivot/contact sports, and patients who participated in competitive pivot/contact sports such as basketball and volleyball (owing to the risk for patellar tendinopathy) had hamstring tendon grafts with a single-bundle semitendinosus-gracilis (STG) technique. The median time delay to surgery was 4.6 weeks (range, 4-6 weeks). During this interval, the patients were instructed to use ice therapy, take anti-inflammatory drugs, and perform range of motion exercises to help with hematoma subsidence and to prepare the knee for surgery.

The medial portal technique was used to create the femoral tunnel in both groups. The femoral tunnel was placed at its anatomic position between the resident's ridge (lateral intercondylar ridge) and posterior cartilage of the lateral femoral condyle. During placement of the guide wire, the knee was bent at full flexion. The Endobutton device (Smith & Nephew) was used to fix the STG graft to the femoral side, and the BIORCI screw system (Smith & Nephew) was used to fix the PT graft there. The tibial tunnel was placed at the intercondylar notch at the level of the posterior border of the anterior horn of the lateral meniscus. The guide wire was placed with an angle of 55°, with the appropriate external drill guide. The tibial side of the graft was fixed with BIORCI screws in both groups. An external post fixation at the tibial side was performed in every STG graft, with a spiked washer screw system (Smith & Nephew).

Partial weightbearing was allowed for the first 6 weeks, progressing to full weightbearing gradually. Bicycling and jogging started 3 months after surgery in combination with muscle reinforcement exercises. Pivot noncontact sports were allowed at 6 months and contact sports at 8 and 9 months. Institutional review board approval was granted for this study.

Statistical Method

The Student t test was used for the quantitative variables and the chi-square test for the qualitative ones. The level of significance was set at $P = .05$.

All patients gave informed consent for their participation in the study.

RESULTS

Out of 958 patients, 811 (85%) completed the study, and 147 (15%) were lost to final follow-up. The PT and STG groups were comparable in terms of the age of patients at the time of surgery, preoperative differential anterior laxity measured by KT-1000 arthrometer, and the type of sports in which they participated (Table 1).

In total, 738 patients (91%) were able to return to their previous sports activities, and 665 (82%) were able to reach the same or higher level. Only 16 (2%) patients changed their prior sports. The results of International Knee

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TABLE 1
Population Characteristics[a]

	PT (n = 257)	STG (n = 554)	*P* Value
Age, y	27.1 (16-39)	28.3 (14-38)	.058
Differential laxity, mm	5.9 (0-15)	6.2 (0-15)	.2
Sports participation			.28
Low impact	6 (2.3)	20 (3.6)	
Track	7 (2.7)	25 (4.5)	
Pivot and pivot/contact	244 (95)	509 (91.9)	
Right:left, n	126:131	265:289	

[a]Values are presented as mean (range) or n (%). PT, patellar tendon; STG, semitendinosus-gracilis.

Documentation Committee, KT-1000, and Telos measurements are depicted in Table 2.

The total rate of complications and adverse events was 39% (316 of 811). The total surgical revision rate for any cause was 28% (227 of 811). The surgical revision rate was significantly higher in the STG group than in the PT group whether the reoperations for hardware removal were included ($P < .001$) or not ($P < .039$).

All the complications and adverse events are listed in Table 3.

The causes of revision are presented in Figure 1.

Anterior Knee Pain

Sixteen percent of patients (130 of 811) reported anterior knee pain during the 2 years after the intervention, which reduced to 2.7% (22 of 811) at the end of that period. Patellar tendinopathies represented 40% (52 of 130) of the cause of this pain, but the symptoms subsided until the final examination (83% of patients were asymptomatic).

Nonspecific anterior knee pain that was not linked to patellar tendinopathy accounted for 60% (78 of 130). Pain resolved completely in 83% of patients after optimal rehabilitation. The prevalence of pain occurring within 2 years after ACL reconstruction was higher in the PT group ($P < .001$). However, there was no significant difference between the PT and STG groups with respect to the duration of the pain at 2 years.

Joint Stiffness

Seventy-two patients (9%) had a lack of knee extension 8 to 12 weeks after surgery. The etiology was Cyclops syndrome in 50% of cases, Hoffa fat pad inflammation in 37%, idiopathic in 11%, and anterior knee fibrosis in 2%. There was not any case of generalized arthrofibrosis. The mean lack of extension was 8.6° (range, 5°-20°); 46 patients had a flexion deformity ≥10° at 8 to 12 postoperative weeks. There was no significant difference in total between PT and STG repairs with respect to stiffness during extension ($P = .12$). However, more cases with Cyclops syndrome occurred in patients who had STG grafts (31 of 554) than in those who had PT grafts (6 of 257, $P = .03$).

Further surgery was required for 63 patients, which consisted of synovectomy and notchplasty when necessary. The mean postoperative interval to surgical restoration of knee extension was 7 months (range, 2-14 months); 5 patients had >1 arthrolysis.

At the end of follow-up, 93% of patients recovered complete extension, while 6% had flexion deformity <5°. One patient had an extension deficit of 10°.

Secondary Meniscal Lesions

Fifty-nine (7%) patients had secondary meniscal lesions. All were new lesions and not related to the previous meniscal injury. The mean time to the occurrence of these lesions was 14 months (range, 6-24 months). Secondary lesions of the medial meniscus accounted for 84%. Lateral meniscal lesions were found in 13% of cases and bimeniscal lesions in 3%. At the time of ACL reconstruction, 423 patients had no meniscal lesion; 257 had a lesion of the medial meniscus; 69 had a lesion of the lateral meniscus; and 62 had a bimeniscal lesion. The initial treatment of these lesions is detailed in Table 4.

The risk of secondary meniscal lesions did not vary with the type of ACL reconstruction used.

Pain Around the Hardware Fixation

Pain around the fixation material was found in 79 patients (10% of the population). This complication was found almost exclusively in the STG group (n = 77), and the reason was irritation from the external post screw. Further surgery for hardware removal was performed for 49 patients. In the PT group, the pain was due to fibrous tissue around the external orifice of the tibial tunnel. The symptoms subsided with the use of anti-inflammatory drugs. There was more pain around the fixation material in the STG group than in the PT group ($P < .001$), but it was expected since no external post fixation was used in the PT group.

Rerupture of the ACL Reconstruction and Contralateral ACL Rupture

Forty-seven patients (5.7%) had a rupture of the graft within 2 years after the initial ACL reconstruction. Their mean ± SD age was 22.6 ± 6.7 years. In all cases, the etiology was new injury during sports activities. There were significantly more patients who had a secondary rupture of the ligamentoplasty in the STG group than in the PT group ($P = .023$) (Table 2). The rupture of the contralateral ACL within 2 postoperative years occurred in 24 patients (3% of the total population). This was significantly more common in the PT group ($P = .016$). The mean age of those patients was 22.1 ± 7 years; after ACL reconstruction, all the patients returned to their sport at the same level.

The percentage of ACL ruptures contralateral to the repair was higher in the PT group (41 of 811 [5%] vs 17 of 811 [2%], $P = .016$).

Fracture of the Patella

Three patients in the entire series (0.3%) with a PT graft suffered from a patellar fracture (1 intraoperative and 2

TABLE 2
Postoperative Results for Both Groups[a]

	PT			STG		
	IKDC	KT-1000	Telos	IKDC	KT-1000	Telos
6 wk	56 (45-68)	3.4 (1-5)	4.8 (4-7)	59 (44-69)	3.6 (1-5)	5.1 (4-7)
3 mo	63 (47-72)	2.8 (1-4)	4.1 (3-7)	65 (48-71)	2.9 (1-4)	4.6 (3-7)
6 mo	72 (53-83)	1.8 (1-3)	3.3 (3-6)	74 (56-82)	2.1 (1-3)	3.9 (3-6)
12 mo	76 (57-84)	1.6 (1-3)	2.9 (2-5)	75 (57-84)	1.7 (1-3)	3.3 (2-5)
24 mo	85 (66-87)	1.3 (1-3)	2.6 (2-5)	84 (65-87)	1.5 (1-3)	3.1 (2-5)

[a]Values are presented as median (range). IKDC, International Knee Documentation Committee; PT, patellar tendon; STG, semitendinosus-gracilis.

TABLE 3
Prevalence of Complications and Adverse Events Based on the Type of Graft[a]

	Patients, n (%)	PT, %	STG, %	*P* Value
Anterior pain during the 2-y period	130 (16)	23.3	12.6	<.001[b]
Persistent pain at 2 y	22 (2.7)	3.1	2.5	.63
Joint stiffness in extension	72 (8.8)	6.6	10	.12
Secondary meniscal lesions	59 (7.2)	5	8.3	.09
Pain around the fixation material	79 (9.7)	0.8	13.9	<.001[b]
Repeated rupture of the ligamentoplasty	47 (5.7)	3.1	7	.023[b]
Rupture of the ACL contralateral to the repair	24 (2.9)	5	2	.016[b]
Fracture of the patella	3 (0.3)	1.1	0	.25
General complications (infection, thromboembolism)	45 (5.5)	7	4.8	.14

[a]ACL, anterior cruciate ligament; PT, patellar tendon; STG, semitendinosus-gracilis.
[b]$P < .05$.

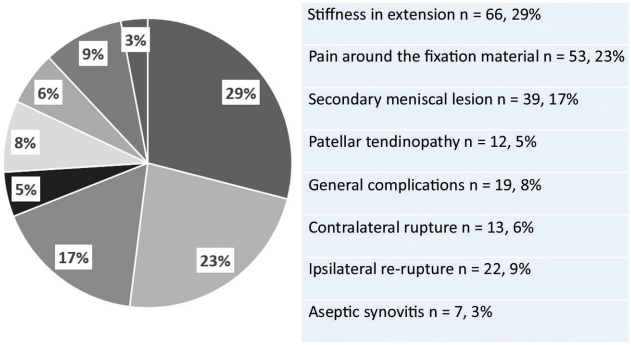

Figure 1. Etiological distribution of surgical revisions within 2 years postoperatively.

postoperative). Treatment with a splint was applied, and the patients resumed their previous physical activities.

General Complications

No severe complications were reported. Thromboembolic complications occurred in 5 patients who had phlebitis (0.6%). Twenty-two patients (2.7%) had postoperative hematoma, and 13 of them required surgical evacuation. Nine patients (1%) had aseptic synovitis, and 7 of them had an arthroscopic synovectomy. Finally, 9 patients (1%) had a surgical site infection. Six of them were superficial, and treatment with antibiotics resolved the problem. The 3 patients with the deep infection had arthroscopic lavage plus antibiotic administration, and the symptoms were resolved without any compromise of the grafts.

DISCUSSION

Complications after ACL reconstruction have been recorded in several studies.[1,9,11,12,14,23,25,30] Anterior knee pain (without associated stiffness) is one of the most frequent complications, ranging from 4% to 50%.[1,13,15,36,38,39] It is mainly attributed to the harvesting of PT grafts, although it is not rare in patients who have had an STG reconstruction.[22] Mohtadi et al[30] studied 330 patients who were randomized to PT and single- and double-bundle STG graft groups. No significant difference was found among these subgroups regarding the frequency of anterior knee pain, secondary meniscal lesions, and stiffness.

Moreover and contrary to our series, which demonstrated a significant difference between the PT and STG groups, Mohtadi et al[30] did not report any pain around the fixation material. This is likely due to the fact that they did not use a double tibial fixation in the STG graft and the tibial fixation of the PT was done with nonabsorbable screws.

TABLE 4
Prevalence and Treatment of Primary Meniscal Lesions[a]

Lesion	Patients	Suture	Partial Meniscectomy	Nonoperative Management	Mixed[b]
None	423 (52)				
Meniscus					
Medial	257 (32)	168 (65)	38 (15)	50 (19.6)	1 (0.4)
Lateral	69 (8.5)	33 (48)	13 (19)	23 (33)	
Both	62 (7.6)	16 (26)	2 (3)	5 (8)	39 (63)

[a]Values are presented as n (%).
[b]Suture and partial meniscectomy.

Other authors have demonstrated that anterior knee pain evolves favorably within 2 years after ACL reconstruction.[8,14,15,17,39] In a series of 90 ligamentoplasties (50 PT and 40 STG), Katabi et al[22] reported that 92% of patients had no pain and 8% had a slight discomfort occurring exclusively with activity. In the same way, Corry et al[10] demonstrated that the frequency of pain after reconstruction with the PT decreased over time: 55% at 1 year and 31% at 2 years. The decrease in anterior knee pain over time was also recorded in the present study, and in our opinion, this must be thoroughly explained to patients such that they not be concerned with this postoperative adverse event.

Arthrofibrosis is one of the commonest complications after ACL reconstruction, causing significant functional deficit[11,27,32] and an increased rate of surgical revision.[18] In our study, this complication was second in frequency, but the prognosis after surgical debridement was good at 2-year follow-up. Cyclops syndrome and extension deficit have been reported to occur with a similar rate with either a hamstring tendon or a bone–patellar tendon–bone graft.[20] There was no difference between the groups in our series regarding the total rate of knee extension deficit; however, more cases with the Cyclops nodule were recorded in the STG group. This could be attributed to the stiffness of the grafts (bone–patellar tendon–bone is more solid) since the surgical technique was the same in all cases.

In our study, pain related to hardware material affected 10% of the patients, and the majority of them had an STG graft. This was probably due to the double tibial fixation technique that was used to increase the resistance to slippage of the graft in the tibial tunnel, thus explaining the increased number of secondary surgical procedures in the STG group. In the literature, the rate of complications associated with the hardware is rarely reported. Such complications include screw migration, accelerated resorption of the material, or inflammatory reactions related to incomplete resorption of the material.[5,7,34,37] In our series, no other hardware-related complications occurred, but it is our opinion that a supplementary tibial fixation is necessary to protect the primary fixation and increase the ultimate tensile load of the graft. To decrease the rate of this complication, it is our proposal to use supplementary fixation devices with a low profile or to restrict their use in special cases, such as older patients or patients with disorders affecting bone mineral density.

Concomitant meniscal lesions quite often accompany ACL injuries, and their treatment can be a meniscectomy or suturing depending on the type of the lesion and the quality of the meniscus.[16,40,41] The success rate after ACL reconstruction associated with a meniscal suture was reported to be 91% in a series by Albrecht-Olsen et al,[2] while similar values were reported by Wasserstein et al[44] and Feng et al.[16]

However, secondary meniscal lesions can occur after an ACL reconstruction, and the main cause is new trauma. In their series, Leroux et al[24] demonstrated that surgical procedures for secondary meniscal lesions account for 45.3%. They also concluded that the incidence of these meniscal lesions increased with younger age.

In our series, the majority of the secondary meniscal lesions occurred in patients who already had an antecedent meniscal lesion and were independent of the type of graft. The main reason was a new knee injury and could be explained by several reasons. The absence of scar formation in the preexisting lesion and the subtle instability putting more stress on a meniscal lesion seem to be the main causes, as we had no root or ramp primary lesions and the majority of secondary meniscal injuries happened relatively early after ACL reconstruction surgery.

One of the main objectives after an ACL reconstruction is the return to sports activities, which exposes patients to new risks of a rerupture. Webster et al[45] concluded that the rate of a secondary rupture was 4.5% in a cohort of 750 patients, while Crawford et al[12] performed a meta-analysis estimating the incidence of this complication to be 6.2%. Participation in pivot and pivot/contact sports, especially at a high level, is one of the most important predictive factors for a new ACL rupture,[3,26,35] but Parkinson et al[33] showed recently that meniscal deficiency is another parameter to be considered to predict graft failure in single-bundle anatomic ACL reconstruction.

Taking into account that all meniscal and ACL injuries were treated following the same protocol in the present study, we believe that the postsurgical activity level can be an important factor for a secondary ACL rupture. However, it is strongly believed that additional parameters, such as the time to return to sports and the compliance with a specific rehabilitation protocol, may contribute to the rerupture of the graft; the patients in the STG group had more rerupture cases, although their activity level was less competitive than that of the PT group.

Regarding the contralateral ACL tears, and despite the similar distribution of pivot/contact sports in our groups, the patients who had a PT graft participated in more competitive sports. Thus, it is strongly believed that the postoperative activity level in these cases led to a higher rate of rerupture than that of the patients having an STG graft.

Patellar fractures occur in patients where a PT graft is used, and their frequency ranges from 0.2% to 0.45%.[43] Whether occurring intraoperatively or postoperatively, this complication is important and may have a negative effect on the rehabilitation and the functional outcome, causing chronic anterior knee pain and stiffness.[28] The rate of patellar fracture in our series was similar to that described in the literature, and, fortunately, the nonoperative treatment had no further effect on the recovery of the patients, since all of them resumed their previous activities.

Certain limitations have to be considered, including the nonrandomization of the groups and the relatively short follow-up. However, this is one of the few reports in the literature where the complications after an ACL reconstruction were recorded, described, and analyzed on the basis of the type of graft. Further strengths of this study include the size of the sample and the fact that the surgical operations were performed by a single surgeon using the same technique and a specific rehabilitation protocol.

CONCLUSION

The total rate of complications after an ACL reconstruction was 39%, and the surgical revision rate was 28% within a 2-year follow-up. Problems with the hardware material were more frequent in the STG group, leading to an increased rate of surgical revision. Anterior knee pain was initially higher in the PT group, but there was no significant difference at the 2-year follow-up. The rerupture rate of the graft was statistically higher in the STG group, and the rupture rate of the contralateral ACL was higher in the PT group. Given that the rate of adverse events reported by the patients is not negligible, a high index of suspicion is advised, and a prolonged follow-up is justified to diagnose and treat them early.

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