Revision Anterior Cruciate Ligament Reconstruction

Surgeon-Reported Causes of Failure From the Norwegian Knee Ligament Register

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Background: Failed anterior cruciate ligament reconstruction (ACLR) leads to reduced quality of life and sometimes the need for repeat surgery. The reason for failure can be multifactorial and difficult to determine. Reports on failure leading to revision are few with limited generalizability. Also, no studies have investigated the reasons for early (<2 years) versus late (≥2 years) revision.

Purpose: To describe patients undergoing revision surgery, the surgeon's reported cause of failure, and the risk of undergoing early versus late revision surgery.

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

Methods: Primary ACLR cases without concomitant ligament injuries or surgery, registered in the Norwegian Knee Ligament Register from 2004 throughout 2023, were eligible. Descriptive analyses were conducted on intraoperative findings and procedures, time from injury to surgery, activity at the time of injury, revision surgery, surgeon-reported cause of revision, and reporting method. The Kaplan-Meier method was used to calculate revision rates. A multivariable Cox regression model, adjusted for confounders, was used to calculate the hazard ratio of early and late revision surgery.

Results: A total of 30,035 primary ACLR cases were analyzed, of which 1599 resulted in revision surgery. The overall revision rate was 7.1% at 15 years. Female patients were younger at the time of both primary and revision surgery (23.8 and 22.5 years, respectively) compared with male patients (28.2 and 22.2 years, respectively). Age at the time of primary surgery was significantly lower for patients who underwent revision (20.4 years) compared with those who did not undergo revision (26.5 years). Male sex, lower age, hamstring tendon graft, and no cartilage injury at the time of primary reconstruction were all associated with a higher risk of early revision. Lower age, hamstring tendon graft, and no meniscal injury were associated with a higher risk of late revision. New trauma (38.1%) was found to be the most common cause of failure leading to revision.

Conclusion: In the current study, representing one of the largest cohorts to date investigating failed primary ACLR leading to revision, the overall 15-year revision rate was estimated as 7.1%. Patients receiving hamstring tendon grafts were at a particular risk for early revision during the first 2 years after primary reconstruction. New trauma was the most common reported cause of failure leading to revision ACLR.

Keywords: cause of revision; anterior cruciate ligament; revision surgery; hamstring tendon; patellar tendon; national registry

Failure to restore stability after an anterior cruciate ligament (ACL) injury leads to reduced sports participation and quality of life in addition to an increased risk of developing osteoarthritis.[12] In the young and active population, reruptures and clinical failure after ACL reconstruction (ACLR) have been reported in 10% to 15% of patients.[4,11] Residual knee laxity often necessitates repeat surgery as patients struggle to maintain their desired level of activity without episodes of instability. The surgical indication for revision ACLR is not clearly defined; some patients with failed primary surgery will either not want to undergo another ACLR procedure or might not benefit from it (as recommended by their surgeon). Therefore, rates of ACL revision surgery, reported to be 4% to 5% at 5 years' follow-up,[1,13,18] are lower than overall failure rates.[4]

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Given the relatively rare occurrence of revision surgery (compared with primary ACLR), the possibility of performing large high-quality studies is limited. Therefore, community-based registries are useful because they accumulate larger series, which can advance our understanding of why ACLR fails.

Several studies have reported new trauma as the most common cause of failure,[3,13] while other frequent causes include graft tunnel malpositioning, inferior graft fixation devices, and failure of graft incorporation.[21,30] Younger age, male sex, type of graft, and smaller graft size have also been reported to increase the risk of ACL revision surgery.[6,11,24,26]

The timing of revision surgery has been associated with different causes of failure. A short duration from primary to revision surgery can be an indication of failure because of technical factors or infections, whereas a longer duration is associated with new trauma.[34]

Patients undergoing revision ACLR are predominantly young and active, and reduced knee function will therefore present a large burden of disease. To counsel patients properly, it is essential to understand the risk factors for failure and, to the extent that it is possible, the primary cause of failure for the individual patient. Currently, there is still insufficient knowledge on the demographic profile of patients undergoing revision surgery as well as the factors that are associated with the timing of revision surgery and the reported cause of failure.

The aim of this study was therefore to (1) describe patients undergoing revision surgery after isolated primary ACLR in Norway based on the Norwegian Knee Ligament Register (NKLR), (2) describe the frequency of early versus late revision surgery and their respective predictors, and (3) report on surgeon-reported causes of failure leading to revision surgery.

METHODS

Norwegian Knee Ligament Register

The NKLR was established in June 2004 to prospectively collect data on all cruciate ligament surgery in Norway.[7] Compliance rates have been monitored since the start, with the latest analysis in 2020 reporting 88%.[10]

Data are collected from a postoperative questionnaire completed by the surgeon in which preoperative and perioperative patient information is requested. In the case of later revision surgery, a new questionnaire is linked to primary surgery using a unique personal identification number given to each inhabitant of Norway. All patients in the NKLR have provided their signed informed consent. The Norwegian Data Protection Authority has authorized the register for data collection, analysis, and publication. For studies based on the register, the Norwegian Regional Ethics Committee has confirmed that no further ethical approval is necessary.

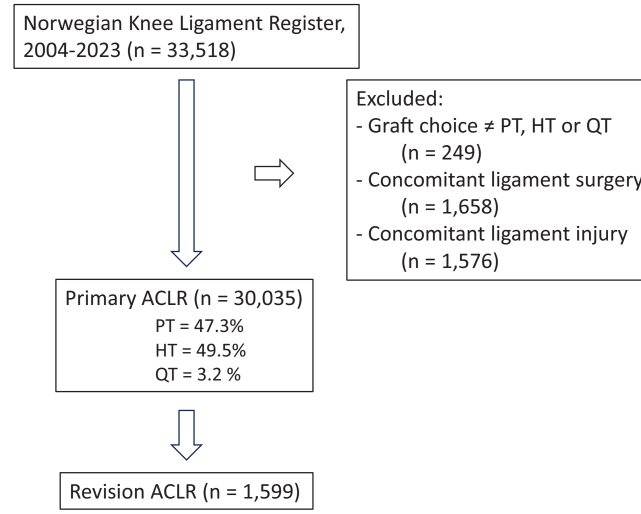

Figure 1. Inclusion and exclusion of patients.

Inclusion and Exclusion Criteria of Patients

All patients registered in the NKLR with primary ACLR were eligible for inclusion. A total of 33,518 primary ACLR cases were recorded in the period from June 2004 throughout 2023. There were 249 reconstruction cases excluded because another graft type was used than the patellar tendon, hamstring tendon, or quadriceps tendon. Additionally, 1576 and 1658 patients were excluded for concomitant ligament injuries or reconstruction at the time of primary ACLR, respectively. Overall, 30,035 primary ACLR cases were included for analysis, of which 1599 resulted in revision surgery (Figure 1).

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Surgeon-Reported Cause of Failure Leading to Revision

The cause of revision is reported postoperatively by the surgeon's best judgment based on available patient history as well as radiographic and intraoperative findings. Between 2004 and 2007, the cause of revision was not inquired. From 2007 to 2010, there were 5 possible causes of revision available to choose from: new trauma, graft failure, untreated concomitant ligament injury, failure of graft fixation device, and infection. From 2011, pain was added as another possible option. With the transition from paper forms to digital forms (from 2017), there were 2 further options added: tunnel malpositioning in the tibia and tunnel malpositioning in the femur. Completion of the form was made mandatory in the digital format; therefore, the formerly used variable "no cause provided" (recorded if no cause was given on the paper form) was eliminated. More than one cause of revision could be selected, and the option to type in a free text was possible throughout the entire study period.

Variables of Interest

The following variables were requested from the register and used for analysis: date of injury, date of primary surgery, date of any revision surgery, and activity at the time of injury. Information on graft type, age, sex, cartilage status at the time of primary surgery, concomitant meniscal injuries, and surgeon-reported cause of failure (leading to revision surgery) was also requested.

The cohort was stratified according to sex, age group (0-20, >20-30, >30 years), graft type (hamstring tendon, patellar tendon), activity at the time of injury (according to the International Knee Documentation Committee [IKDC] classification of activity levels: 1 = jumping, pivoting, hard cutting, football, soccer; 2 = heavy manual work, skiing, tennis; 3 = light manual work, jogging, running; 4 = sedentary work [activities of daily living]),[9] cartilage injury (yes, no), meniscal injury (yes, no), early or late revision (<2 years, ≥2 years), time period in which primary surgery was performed (2004-2009, 2010-2014, 2015-2023), and data collection form (paper/digital).

Statistical Analysis

All statistical analyses were performed using SPSS Statistics (Version 29.0; IBM). An a priori *P* value of .05 was used to denote statistical significance. As measures of central location and spread of data, the mean and standard deviation or median and interquartile range were used. The normality of continuous variables was confirmed using Q-Q plots and the Shapiro-Wilk test. If normality was found, independent-samples *t* tests were used; if not, independent-samples median tests were used. The chi-square test was used to examine categorical variables. To assess revision rates, the Kaplan-Meier method was used with overall revision as the endpoint. A multivariable Cox regression model adjusted for confounders was used to calculate the hazard ratio (HR) with the 95% confidence interval. In multivariable analysis, the following variables were considered as possible confounding factors: sex, age at the time of surgery, graft type, activity at the time of injury, cartilage and meniscal injuries, and surgical period.

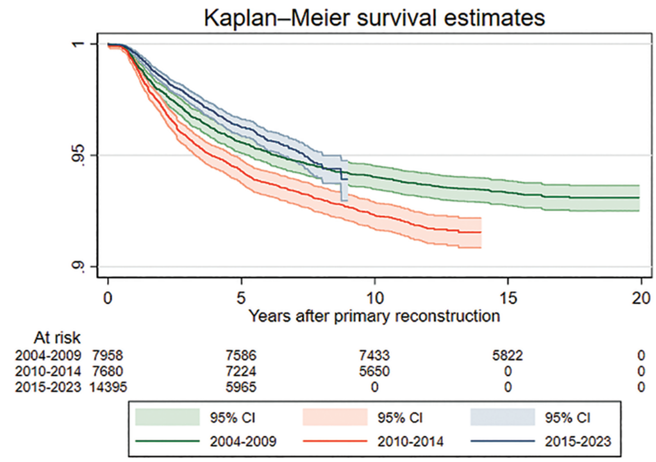

Figure 2. Kaplan-Meier survival estimates stratified by surgical period.

RESULTS

The estimated cumulative revision rates in the entire cohort at 2, 5, 10, and 15 years were 2.1%, 4.5%, 6.6%, and 7.1%, respectively (Figure 2).

Patient Characteristics

Female patients represented 45.1% of primary ACLR cases compared with 46.8% of revision cases. The median age at the time of primary surgery was 26.5 years. Female patients were younger at the time of both primary and revision surgery (23.8 and 18.3 years, respectively) compared with male patients (28.2 and 22.2 years, respectively) (Table 1).

The distribution of age at the time of primary surgery for patients undergoing revision surgery compared with those not in need of revision surgery is shown in Figure 3. Patients undergoing revision surgery had a significantly lower age at the time of primary surgery compared with those without the need for further ACLR ($P < .001$).

Activity at Primary Injury

Sports participation at IKDC level 1 at the time of primary injury was reported for 56.9% of patients, followed by level 4 and level 2 activities in 17.1% and 16.3% of patients, respectively. Level 3 activities accounted for the remaining 9.7%. Only minor differences in the distribution of activity level at the time of injury were seen between male and female patients. In a subanalysis for specific types of

TABLE 1
Patient Characteristics[a]

	No Revision (n = 28,436)	Revision (n = 1599)	*P* Value
Sex, %			
Male	54.9	53.2	NS[b]
Female	45.1	46.8	NS[b]
Age at primary surgery, y	26.5 (19.5-36.5)	20.4 (17.2-26.9)	<.001[c]
Male	28.2 (21.8-36.7)	22.2 (18.8-28.5)	<.001[c]
Female	23.8 (17.7-36.0)	18.3 (16.2-24.0)	<.001[c]
Age at revision surgery, y	N/A	24.7 (20.5-31.5)	N/A
Male	N/A	26.6 (22.1-32.7)	N/A
Female	N/A	22.5 (18.9-28.9)	N/A
Time from injury to primary surgery, mo	7.3 (3.7-16.2)	6.0 (3.5-11.4)	<.001[c]
Male	7.8 (4.0-17.7)	6.5 (3.7-11.8)	<.001[c]
Female	6.8 (3.5-14.5)	5.7 (3.2-11.1)	<.001[c]
Time from primary to revision surgery, mo	N/A	34.4 (18.1-63.9)	N/A
Male	N/A	35.0 (18.2-64.7)	N/A
Female	N/A	33.8 (17.9-62.9)	N/A

[a]Data are presented as median (interquartile range) unless otherwise indicated. N/A, not applicable; NS, not significant.
[b]Chi-square test.
[c]Independent-samples median test.

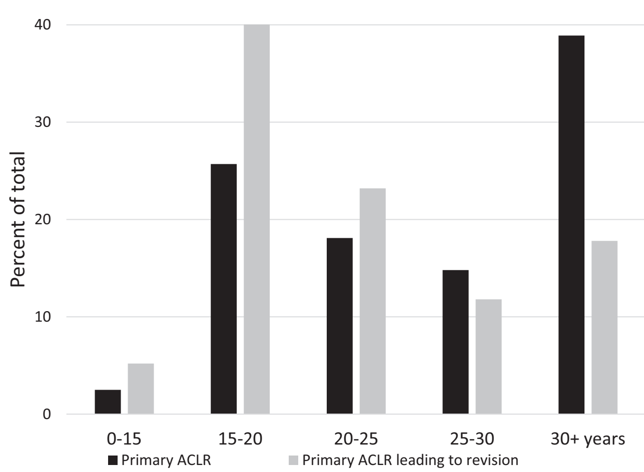

Figure 3. Distribution of age between primary anterior cruciate ligament reconstruction (ACLR) with no revision and primary ACLR leading to revision. Data are presented as percentages for each age interval.

activities, soccer accounted for 53.0% of preinjury activities in male patients but only 26.9% in female patients. Team handball was the most frequently reported activity in female patients (26.5%) but was only reported in 3.9% of male patients.

Risk Factors for Early and Late Revision Surgery

Multivariable analyses exploring risk factors for early and late revision surgery are presented in Tables 2 and 3, respectively. The HR for early revision was 1.2 for male patients compared with female patients, indicating that male patients had a 20% higher risk of early revision compared with female patients. The HR was 4.5 and 2.1 for the 2 younger age groups, respectively, compared with the >30-year age group. The HR for early revision was 2.3 for the hamstring tendon graft compared with

TABLE 2
Risk Factors for Early Revision[a]

	Hazard Ratio (95% CI)	*P* Value
Sex		
Male	1.2 (1.0-1.5)	.022
Female	Reference	
Age at surgery		
0-20 y	4.5 (3.5-5.7)	<.001
>20-30 y	2.1 (1.6-2.7)	<.001
>30 y	Reference	
Graft type at primary surgery		
Hamstring tendon	2.3 (1.9-2.8)	<.001
Patellar tendon	Reference	
Activity at primary injury		
Level 1	Reference	
Level 2	0.8 (0.6-1.1)	NS
Level 3	0.9 (0.6-1.2)	NS
Level 4	0.9 (0.7-1.2)	NS
Cartilage injury		
No	1.3 (1.0-1.7)	.025
Yes	Reference	
Meniscal injury		
No	1.2 (1.0-1.4)	NS
Yes to one or both	Reference	
Surgical period		
2004-2009	1.1 (0.9-1.4)	NS
2010-2014	1.4 (1.1-1.8)	.002
2015-2023	Reference	

[a]Analysis was adjusted for confounding variables. NS, not significant.

TABLE 3
Risk Factors for Late Revision[a]

	Hazard Ratio (95% CI)	P Value
Sex		
Male	1.1 (0.9-1.2)	NS
Female	Reference	
Age at surgery		
0-20 y	3.8 (3.2-4.6)	<.001
>20-30 y	2.6 (2.2-3.2)	<.001
>30 y	Reference	
Graft type at primary surgery		
Hamstring tendon	1.5 (1.3-1.7)	<.001
Patellar tendon	Reference	
Activity at primary injury		
Level 1	Reference	
Level 2	0.9 (0.8-1.1)	NS
Level 3	0.8 (0.6-1.0)	NS
Level 4	1.1 (0.9-1.1)	NS
Cartilage injury		
No	0.9 (0.8-1.1)	NS
Yes	Reference	
Meniscal injury		
No	1.3 (1.1-1.4)	<.001
Yes to one or both	Reference	
Surgical period		
2004-2009	0.8 (0.7-0.9)	.007
2010-2014	1.0 (0.9-1.2)	NS
2015-2023	Reference	

[a]Analysis was adjusted for confounding variables. NS, not significant.

the patellar tendon graft, and an HR of 1.3 was seen for those with no cartilage injury compared with those with a cartilage injury at the time of primary surgery. A 42% increased risk of early revision was seen in the 2010-2014 period compared with the 2015-2023 period (Table 2).

No differences were found between the sexes for late revision after adjusting for confounders. The 2 younger age groups had an increased HR of 3.8 and 2.6, respectively, compared with the oldest age group. The HR for late revision was 1.5 for the hamstring tendon graft compared with the patellar tendon graft, and an HR of 1.3 was observed for no meniscal injury compared with an injury to one or both menisci. A small reduced risk of late revision was seen for the 2004-2009 surgical period compared with the 2015-2023 period (Table 3).

Cause of Failure as Reported by Surgeons

The primary reported cause of failure leading to revision reconstruction was collected from paper forms (n = 1292) and digital forms (n = 307). For the revision group (n = 1599), new trauma (38.1%) was the most frequently reported cause, followed by graft failure (24.5%) and no cause provided (15.2%); for the latter, the surgeon had not given a cause of failure. Further, the combination of new trauma and graft failure accounted for 10.3%, and tunnel malpositioning was reported in 5.2% of cases.

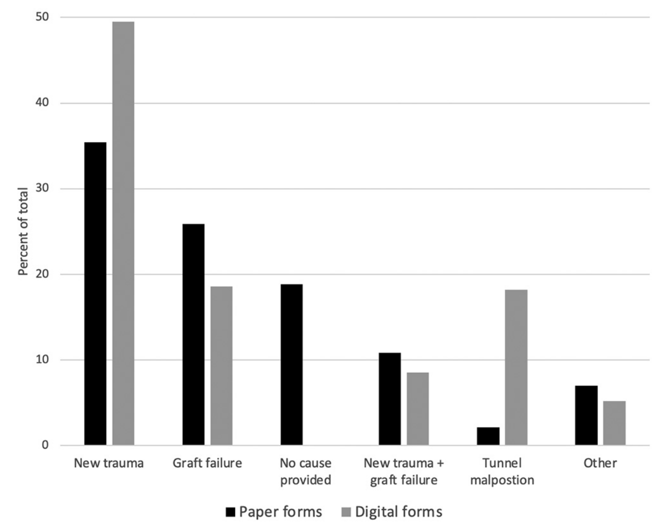

Figure 4. Surgeon-reported cause of revision. Distribution between paper forms and digital forms. Data are presented as percentages for each cause.

None of the other causes or combinations exceeded 3.0% each, and altogether, they accounted for 6.7% of the cases in total. In Figure 4, surgeon-reported cause of revision is stratified between paper forms and digital forms. A significant shift in distribution was found with the introduction of a web-based digital form that eliminated missing data and introduced 2 new choices ($P < .001$). A higher proportion of new trauma and tunnel malpositioning was reported. Analysis of the distribution of cause of failure for early and late revision was conducted, and no significant differences were found between them.

DISCUSSION

In the current study from the NKLR, the cumulative 15-year revision rate was 7.1% among 30,035 patients who underwent primary ACLR between 2004 and 2023. Those who underwent revision were 6 years younger at the time of primary surgery, and the time from injury to primary surgery was shorter, compared with those who had not undergone revision. Most frequently, these patients had participated in pivoting, hard cutting, and jumping sports. Several risk factors for early and late revision were identified, including the use of a hamstring tendon graft and younger age at the time of surgery. The most frequent causes of failure leading to revision were reported to be new trauma and graft failure. Finally, with the introduction of a web-based mandatory reporting form, with new choices for the reporting surgeon, the distribution of cause of revision changed significantly, with a large increase in tunnel malpositioning and new trauma and a decrease in graft failure as causes of failure.

We found revision rates at 2, 5, 10, and 15 years of 2.1%, 4.5%, 6.6%, and 7.1%, respectively. The rates at 2 and 5 years were slightly higher than those previously reported from this register[24] but resemble findings from both the Danish[13] (2-year revision rate of 2.9%) and Swedish[1] (5-year revision rate of 4.1%) ACLR registers. We were not able to find previously published data on 10- and 15-year revision rates from other national registries. Lindanger et al[14] reported a 9% overall revision rate at 25 years' follow-up of a clinical cohort, which may be similar to our cohort at a later longer follow-up time point. In a meta-analysis of 16 studies including 1771 patients, with a minimum follow-up of 24.8 years, Grassi et al[8] found an overall revision rate of 7.9%. The substantial increase in the revision rate from 5 to 10 and 15 years highlights the importance of a long follow-up time when reporting outcomes.

Younger age has previously been reported as a risk factor for revision.[6,15,16,24,26,32,33] In the current study, patients who underwent revision were, on average, 6 years younger at the time of primary ACLR than those not in need of further stabilizing surgery. The same findings were evident for male and female patients separately. When stratified by age, patients aged ≤20 years had more than a 4-fold risk of early revision, and a nearly 4-fold risk of late revision, compared with the >30-year group. A smaller, but still substantial, increased risk was found when comparing the >20-30–year group with the >30-year group. This is in line with reports from other register studies from Scandinavia, the United States, and New Zealand.[5,16,24,26] The association between younger age and an increased risk of revision may be explained by several factors. First, age and level of activity have been found to correlate inversely by Marx et al[20] and hence a chance of returning to pivoting sports with a higher risk of reinjuries. Second, older patients are thought to be more likely to accept reduced knee function[28] and therefore accept living with an unstable knee. Lastly, we saw that the revision group had a shorter time from injury to surgery, which can also reflect a more active group eager to go back to their sports.[29]

The sex-specific risk of revision has previously been reported with diverging findings. Reports from the national register in New Zealand and from the United States–based Kaiser Permanente register demonstrated a 2 and 1.4 times higher risk of revision for male patients compared with female patients, respectively.[19,26] However, findings from Scandinavian registries have not been in concordance with this.[6,13,24] The differences between countries may be attributed to the different distribution of high-risk sports between male and female patients. In the present study, we only found a slightly increased HR of 1.2 for male patients compared with female patients for early revision (<2 years) but no difference for late revision (≥2 years). It has been shown that male patients have a higher rate of return to preinjury levels of sports.[2] One can presume that male patients therefore acknowledge recurrent instability faster, or suffer a reinjury earlier, than their female counterparts.

The present study identified a 42% increased risk of early revision surgery for procedures conducted between 2010 and 2014 compared with those performed from 2015 and onward. However, no increased risk was noted for late revision surgery. During the 2010-2014 period, many Norwegian clinics transitioned from a transtibial drilling technique to an anteromedial portal drilling technique for the femoral tunnel. These findings may suggest a learning curve associated with the adoption of this new and, for some, more complex technique, similar to what has been reported in a study from the Danish register,[27] showing an increased relative risk of revision of 2.04 for the anteromedial portal technique compared with the transtibial technique.

Previously published data from the Norwegian register during 2004-2012 found an HR for revision of 2.3 (95% CI 1.8-3.0) with the hamstring tendon graft compared with the patellar tendon graft. Similar results have been published by Maletis et al.[17] In this study, we found a similarly greater risk of early revision (<2 years) between the grafts (HR, 2.3), but for late revision (≥2 years), the risk was somewhat lower (HR, 1.5). This finding shows that patients treated with hamstring tendon grafts were particularly at risk for early failure. We can only speculate if this is because of less persistent graft incorporation with tendon-bone healing both in the femur and tibia, which would lead to a weaker construct more prone to fail when the patient is exposed to exercises during rehabilitation and return to more demanding activities. Additionally, the difference in the revision risk between the early and late periods may support an argument that hamstring tendon grafts require distinct rehabilitation progression and possibly later exposure to high-risk activities.

The present study indicated a small increased risk of late revision surgery for patients with no meniscal injury at the time of primary surgery. In a previous study, failed meniscal repair was associated with a higher risk of revision.[31] The biomechanical effect of the menisci on stability, and the effect on joint presevation, is believed to be substantial.[23,25] The finding in the present study can be interpreted to support this notion as the operating surgeon would be more inclined to perform repeat surgery in knees with intact menisci. A similar argument can be made in regard to the findings on cartilage injuries. We saw an increased risk of early revision with no cartilage injury at the time of primary surgery, and again, the operating surgeon may be more open to repeat surgery in the knee with intact joint cartilage than in a knee with a substantial cartilage injury. Patients without meniscal or cartilage injuries may also be more likely to return to a higher activity level, which again might increase their risk of reinjuries and therefore revision.

The distribution of cause of failure in the entire cohort has some similarities with reports from the Danish registry by Lind et al[13] in which they identified new trauma as the main cause of failure leading to revision (38%) and further observed an unknown cause of failure in 24% and graft tunnel malpositioning in 26%. Trojani et al[30] reported graft tunnel malpositioning in 47%, new trauma in 30%, no cause found in 15%, and impingement in 12% of those who underwent revision. Finally, Chen et al[3] examined the MARS cohort using slightly different terminology for various options in reporting failure. Trauma was the cause of failure in 35%, while technical errors (21%) and the combination of technical errors and trauma (16%) were less frequent causes. Of the 1599 revision ACLR cases included in the present study, the cause of failure was reported to be new trauma (38.1%), followed by graft failure (24.5%), no cause provided (15.2%), the combination of new trauma and graft failure (10.3%), and tunnel malpositioning (5.2%) in declining order of frequency. Graft fixation failure, infections, untreated concomitant ligament injuries, pain, and other combinations accounted for the remaining 6.7%.

Revision ACLR is a heterogeneous procedure, and the cause of failure leading to revision is often multifactorial. There is a lack of clear and universal agreed upon indications for such surgery, and there is a need for more objective criteria to properly classify the causes of failure leading to revision surgery. This is emphasized in the study by Matava et al,[21] who reported large interobserver variability in a group of knee experts assessing why ACLR had failed. The heterogeneity in the reporting of cause of failure between the previously discussed studies[3,13,30] suggests that a consensus of definitions of revision causes would improve comparisons across studies and across registries.

In past decades, there has been an increased focus on correct graft tunnel placement, although there is no consensus of when a tunnel is malpositioned and therefore results in the failure of ACLR.[22] This ongoing debate is reflected in the data from the present study in which the introduction of added options and mandatory registration has led to several shifts in reporting. We found significant differences when comparing data captured digitally to that reported by paper forms. New trauma was previously reported in 35% of cases and increased to 50% with electronic registration. Graft failure declined from 26% to 19%, and the group (19%) that had no reported cause was eliminated with the transition from paper forms. Another finding was that tunnel malpositioning increased from 2% to 18%.

These changes in the reported cause of failure in data derived from digital forms are probably influenced by forced mandatory completion, and the proportion classified as no cause provided was therefore distributed among the other options. Changes can also be influenced by other time-dependent factors between patients who underwent surgery early versus late in the study period: for instance, changes in graft choice. Our understanding of how these specific factors, whether they be early or late revision or other patient or surgical factors, affect the risk of a surgeon reporting a particular cause of revision, or a combination of these, remains limited. However, the improvements in registration will hopefully highlight the focus on "discovery" and possibly more accurately conceive the cause of failure leading to revision.

Strengths and Limitations

The high number of patients included in the study, more than 30,000 patients and almost 1600 revision cases, is a major strength. This makes it possible to detect differences in the population, despite the relative rare occurrence of revision surgery. However, there are some important limitations. The lack of complete information on some aspects of the surgical technique, especially femoral tunnel drilling, and some baseline patient data (body mass index, registration only started in 2011), in addition to data on rehabilitation, may have affected our results. The absence of comprehensive data on the specific types and frequency of meniscal and cartilage procedures is acknowledged as a limitation, as it may affect the accuracy of the results. Additionally, the activity at the time of injury may not accurately represent the patient's athletic aspirations and can therefore both overestimate and underestimate the actual level. Another limitation associated with this investigation is that the increase in the familywise error rate across the reported statistical analyses was not controlled for.

A fact that can be both a strength and a weakness in the register is that surgical procedures are only registered with the operating hospital or clinic but not with the specific surgeon. This can have a positive effect on the surgeon's likeliness to honestly report on the cause of failure. However, it might also be biased by the possibility of the same surgeon performing both primary and revision ACLR and hence be reluctant to critically evaluate his or her own work. Further, surgeons might be applying the definitions of causes of failure differently or unevenly from case to case, which will possibly weaken the results.

CONCLUSION

In the current study, the overall 15-year revision rate was estimated as 7.1%. Patients who underwent revision were 6 years younger at the time of primary surgery compared with patients with no revision. Patients receiving hamstring tendon grafts were in particular at risk for early revision during the first 2 years after primary reconstruction. An increased risk for late revision was found for hamstring tendon grafts and younger age but at lower levels than for early revision. New trauma was the most common cause of failure leading to revision ACLR. There is a need for an international agreed upon and validated classification system to further improve our understading of factors leading to specific revision causes and for comparisons across nations and registries.

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