



Seventy percent long-term survival of the repaired ACL after dynamic intraligamentary stabilization

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Abstract

Purpose Primary repair of the anterior cruciate ligament (ACL) is regaining popularity. Long-term results are lacking. The purpose of the current study was to determine the survival of the primarily repaired ACL after dynamic intraligamentary stabilization.

Methods Between 2011 and 2013, 57 patients with acute proximal ACL ruptures underwent DIS repair within 3 weeks from injury and were available for final follow-up at least 5 years postoperatively. Failure as an end point was defined as conversion to ACL reconstruction, failure to restore stability with persisting laxity side-to-side laxity of > 5 mm or a late-traumatic re-rupture or loss of stability. Kaplan–Meier survival analysis was performed.

Results Kaplan–Meier survival analysis demonstrated an overall survival of 70.0% (standard error SE 6.6%) at 74 months follow-up. Patients performing competitive sports prior to injury demonstrated an inferior long-term ACL survival of 56.4% (SE 11.6%). Patients performing recreational sport activities demonstrated a survival rate of 79.2% (SE 7.7%). The one factor demonstrating a direct influence on failure after adjustment was a high-pre-injury level of physical (odds ratio 4.0 confidence interval 1.0–15.8, $p = 0.04$).

Conclusion The minimum 5 years survival rate after primary ACL repair using this technique was 70%. This value dropped to 56% in highly active patients performing competitive sports. Patients not suffering failure of repair demonstrated adequate restoration of knee laxity and high satisfaction. This study not only underlines the potential of ACL repair, but also highlights the danger of the procedure if strict patient selection is not appreciated.

Level of evidence Level IV.

Keywords Anterior cruciate ligament · ACL · Primary ACL repair · Ligamys · Dynamic intraligamentary stabilization · Stabilization · Internal brace · ACL healing · Healing · Proximal rupture

Introduction

In the last decade, primary anterior cruciate ligament (ACL) repair has been reestablished as a treatment principle for ACL tears. Techniques have been revised and several authors have advocated a potential role for primary repair techniques in the ACLF decision tree [1, 3, 5, 15].

However, it is of major importance to avoid the previously done mistakes and learn from the failures of primary ACL repair in the past [1].

One of the well-established techniques for treating acute ACL tears is the “dynamic intraligamentary stabilization” system (DIS). The idea was initially established as a biomechanical solution to overcome the problematic issue of cyclic loading of the repaired ACL [10]. Mechanical protection

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against anterior tibial translation during the healing period represents the treatment principle of this technique.

Although the procedure has demonstrated promising short-term results overall [11], these good results are mainly limited to proximal ACL tears [12].

Hence, it is fair to question whether contemporary techniques are superior to previous historic methods and whether modern fixation techniques are responsible for such superiority. Long-term follow-up of modern primary ACL repair techniques are lacking, therefore, true conclusions regarding long-term success cannot be made [5, 11]. As a matter of fact, the results of only 10 patients at 5 years have been reported.

It was hypothesized that the results of ACL repair are maintained for more than 5 years. The aim of the study was to evaluate the outcome of ACL DIS repair at long-term follow-up.

Materials and methods

Patients that underwent DIS repair for isolated acute proximal ACL ruptures between 2011 and 2013 were considered eligible for inclusion in the study, provided that the following inclusion criteria were fulfilled: (1) More than 18 years of age. (2) Confirmed diagnosis of an ACL tear based on MRI and an increased delta anterior translation (Δ ap) of more than 5 mm in 25° of flexion and 134°N anterior force using a KT-1000 device, constituting an International Knee

Documentation Committee (IKDC) grade of C or D. (3) A high-activity level with a Tegner score of > 4 prior to injury. (4) Surgical repair of the ACL performed within a 3-weeks timeframe from the day of injury. (5) A minimum follow-up of 5 years. Distal and mid-substance ACL ruptures were excluded from analysis.

Figure 1 presents a flowchart of patients included in the current study. Patient demographics are presented in Table 1.

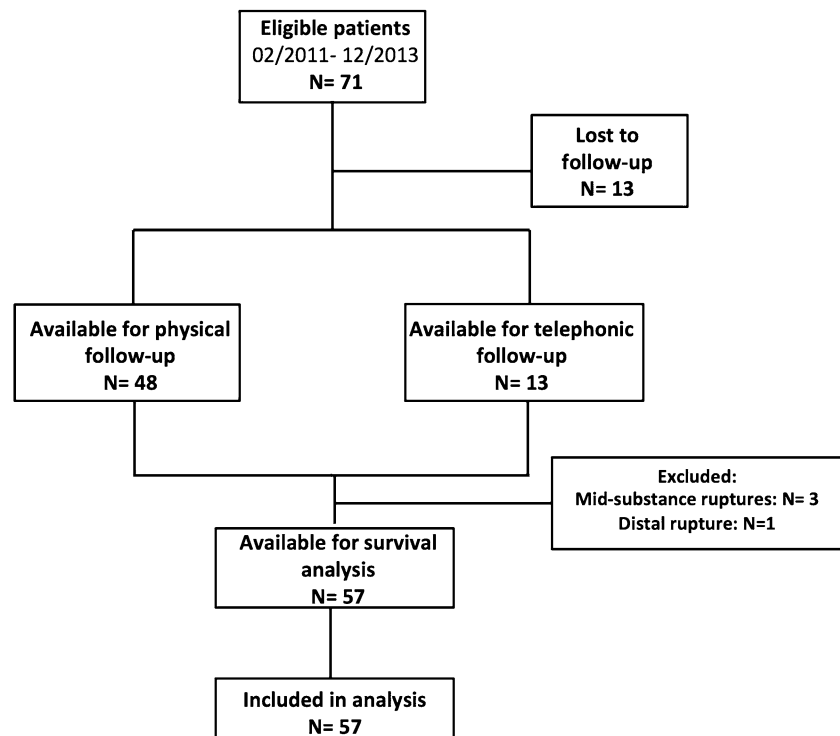
Surgical technique

The surgical technique was performed as previously described [11]. In the presence of a concomitant meniscal lesion, repair or partial debridement was performed based on individual need.

Table 1 Patient demographics

	Mean (SD) (range)	Proportion (%)
Age (years)	38.6 (12) (20–65)	–
Gender		
Female		28/57 (49.1%)
Male		29/57 (50.9)
Meniscal tear	–	38/57 (66.6)
Medial	–	6/57 (10.5)
Lateral	–	16/57 (28.0)
Both	–	16/57 (28.0)
Follow-up (months)	76.0 (60–90)	–

Fig. 1 Flowchart illustrating patient inclusion



Outcome measures

The median follow-up was 76 months (range 60–90 months) during which the following outcome measures were obtained:

For subjective assessment, the Tegner, Lysholm and IKDC_{subjective} were obtained for all 57 patients [7, 9, 14, 17].

For objective assessment, the IKDC_{objective} (Groups 1–4) measures including KT-1000 measurements of anterior translation were performed for patients who were physically available for follow-up. Side-to-side translation was measured based on the mean of three repetitive measures to ensure measurement accuracy.

Endpoint definition of failure

Failure was defined as revision of the ACL in the sense of conversion to an ACL reconstruction, failure to restore stability with persisting laxity presenting an IKDC > B (5 mm). A late retear or loss of stability was also considered a failure. The presence of any of the above was considered as failure. The timepoint of failure was noted for survival analysis.

Statistical analysis

Normally distributed data are presented as mean (standard deviation and range) and non-normally distributed data as median (range). Survival analysis was performed using Kaplan–Meier estimates. Logistic regression was applied to identify factors influencing failure.

Results

Survival analysis

Kaplan–Meier survival analysis demonstrated an overall survival of 70.0% [standard error (SE) 6.6%] at 74 months follow-up. Figure 2a illustrates the Kaplan–Meier overall survival curve. Patients performing competitive sports prior to injury with a high-Tegner score of 7 or more demonstrated an inferior long-term ACL survival of 56.4% (SE 11.6%). Whereas, patients performing recreational sport activities demonstrated a survival rate of 79.2% (SE 7.7%) as shown in Fig. 2b.

Outcome measures

At final follow-up of mean 73.9 months postoperatively, the median IKDC subjective score was 94 (range

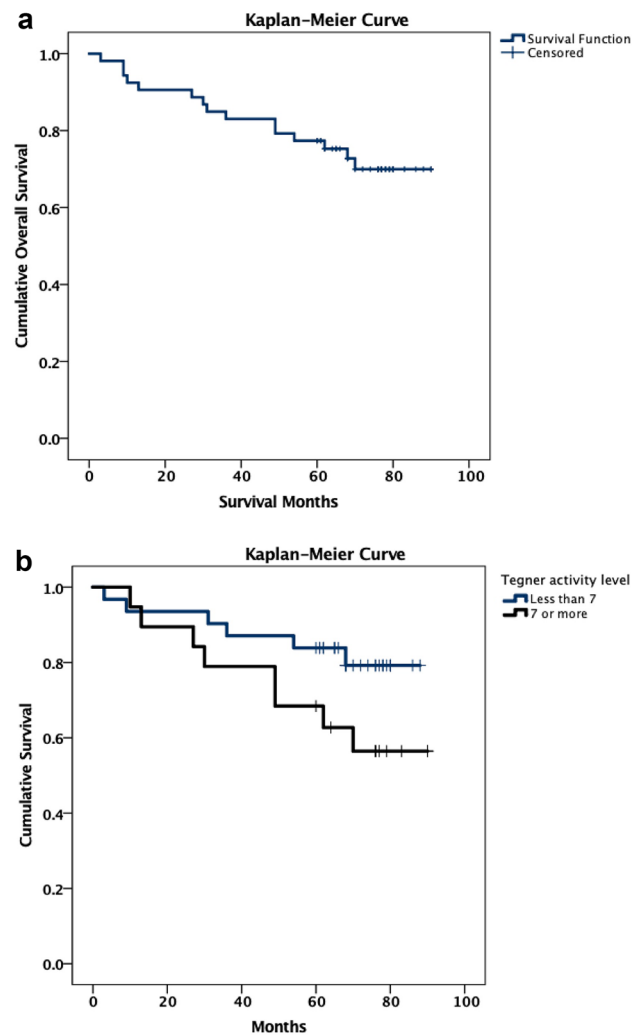


Fig. 2 a Kaplan–Meier overall survival curve of the repaired ACL. **b** Kaplan–Meier survival curve for showing the survival of the repaired ACL in highly active patients performing competitive sports (Tegner 7 or more) vs. Tegner patients only performing recreational sports (Tegner < 7)

63.2–100), the median Lysholm score was 94 (range 64–100) and the median Tegner score was 6.0 (range 3–9).

Anterior translation was (0.8 mm SD 2.3 mm) more than the contralateral healthy knee.

Objective measures based on IKDC groups 1–4 at final follow-up are illustrated in Table 2. The table includes patients who have not suffered failure and were available for clinical examination.

Regression analysis

Due to the small-sample size, it was not possible to perform an adequate regression analysis. However, the one factor demonstrating a direct influence on failure after adjustment was a high-pre-injury level of physical defined as a Tegner

Table 2 Objective outcome measures based on the IKDC objective measures for individuals with intact DIS repair

Group	Proportion (%)
IKDC group 1 (effusion)	29/29 (100) A
IKDC group 2 (passive motion deficit)	24/29 (82.8) A 5/29 (17.2) B
IKDC group 3 (ligament examination)	15/29 (51.7) A 12/29 (41.4) B 1/29 (3.7) C 1/29 (3.4) D
IKDC group 4 (compartment findings)	21/29 (72.4) A 7/29 (24.1) B 1/29 (3.4) D

activity level of 7 or more on a competitive level, (odds ratio 4.0 confidence interval (CI) 1.0–15.8 $p=0.04$).

Discussion

The most important finding of the study reflected the fact that the overall long-term survival rate of the ACL after DIS repair was 70%. However, the rate falls to 56% in highly active patients performing competitive sport activities.

It is reasonable to question whether these long-term results are any better than the previously published poor-historic results for primary ACL repair that have led to wide abandonment among knee surgeons. Considering the historic literature, Feagin and Curl published their 5 year results of a series of cadets treated between 1967 and 1971 [6]. The study was published in 1976 and is very frequently cited until today [6]. The main findings were that 17 (53.1%) of the 32 patients available for follow-up suffered a traumatic re-tear and 94% of patients reported a considerable degree of instability [6]. However, at the time the study took place, there were no standardized outcome batteries for clinical evaluation. Therefore, the quality of the Feagin report would unfortunately not hold the current scientific quality standards of clinical ACL studies [2]. Another study by Weaver et al. in 1985 demonstrated a failure rate of 36% at a mean follow-up of 42 months [19]. However, the follow-up period of the study falls within the range of short-term, therefore it does not provide a good base for comparison. As a matter of fact, the results are inferior to the previously reported short-term results of DIS repair [8, 11]. A further study published in 1991 by Sherman et al. provided a detailed report of the long-term results of 50 primary ACL repairs with an average follow-up of 61 months [16]. The results showed that 52% of patients had restored and maintained stability in the long-term with normal anterior laxity. Only 6% demonstrated gross laxity and 18% suffered a re-tear [16].

It is difficult to draw statistically robust conclusions regarding superiority of DIS repair compared to historic reports, but based on the available literature and the present data it appears that DIS leads to slightly improved survival rates and lower re-tear rates.

One issue that definitively needs to be emphasised is that stricter indications would have likely resulted in an overall better outcome as shown in the subgroup analysis. Highly active patients are more likely to suffer failure of repair. Given the fact that evidence regarding the ideal surgical candidate was lacking at the time of patient enrolment for this study, the potential danger of inappropriate patient selection is actually demonstrated here.

The landmark articles that have brought light to the importance of correct patient selection and the art of setting the correct indications actually represent the true revolution of the principle of ACL repair [5, 12, 18]. The progress achieved in improving the understanding of ACL healing alongside the revision of indications, most likely outweigh the biomechanical benefit effects of device innovations that have appeared on the market.

The reality is that despite the proven healing potential of the ACL, the results of DIS repair seem inferior to ACL reconstruction in the long-term, if compared to the literature [4, 13]. This is left to be freely interpreted at this juncture, given that the study is not comparative in nature.

The main limitation of the study was the small-sample size that limited the possibility of performing a comprehensive cox-regression analysis to determine factors influencing survival. The confidence intervals would have been unacceptably large. However, this was not the primary aim of the current study. The authors, therefore, agreed to accept the limitation. Second, a proportion of patients were not available for physical follow-up and were contacted telephonically, therefore, there might have been some missed instability that may not be a subjective concern to some patients. However, all revisions and re-ruptures were captured.

Conclusion

The minimum 5 years survival rate after primary ACL repair using DIS was 70%. This value dropped to 56% in highly active patients performing competitive sports and was 79% in patients performing recreational sports. Patients not suffering failure of repair demonstrated adequate restoration of stability and high satisfaction. This study not only underlines the potential of ACL repair, but also highlights the potential danger of the procedure if strict patient selection is not appreciated.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval The study was performed according to its approval by the ethical commission of the canton of Bern, Switzerland (KEK-BE 253/2014).

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