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Anatomic ACL Repair with Suture Tape Augmentation and Cortical Button Fixation Compared with Hamstring Autograft Reconstruction for Acute Proximal ACL Tears: A Retrospective Cohort Study at Short-Term Follow-up

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Research Article

Keywords: acute proximal ACL tears, ACL repair, ACL reconstruction, Ligabrace technique, suture tape augmentation

Posted Date: May 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9597870/v1

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Additional Declarations: No competing interests reported.

Abstract

Purpose: Anterior cruciate ligament (ACL) reconstruction using tendon grafts remains the standard treatment for ACL ruptures, although ligament-preserving techniques have gained increasing interest for selected injury patterns. This retrospective cohort study aimed to evaluate clinical and radiologic outcomes of a ligament-preserving ACL repair technique (Ligabrace), involving suture tape augmentation and cortical button fixation, compared with hamstring autograft reconstruction in patients with acute proximal ACL tears.

Methods: A retrospective cohort of 50 patients with isolated acute proximal ACL rupture (Sherman I/II) without concomitant injuries was analyzed. Patients were allocated to either Ligabrace repair (n=25) or hamstring autograft reconstruction (n=25) based on intraoperative assessment of tissue quality. Clinical outcome measures (Tegner, Lysholm, and IKDC scores) were assessed preoperatively (T0) and at 12 months postoperatively (T2). In addition, magnetic resonance imaging (MRI) and clinical knee examinations, including instrumented anterior-posterior (AP) laxity measurements, were performed at defined follow-up intervals.

Results: At 12 months (T2), no statistically significant differences were observed between groups in any of the evaluated outcome measures ($p > 0.05$). The Ligabrace group demonstrated mean Lysholm scores of 90.3 ± 7.9 (range 71 - 100) and IKDC scores of 87.1 ± 11.3 (range 62 - 100), comparable to the reconstruction group. Tegner activity levels were 6.2 ± 1.7 in the Ligabrace group and 5.8 ± 1.7 in the reconstruction group. Mean side-to-side AP laxity was 0.56 mm in the Ligabrace group and 0.72 mm in the reconstruction group.

Conclusion: Primary ACL repair using the Ligabrace technique demonstrated comparable short-term clinical and radiologic outcomes to hamstring autograft reconstruction in a selected cohort of patients with acute proximal ACL tears. These findings should be interpreted considering the retrospective design and potential selection bias, and further prospective studies are warranted.

Level of Evidence: Level III, retrospective cohort study

Introduction

Anterior cruciate ligament (ACL) reconstruction using autograft tendons is considered the gold standard treatment for ACL tears [1]. However, despite advances in technical and biomechanical aspects, clinical outcomes remain suboptimal. Reported limitations include loss of proprioception and graft site morbidity, which may result in persistent altered movement patterns and gait kinematics, respectively [2, 3]. In addition, revision surgery can be more challenging due to the loss of available graft tendons [4]. Furthermore, ACL reconstruction has been associated with an increased risk of osteoarthritis [5, 6].

Despite these limitations, ACL reconstruction remains the standard of care. However, increasing attention has been directed toward ligament-preserving approaches in selected patient populations.

Therefore, primary repair of the ACL has received renewed attention in recent years. Although it was a common treatment until the early 1990s, mid- and long-term outcomes were unsatisfactory [7–9]. More recently, encouraging results have been reported with suture tape augmentation techniques. Heusdens et al. observed a failure rate of 11.4% at two-year follow-up [10], and Jonkergouw et al. confirmed these findings with a similar failure rate of 10.7% [11]. In both studies, internal bracing was performed for proximal avulsion tears, with femoral fixation achieved using a suture anchor. A systematic review concluded that internal bracing in carefully selected patients with proximal tears produced favourable clinical outcomes, and that bracing with a nonabsorbable suture, scaffold, or graft further increased the success rate of ACL reconstruction. In addition, marrow venting at the femoral insertion site has been shown to release pluripotent cells, potentially enhancing the healing response [12]. Clinical outcomes for patients with proximal ACL tears have improved due to advances in diagnostics, arthroscopic techniques, and patient selection. Magnetic resonance imaging (MRI) is now widely used to identify candidates for primary repair [14]. Moreover, minimally invasive surgery, early range-of-motion rehabilitation, and the use of suture anchors have contributed to improved outcomes of primary ACL repair [15]. Recent studies have reported excellent results in selected patients with proximal avulsion tears [16, 17]. However, the use of intraosseous implants as a fixation method may complicate revision surgery if required.

However, despite these encouraging results, direct comparative clinical data between ligament-preserving repair techniques without intraosseous implants and established ACL reconstruction techniques in well-defined patient populations remain limited.

The present investigation aimed to compare the clinical and radiologic results of an ACL repair technique, hereafter referred to as Ligabrace technique, that avoids the use of intraosseous implants, with those of single-bundle ACL reconstruction in patients with acute proximal ACL tears. We hypothesized that clinical and radiologic outcomes following the Ligabrace technique would be comparable to those of ACL reconstruction at short-term follow-up (12 months).

Methods

Patients

Between August 2017 and April 2019, a total of 269 patients underwent surgical treatment for ACL injuries. From the initial cohort of 269 patients treated surgically for ACL injuries, patients were screened according to predefined inclusion and exclusion criteria. Only patients with acute, isolated proximal ACL tears (Sherman type I or II) and complete clinical, imaging, and follow-up data were included. Patients were excluded if they presented with insufficient tissue quality for repair, concomitant injuries, or incomplete datasets, resulting in a final study population of 50 patients. This study was designed as a retrospective, non-randomized, single-centre cohort study. Allocation to treatment was based on intraoperative tissue quality and was therefore not randomized.

The Ligabrace group (LGB) comprised 25 patients who underwent arthroscopic primary ACL repair using suture tape augmentation and cortical button fixation. Eligible patients had an acute proximal ACL tear (Sherman type I or II) with excellent tissue quality confirmed by preoperative MRI and intraoperative assessment. Excellent tissue quality was defined as a proximal tear pattern (Sherman type I/II), continuous fibre structure, absence of significant retraction, and preserved synovial coverage. Surgery was performed within four weeks of injury. Patients were required to have completed a clinical examination, including instrumental stability testing (Rolimeter®, Aircast, CA, San Diego, USA), and to provide complete patient-reported outcome scores (IKDC, Lysholm, Tegner) preoperatively and at 12-month follow-up. All patients were also available for MRI follow-up at 12 months. Patients with insufficient intraoperative tissue quality were not considered for ACL repair [15].

The control group included 25 patients with isolated proximal ACL tears (Sherman type I or II) who did not meet the tissue quality requirements for repair and therefore underwent anatomic ACL reconstruction using a quadruple semitendinosus/gracilis autograft within four weeks of injury. The diagnosis was confirmed by MRI, and all patients provided informed consent to participate in the study.

Exclusion criteria for both groups were previous unilateral knee ligament surgery, multiligament injuries involving more than two ligaments, meniscal injuries requiring repair, contralateral knee ligament injury, or concomitant cartilage lesions greater than Outerbridge grade II. Patients requiring meniscal repair were excluded to reduce potential confounding effects of concomitant procedures on clinical outcomes and to ensure a more homogeneous study population. All procedures were performed by the senior author.

The 12-month follow-up was defined as the primary observation period for this retrospective analysis, as complete and consistent longer-term follow-up data were not available for all patients.

Clinical Examination

All patients underwent a standardized clinical examination at baseline (T1) and at follow-up. The mean follow-up period was 12.0 ± 1.6 months, with a minimum of 10 months (T2). The evaluation was based on the International Knee Documentation Committee (IKDC) knee examination form. Instrumental anterior tibial translation was measured quantitatively using a Rolimeter® (Aircast, San Diego, CA, USA), and results were compared with the contralateral uninjured knee. Patient-reported outcome measures included the IKDC subjective score, the Lysholm score, and the Tegner activity scale. These were collected retrospectively for the pre-injury status (T0) and prospectively at 12 months postoperatively (T2). Data were reported as mean, standard deviation, and range. No predefined primary outcome parameter or minimal clinically important difference (MCID) was specified due to the retrospective study design.

Failure was defined as graft rupture, need for revision surgery, or clinically relevant instability requiring surgical intervention.

MRI Evaluation

Preoperative MRI was performed at initial presentation to confirm the indication for primary repair. Follow-up MRI was obtained at a mean of 12.0 ± 1.6 months, shown as an example in Fig. 1. All examinations were conducted by two board-certified radiologists using a standardized protocol on a 3.0-Tesla scanner (Magnetom Trio/Vario, Siemens Medical Solutions, Erlangen, Germany) with a dedicated knee coil. Patients were examined in the supine position with the knee in neutral alignment.

ACL integrity was assessed on sagittal images and defined as a continuous band of hypo- or isointense signal extending from the tibia to the femur without interruption. Interrupted or wavy contours and diffuse high signal intensity within the ACL substance were considered indicative of graft failure. Concomitant meniscal injuries and cartilage defects were also evaluated. Ligament maturity was graded according to the system commonly used in the ACL reconstruction literature, shown in Table 1 [3, 18, 19]. Radiological assessment was not performed in a blinded fashion, and interobserver reliability was not assessed.

Surgical Technique:

Refixation Procedure: The tibial insertion of the ACL was first exposed. Using an ACL tibial guide introduced through the medial portal, a guide pin (2.4 mm) was placed at the center of the tibial footprint via a 1-cm incision medial to the tibial tuberosity and proximal to the pes anserinus. A 4.5-mm cannulated drill was advanced to create the tibial tunnel, stopping once the tibial plateau was breached. A doubled 2 – 0 monofilament suture was then passed through the tibial tunnel and proximal ACL remnant with a suture shuttle (Accu-Pass, Smith & Nephew GmbH, Hamburg, Germany), and the loop was retrieved through the medial portal.

The femoral footprint of the ACL was identified, and an ACL femoral guide was introduced through the medial portal. With the knee flexed to 120°, a 2.4-mm guide pin was positioned in the anatomic center of the footprint and advanced to exit the lateral femoral cortex. A 4.5-mm cannulated drill was then used to create the femoral tunnel.

The ACL remnant was sutured with a nonabsorbable 2 – 0 suture (Ultrabraid, Smith & Nephew GmbH, Hamburg, Germany) using a suture passer (Firstpass Mini, Smith & Nephew GmbH, Hamburg, Germany). Three passes were made 10–12 mm distal to the tear, each approximately 2–4 mm apart, to create a whipstitch configuration. The free ends of the sutures were retrieved through the medial portal. The Ultrabraid sutures and monofilament passing suture were then retrieved together through the medial portal to prevent tissue interposition. The remnant sutures were shuttled through the femoral tunnel using the guide pin and monofilament suture. A continuous-loop EndoButton® (Smith & Nephew GmbH, Hamburg, Germany) loaded with two Ultratapes (Smith & Nephew GmbH, Hamburg, Germany) was advanced through the tibial tunnel into the femoral canal and secured on the lateral femoral cortex (Fig. 2).

For femoral fixation, the remnant sutures were tied to the EndoButton using a knot pusher via a stab incision. For tibial fixation, the Ultratapes were secured to a 4 × 12-mm EndoButton with the knee in near-full extension. Finally, microfracture was performed at the femoral insertion site using a 1.5-mm awl to enhance the biological healing response (Fig. 3).

ACL Reconstruction Technique: The patient's torn ACL was surgically reconstructed utilizing a quadruple semitendinosus/gracilis autograft, and an anatomical single-bundle technique was employed. Following the procedure, an EndoButton® (Smith & Nephew GmbH, Hamburg, Germany) was used for femoral fixation, and a bioabsorbable screw was employed for tibial fixation, based on the diameter of the graft.

Rehabilitation

Postoperative rehabilitation was identical for both groups and followed a standardized protocol. Patients were instructed to wear a knee brace for one week to maintain full leg extension and were permitted 90° of knee flexion for the following five weeks. Partial weight bearing was allowed, and crutches were used for two to three weeks. Closed-chain exercises commenced after one week, and strength, coordination, and endurance exercises were initiated after six weeks. Patients were cleared for return to cutting and competitive activity at least eight months after surgery if they successfully completed a series of functional tests, including strength tests, hop tests, and measurements of movement quality.

Statistical Analysis

All data were collected and analyzed using the SPSS software (Version 26.0) to determine the patients' demographic characteristics and outcomes. A post-hoc power analysis was conducted using G*Power (Version 3.1; Germany) to determine the study's power. Based on the results of the Mann-Whitney U test, an effect size of 0.95 was calculated. With this effect size and a standard deviation of 0.05, a power of 0.82 was calculated. No a priori power calculation was performed due to the retrospective nature of the study.

Table 1
GRADES OF ACL-MATURATION IN MRI

Grade	Maturation of the ACL
Hypointense	the intensity of the repaired ligament was similar to that of the posterior cruciate ligament (PCL) and lower than that of the posterior muscles (i.e., gastrocnemius muscle and semimembranosus).
Isointense	more than 50% of the ligament had the same intensity as the PCL and the intensity was similar to that of the posterior muscles.
Hyperintense	less than 50% of the ligament had the same intensity as the PCL and greater intensity than the posterior muscles.

Table 1

Grade of maturation of the ACL after bracing, similar to how graft maturation is graded in the ACL reconstruction literature (3,18,19).

Results

Patient characteristics: Fifty patients with acute isolated proximal ACL tears were included, with 25 treated using the Ligabrace technique and 25 undergoing ACL reconstruction (ACLR) with hamstring autograft. Baseline demographics were similar between groups (Table 2). The mean age was 29.5 ± 12.2 years in the LGB group and 31.0 ± 12.3 years in the ACLR group (p = 0.662). The sex distribution was balanced (LGB: 9 men, 16 women; ACLR: 11 men, 14 women; p = 0.564). The mean follow-up was 12.0 ± 1.6 months in the LGB group and 12.3 ± 2.1 months in the ACLR group (p = 0.753).

TABLE 2: CLINICAL RESULTS

	LGB	ACLR	p- value
Sex, n	9 M, 16 W	11 M, 14 W	p=.564
Age, mv (SD)	29.52 (± 12.22)	30.96 (± 12.28)	p=.662
Follow-up (Months), mv (SD)	11.96 (± 1.65)	12.32 (± 2.14)	p=.753
T0 (preinjury)			
IKDC Score, mean (SD)	99.26 (± 1.99)	99.36 (± 1.56)	p=.976
Lysholm, mean	100	100	p=1.00
Tegner, mean (SD)	6.52 (± 1.56)	6.60 (± 1.63)	p=.810
T1 (preoperative)			
Rolimeter, mv, mm (SD)	5.16 (± 1.89)	6.12 (± 1.59)	p=.144
IKDC Grade, n	0 A, 0 B, 16 C, 9 D	0 A, 0 B, 15 C, 10 D	p=.771
T2 (follow-up 12.0 months ± 1.6)			
IKDC Score, mean (SD)	87.08 (± 11.25)	84.23 (± 12.38)	p=.420
IKDC Grade, n	24 A, 1 B, 0 C, 0 D	21 A, 4 B, 0 C, 0 D	p=.349
Lysholm, mean (SD)	90.32 (± 7.90)	87.80 (± 12.14)	p=.446
Tegner, mean	6.24 (± 1.69)	5.84 (± 1.68)	p=.532
Rolimeter, mean, mm (SD)	0.56 (± 0.71)	0.64 (± 0.76)	p=.722
MRI ACL Intact/Nonintact, n	25 intact	25 intact	
MRI Intensity of the Signal, n	11 hypointens 11 isointens 3 hyperintens	11 hypointens 10 isointens 4 hyperintens	p=1.00

TABLE 2: *Clinical results preinjury, preoperatively and at the 12-month follow-up (T2) for the two groups (Ligabrace (LGB) and ACL reconstruction (ACLR). The significance level p was determined as a standard deviation (p-value) of 0.05. (LGB, Ligabrace; ACLR, anterior cruciate ligament reconstruction; IKDC, International Knee Documentation Committee; Rolimeter, manual maximum displacement test; mm, millimeter; mv, mean value; SD, standard deviation)*

Patient-reported outcomes: Preinjury activity levels (T0) did not differ significantly between groups (Tegner: LGB 6.5 ± 1.6 vs ACLR 6.6 ± 1.6, p = 0.810). At 12-month follow-up (T2), the mean IKDC

subjective score was 87.1 ± 11.3 (range, 62–100) in the LGB group and 84.2 ± 12.4 (range, 48–99) in the ACLR group (p = 0.420). Lysholm scores were 90.3 ± 7.9 (range, 71–100) and 87.8 ± 12.1 (range, 43–99), respectively (p = 0.446). Tegner activity levels were 6.2 ± 1.7 in the LGB group and 5.8 ± 1.7 in the ACLR group (p = 0.532) (Table 3).

TABLE 3: PROMS 12 MONTHS POSTOPERATIVELY

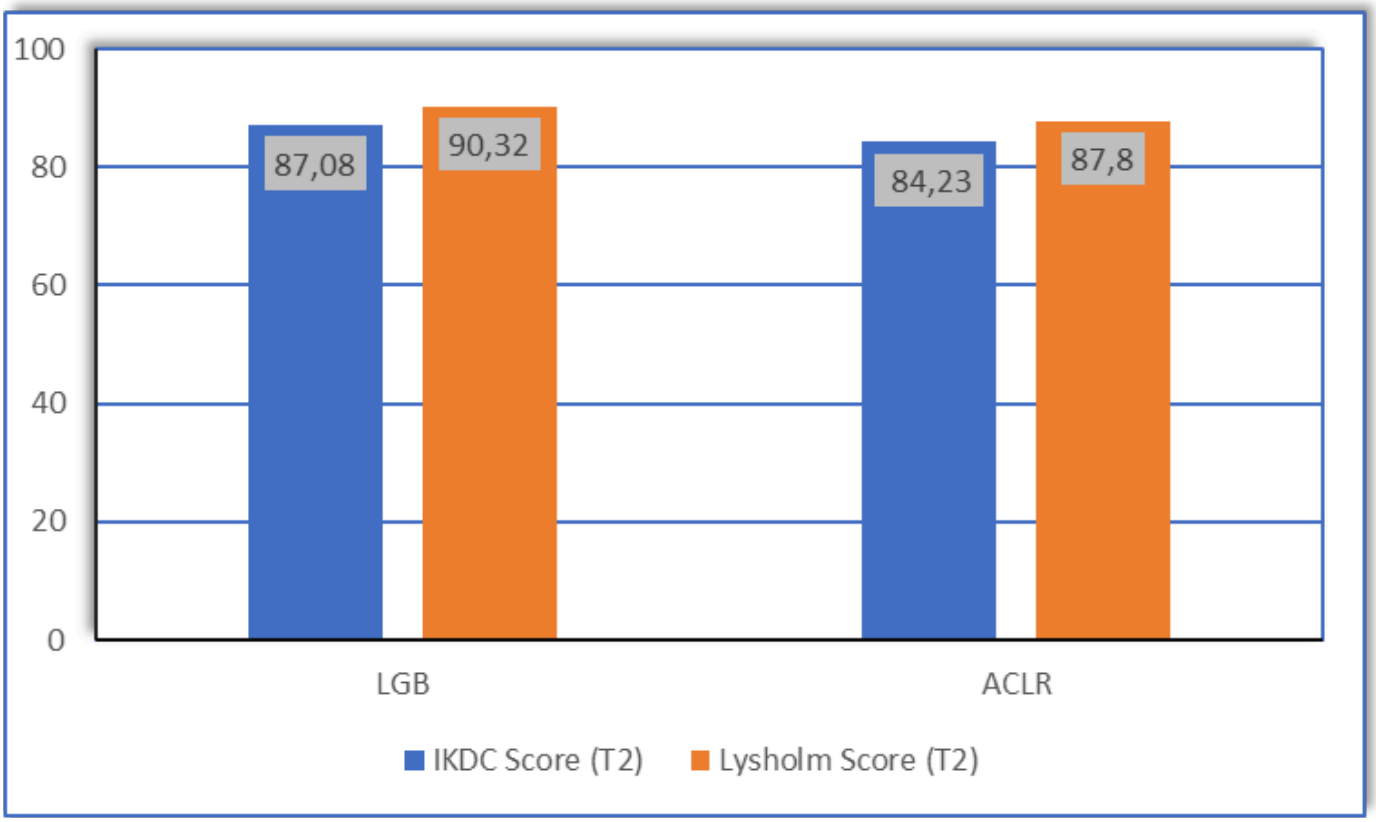


TABLE 3: *IKDC and Lysholm scores at T2 (12 months postoperatively) for the two groups (LGB, Ligabrace group; ACLR, ACL reconstruction group).*

Objective outcomes: At baseline (T1), mean anterior translation measured with the Rolimeter was 5.2 ± 1.9 mm in the LGB group and 6.1 ± 1.6 mm in the ACLR group (p = 0.144). At follow-up (T2), translation decreased to 0.6 ± 0.7 mm and 0.7 ± 0.8 mm, respectively (p = 0.722). No patient demonstrated a side-to-side difference greater than 2 mm at T2. IKDC grades at T2 were distributed as follows: in the LGB group, 24 patients were graded A and one patient B; in the ACLR group, 21 patients were graded A and four B (p = 0.349).

MRI findings: MRI follow-up demonstrated intact ligament continuity in all patients. Signal intensity distribution was comparable between groups. In the LGB group, 44% of ligaments were hypointense, 44% isointense, and 12% hyperintense. In the ACLR group, 44% were hypointense, 40% isointense, and 16% hyperintense (p = 1.0).

Complications: No failures, re-ruptures, or postoperative complications were observed. The reoperation rate was 0% in both groups.

Discussion

The present study demonstrated that the Ligabrace technique, which combines ACL repair with suture tape augmentation and cortical button fixation, yielded comparable short-term results in a selected patient population to ACL reconstruction with hamstring autografts in terms of patient-reported outcomes, clinical stability, and radiological findings at 12 months. Importantly, no failures, reoperations, or complications occurred during the observation period; however, the relatively short follow-up period should be considered when interpreting these findings, as failure rates after ACL repair may increase over time. Subjective outcome measures were comparable between the two groups and consistent with previous reports.

Although ACL reconstruction with autologous tendon grafts is widely considered the gold standard, limitations in clinical outcomes remain [1]. Despite technical and biomechanical advances, patients may experience deficits such as impaired proprioception and donor-site morbidity. These deficits can contribute to persistent alterations in movement patterns and gait mechanics [2, 3]. In recent years, suture tape augmentation has shown promising results. Heusdens et al. reported an 11.4% failure rate at the two-year follow-up, while Jonkergouw et al. observed a similar rate of 10.7%. Both studies focused on proximal avulsion tears treated with internal bracing and femoral fixation using a suture anchor. Successful ACL repair has the potential to overcome two major disadvantages of reconstruction: loss of proprioception due to removal of the native ligament and harvest-site morbidity. In particular, the absence of afferent proprioceptive input after ACL replacement has been linked to altered neuromuscular control of the knee [18, 22]. These insights have rekindled interest in ACL repair, particularly in selected patients with proximal tears.

Several authors have emphasized the importance of tear location and tissue quality in determining suitable candidates for ACL repair [9], a concept originally introduced by Sherman et al. [23]. Historically poor results were likely related to the inclusion of all tear types regardless of morphology or tissue quality, as well as the relatively high surgical morbidity [7]. In contrast, more recent studies limited to proximal ACL tears have demonstrated low reoperation rates and high patient satisfaction at both short- and long-term follow-up [14–16]. In our study, only patients with acute proximal ACL tears (Sherman type I or II) and excellent tissue quality confirmed by preoperative MRI and intraoperative assessment were included. Allocation to treatment was based on intraoperative tissue quality and was therefore not randomized, which introduces a relevant selection bias and limits direct comparability between groups. The average age was similar between groups and fell within the range with the highest incidence of ACL rupture, as previously reported [20]. The female-to-male ratio of 3:2 also reflected the higher incidence of ACL ruptures in women [21].

The use of cortical button fixation in the present technique may offer potential biological and biomechanical advantages. By avoiding intraosseous anchor placement, bone stock is preserved, which may facilitate potential revision procedures. In addition, cortical fixation may allow for stable load sharing between the repaired ligament and the suture tape augmentation, potentially supporting the biological healing process at the femoral insertion site.

However, suture tape augmentation also carries potential risks, including overtensioning of the construct, which may lead to altered knee kinematics or stress shielding of the healing ligament. Careful intraoperative tensioning and standardized surgical technique are therefore essential.

Discrepancies have been reported regarding the time course of graft remodelling on MRI after ACL repair. Ferretti et al. observed normalization of morphology and signal intensity at six months [25], whereas van der List et al. described a gradual sequence with hyperintensity in the first postoperative year, isointensity between one and two years, and hypointensity thereafter [19]. In our cohort, continuity and remodelling were observed at 12 months in both groups. Graft maturation was comparable, with 88% and 84% of repaired ligaments being hypo- or isointense, respectively. Three patients in the repair group and four in the reconstruction group showed hyperintense signals. No significant difference was found between techniques ($p = 1.0$). Furthermore, no evidence of strangulation or abnormal signal patterns was detected in the tibial or femoral portions of the braced ACL, which might have occurred with the whipstitch technique. Radiological assessments were not performed in a blinded fashion, and interobserver reliability was not assessed, which should be considered when interpreting MRI-based findings. It should be also noted that the MRI-based grading system is derived from ACL reconstruction literature and has not been specifically validated for repaired ACLs and should therefore be interpreted as a surrogate parameter. In addition, the presence of synthetic suture tape augmentation may potentially influence MRI signal characteristics and should be considered when interpreting ligament signal intensity and maturation patterns.

Recent systematic reviews have confirmed that ACL repair and reconstruction yield similar results with respect to Lysholm score, IKDC score, side-to-side laxity, pivot-shift grade, and graft rupture rate [21]. Van der List et al. reported mean functional outcomes exceeding 85% of maximum scores and cumulative failure rates of 7–11% across recent ACL repair studies [19]. These findings are in line with the results of the present study, in which both repair and reconstruction groups achieved good to excellent functional outcomes at short-term follow-up, with no observed failures during the study period.

Several individual studies have further explored the role of internal bracing. Mackay et al. [24] evaluated ACL repair with internal brace augmentation and reported a reoperation rate of 6% in 68 patients at one-year follow-up. Achtnich et al. [16] compared primary repair with ACL reconstruction and observed a 15% failure rate and 20% reoperation rate in the repair group, compared with 0% in the reconstruction group, at a mean of 28 months. However, these results should be interpreted in the context of differing follow-up durations, as the mean follow-up in the study by Achtnich et al. was substantially longer, and failure rates may increase over time. Douoguih et al. [17] reported a 14.8% failure rate at a mean follow-up of

2.8 years in patients undergoing ACL repair with suture augmentation. In contrast, the present study demonstrated no failures in either group. This finding should be interpreted with caution given the limited follow-up duration. We hypothesize that strict patient selection—limiting inclusion to isolated proximal tears with excellent tissue quality—together with the use of a small femoral drill hole may have contributed to favourable healing at the femoral avulsion site. This may represent an advantage over anchor-based techniques, which have shown failure rates of approximately 11% after two years [10–12].

In our series, all patients in both groups achieved good to excellent knee function according to the IKDC score at the final follow-up, with restored physiological stability and no significant differences between groups. These findings should be interpreted considering the retrospective study design, the absence of randomization, the limited sample size, and the lack of a predefined primary outcome measure or a priori power calculation. Furthermore, the strict inclusion criteria, including acute proximal tears with excellent tissue quality, limit the generalizability of the findings to a highly selected subgroup of ACL injuries. These results are consistent with systematic reviews showing no major differences between ACL repair and reconstruction in terms of functional outcomes or failure rates [19, 21].

In addition, the described technique may be associated with a learning curve, particularly regarding remnant handling and tensioning of the augmentation construct. Potential cost implications related to specialized implants and materials should also be considered when comparing treatment strategies.

Limitations

This study has several limitations. First, the relatively small sample size may have reduced the ability to detect differences in secondary outcomes or rare events such as graft failure, and the study may therefore be underpowered to detect complications. Second, selection bias may have been introduced, as ACL reconstruction was performed in proximal tears with poor tissue quality, while repair was reserved for tears with excellent tissue quality. Allocation to treatment was based on intraoperative tissue quality and was therefore not randomized, which limits comparability between groups. Nevertheless, this reflects real-world clinical decision-making.

All patients were examined by a single experienced clinician who was aware of group allocation. While this could introduce bias, it also ensured consistency of assessment. Although MRI was assessed by two board-certified radiologists, the possibility of inter- and intra-observer variability cannot be excluded, and radiological assessments were not performed in a blinded fashion.

Furthermore, no predefined primary outcome measure or minimal clinically important difference (MCID) was specified, and no a priori power calculation was performed due to the retrospective study design. Finally, the follow-up of 12 months is relatively short and may not fully capture long-term complications, graft durability, or potential differences in failure rates between techniques. In addition, the strict inclusion criteria limit the generalizability of the findings to a highly selected subgroup of patients with proximal ACL tears.

Return-to-sport data, particularly regarding return to pre-injury level of cutting and pivoting activities, were not consistently available for all patients and were therefore not included in the analysis, which represents a limitation of the present study.

Conclusion

Short-term outcomes of primary ACL repair using suture tape augmentation and cortical button fixation (Ligabrace technique) were comparable to those of standard hamstring tendon ACL reconstruction in a selected patient population. At 12 months, patient-reported scores, objective stability, and MRI findings indicated restoration of knee function; however, these findings should be interpreted with caution given the limited follow-up and study design.

These results suggest that the Ligabrace technique is a feasible treatment option for ligament preservation in carefully selected patients with acute proximal ACL tears. Although limited by its retrospective design, small cohort, and short follow-up, the findings support further investigation. Prospective randomized controlled trials with larger cohorts and longer follow-up are required to determine whether these short-term results can be maintained and to allow for a more robust comparison between treatment strategies.

Abbreviations

ACL	anterior cruciate ligament
ACLR	anterior cruciate ligament reconstruction
AP	anterior-posterior
BMI	Body Mass Index
IKDC	International Knee Documentation Committee
MRI	Magnetic resonance imaging
LGB	Ligabrace
PROMs	Patient Reported Outcome Measures
SD	Standard deviation

Declarations

Ethics approval and consent to participate

This study was approved by the ethical review board of the Medical Association of North Rhine (Ärztekammer Nordrhein). Registration Number: 2018266. Registered 28. September 2018–Retrotively registered.

Informed consent was obtained from all patients and volunteers involved in this study.

Consent for publication: All the patients provided written informed consent to participate in the study.

Data availability: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interest: The authors declare that they have no competing interests

Funding: This study was funded by the Bundesinstitut für Sportwissenschaften (Studynumber 070602/24-27)

Authors Contributions Statement:

All authors fulfil the ICMJE criteria for authorship

All authors have read and agreed to the final version of this manuscript.

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Acknowledgements: Not applicable

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Figures

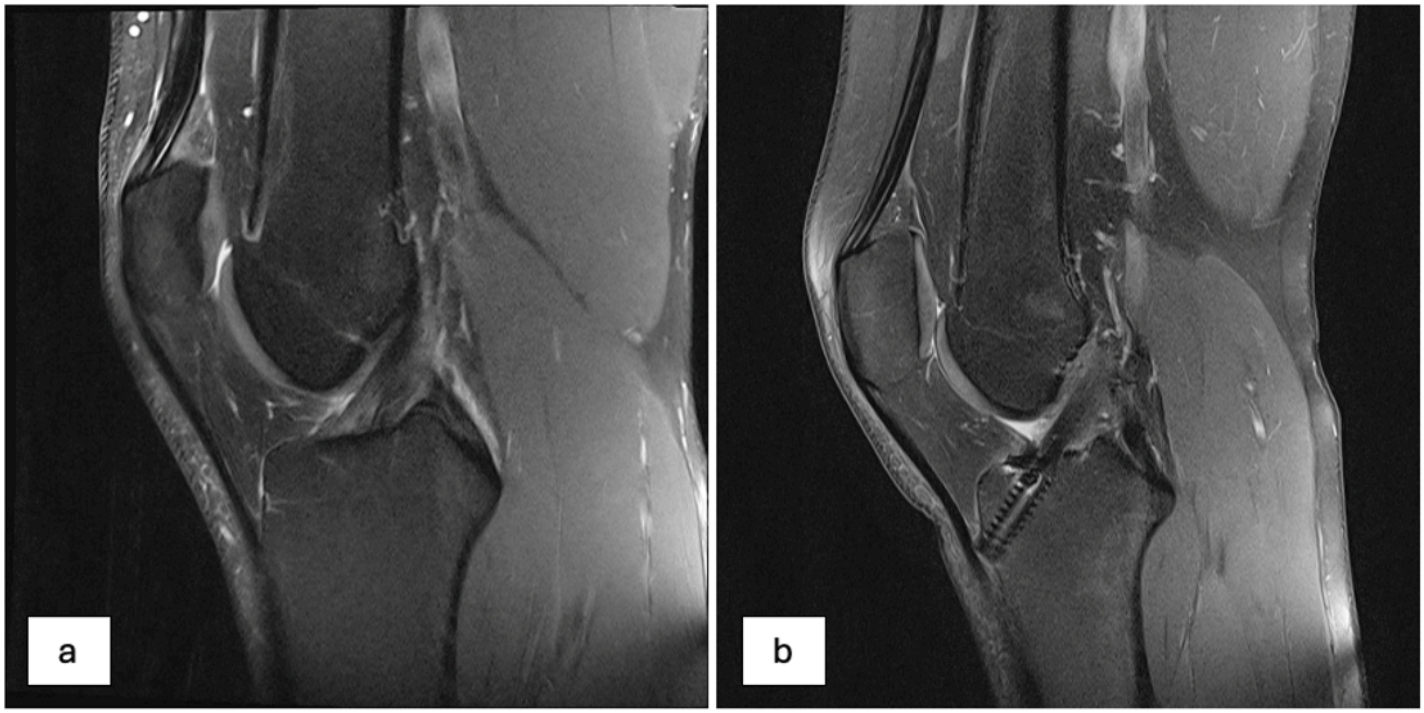


Figure 1

MRI T2-IMAGING 12 MONTHS POSTOPERATIVELY

T2-weighted RI obtained 12 months postoperatively

*a) **Ligabrace Technique**: Sagittal view of the left knee demonstrating an intact, isointense ACL. Tibial Endobutton fixation is visible, and Ultratape (Smith & Nephew GmbH, Hamburg, Germany) is slightly detectable.*

*b) **ACL Reconstruction with hamstring tendons and tibial screw fixation**: Dedicated ACL view demonstrating an intact, isointense ACL with a visible tibial screw.*



Figure 2

POSTOPERATIVE MRI DEMONSTRATING ANATOMIC FEMORAL TUNNEL PLACEMENT

Postoperative sagittal MRI demonstrating the femoral insertion site with an anatomically positioned drill tunnel (*).

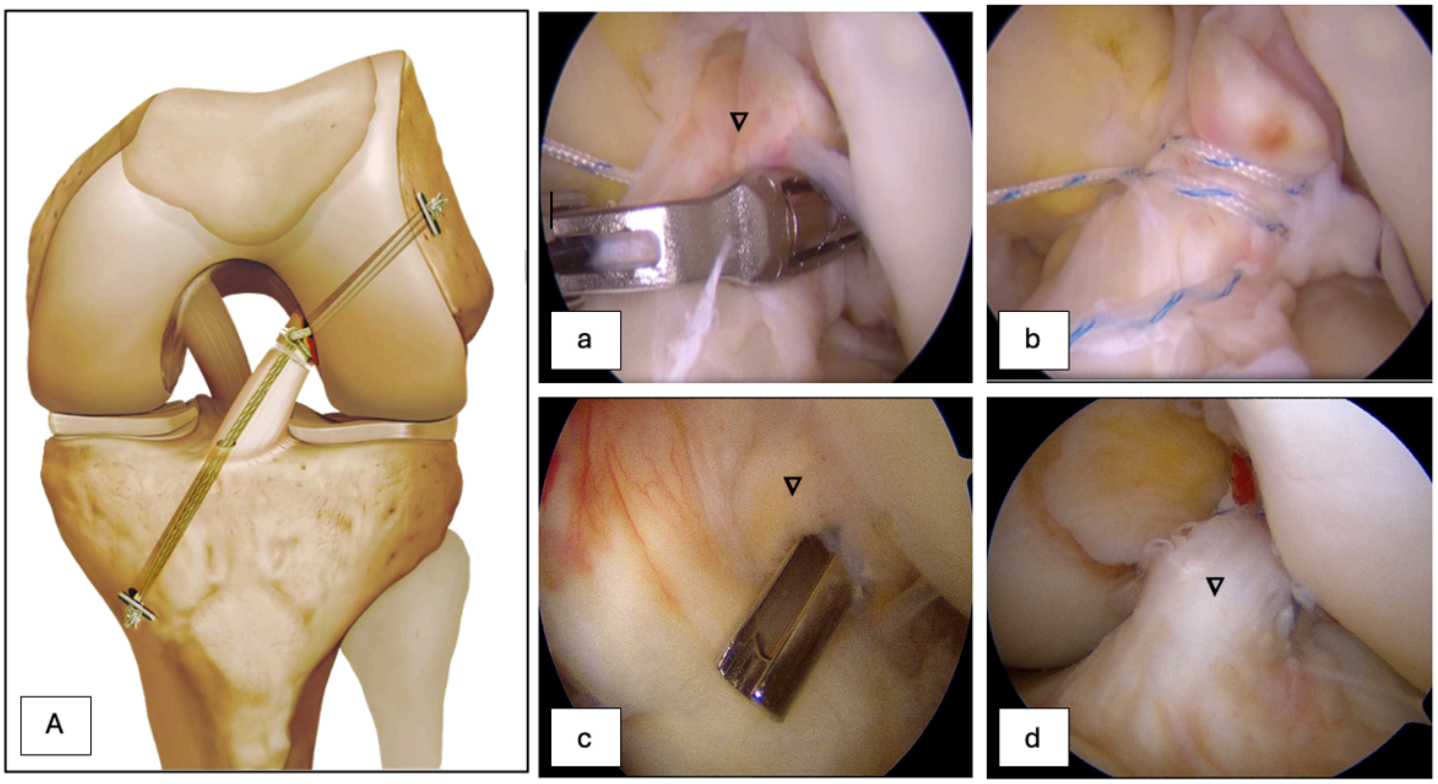


Figure 3

SCHEMATIC PRESENTATION OF THE LIGABRACE TECHNIQUE

Schematic presentation of the Ligabrace technique with tibial and femoral Endobutton (Fa. Smith and Nephew) fixation and an intraligamentous Ultratape brace (A) and ist intraoperative imaging a) A No. 2 Ultrabraid suture (Smith & Nephew GmbH, Hamburg, Germany) is passed through the intact portion of the AC (Ñ) remnant, 6-8 mm to the avulsed end with a Firstpass Mini device (Smith & Nephew GmbH, Hamburg, Germany). The suture is captured and retrieved through the medial portal. b) The passage is repeated with the same end of the Ultrabraid suture 2 mm more distally and again 2 mm more proximally to create a whipstitch-type suture. c) View from the medial portal. Femoral guidewire positioned in the femoral drill hole with the intact ACL remnant. (Ñ) attached femoral ACL remnant; (¬) guidewire inside the femoral drill hole with which the the ultrabraid suture is shuttled through the femoral drill hole. d) After femoral fixation with an Endobutton, the ACL remnant (Ñ) is reattached to the femoral avulsion side