Original article
https://doi.org/10.17816/2311-2905-17562

Primary Repair vs Arthroscopic Reconstruction for Proximal Anterior Cruciate Ligament Tears: A Comparative Study

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Abstract

Background. Anterior cruciate ligament (ACL) reconstruction is the gold standard surgical option for ACL tears. Another treatment method is primary ACL repair. The latter has some limitations such as a small range of indications — proximal tears only. However, they still constitute a significant portion of ACL injuries. Although the primary repair has been known for a long time and is still developing, recent publications show conflicting opinions regarding its application.

The aim of study is to compare functional outcomes of patients who underwent anterior cruciate ligament reconstruction and primary repair.

Methods. In the period from 2020 to 2023, we conducted randomized prospective multicenter control comparative study, which enrolled 170 patients with the ACL tear types A, B, E according to the Gächter classification. The injuries were no older than 3 months. The patients were divided into two groups: Group 1 — primary repair of the ACL, Group 2 — standard technique of the ACL reconstruction with a tendon auto graft. Knee function was assessed before surgery and 3, 6, 12, 24 months postoperatively using the IKDC 2000 and Lysholm Knee Score.

Results. Type E of ACL injury prevailed in the sample. The most common associated injury in both cohorts was medial meniscus tear — 39.3±0.05% and 45.3±0.05% for Group1 and 2, relatively. Chondrolabral defects were observed in 15.5±0.04% of patients with primary repair, and in 10.5±0.03% of patients from the reconstruction group. Pain relief therapy in the form of opioid analgesics received 46.03±0.06% patients in Group 2 and 25.35±0.05% in Group 1 ($p<0.05$). The proportion of patients requiring reoperation for ACL injury in Group 1 was 3.5% and 1.2% in Group 2 ($p>0,05$). Both groups had a statistically significant increase in functional outcomes according to the scales at 3, 6, 12 months ($p<0.05$). The difference in knee function between the groups was not statistically significant ($p>0.05$).

Conclusion. Primary ACL repair still retains a large number of limitations. It cannot and should not replace ACL reconstruction. However, with strict adherence to the indications and surgical technique, primary ACL repair demonstrates comparable functional outcomes.

Keywords: anterior cruciate ligament injury, ACL reconstruction, primary repair, arthroscopy, knee joint instability.

Cite as: Gerasimov S.A., Morozova E.A., Naida D.A., Kolmakov D.O., Zykin A.A., Khramtsova E.V. Primary Repair vs Arthroscopic Reconstruction for Proximal Anterior Cruciate Ligament Tears: A Comparative Study. *Traumatology and Orthopedics of Russia*. 2024;30(4):82-91. (In Russian). https://doi.org/10.17816/2311-2905-17562.

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Submitted: 04.06.2024. Accepted: 19.08.2024. Published Online: 08.11.2024.

Научная статья
УДК 616.728.380007.251-089
https://doi.org/10.17816/2311-2905-17562

Реинсерции или аутопластика передней крестообразной связки при ее проксимальных разрывах: сравнительное исследование

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Реферат

Актуальность. Золотым стандартом восстановления передней крестообразной связки (ПКС) принято считать артроскопическую аутопластику. Иным вариантом лечения является реинсерция. Последняя имеет свои ограничения, в частности выполняется только при проксимальных разрывах, однако они составляют достаточную долю в структуре повреждений ПКС. Несмотря на то, что реинсерция известна давно и развивается с течением времени, в современных публикациях описаны противоречивые мнения о целесообразности ее применения.

Цель исследования — сравнить функциональные результаты лечения пациентов, перенесших артроскопическое восстановление передней крестообразной связки с помощью реинсерции и сухожильной аутопластики.

Материал и методы. С 2020 по 2023 г. в многоцентровое проспективное рандомизированное контролируемое сравнительное исследование было включено 170 пациентов с повреждением ПКС типов A, B, E согласно классификации Gächter и давностью травмы не более 3 мес. В первой группе пациентов выполнялась реинсерция, пациентов второй группы оперировали с применением стандартной техники аутопластики сухожильным трансплантатом. Оценка функционального состояния коленного сустава проводилась в предоперационном периоде, а также в сроки 3, 6, 12, 24 мес. после операции с помощью шкал IKDC 2000 и Lysholm Knee Score.

Результаты. В общей выборке преобладал тип E повреждения ПКС. Наиболее распространенным сопутствующим повреждением смежных структур в обеих группах был разрыв внутреннего мениска — 39,3±0,05% и 45,3±0,05% соответственно. Хондральные дефекты выявлены у 15,5±0,04% в группе реинсерции и у 10,5±0,03% — в группе пластики. В группе пластики обезболивающую терапию в виде сильнодействующих препаратов получали 46,03±0,06% пациентов, в группе реинсерции — 25,35±0,05% (p<0,05). Доля пациентов с необходимостью повторной операции по поводу повреждения ПКС в группе реинсерции составила 3,5%, в группе пластики — 1,2%. В обеих группах выявлен статистически значимый прирост баллов по шкалам до операции и в сроки 3, 6, 12 мес. (p<0,05). Функциональная оценка состояния коленного сустава по шкалам в предоперационном периоде и в контрольные сроки наблюдения в группах были сопоставимы (p>0,05).

Заключение. Реинсерция передней крестообразной связки, являясь одним из методов стабилизации коленного сустава, на сегодняшний день сохраняет большое количество ограничений, не может и не должна заменить сухожильную аутопластику, но при четком соблюдении показаний и техники хирургии демонстрирует сравнимые функциональные результаты.

Ключевые слова: повреждение передней крестообразной связки, аутопластика ПКС, реинсерция, артроскопия, нестабильность коленного сустава.

Для цитирования: Герасимов С.А., Морозова Е.А., Найда Д.А., Колмаков Д.О., Зыкин А.А., Храмцова Е.В. Реинсерции или аутопластика передней крестообразной связки при проксимальных разрывах ПКС: сравнительное исследование. *Травматология и ортопедия России*. 2024;30(4):82-91. https://doi.org/10.17816/2311-2905-17562.

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Рукопись получена: 04.06.2024. Рукопись одобрена: 19.08.2024. Статья опубликована онлайн: 08.11.2024.

INTRODUCTION

Anterior cruciate ligament (ACL) tear is one of the most common injuries of the knee joint [1]. According to registry data, the incidence of ACL injuries varies across different countries: in Scandinavian countries, this figure is approximately 37 people per 100,000 population, while in the United States, it reaches 69 per 100,000 population [2]. Most patients with ACL injuries are young, active people engaged in sports [3]. Based on a systematic review by A.V. Montalvo et al., the prevalence of ACL injuries among male athletes is approximately 2%, while for female athletes, it is 3.5%, with amateur athletes being more prone to such injuries than professionals [4].

Currently, the gold standard for treating ACL tears is arthroscopic reconstruction using an autograft, which restores knee stability, prevents damage to adjacent structures that inevitably occurs with prolonged instability, and slows the joint's degenerative process [5, 6]. This surgical procedure is widely practiced: in Sweden, approximately 4,000 interventions are performed annually [7], in the United Kingdom — more than 2,000 [8], and in Norway — around 2,000 [9]. Reliable data on the prevalence of this procedure in Russia are unavailable due to the absence of a national registry.

Over the past two decades, surgical and graft fixation techniques have been significantly improved, yet some complications and adverse effects remain, such as neuropathy, pain at the graft harvesting site, muscle hypotrophy, and failure of fixation [10, 11, 12]. All these factors influence the overall functional outcome. Moreover, recurrent instability due to ACL graft failure remains a serious issue, with reported rates reaching up to 17%, necessitating careful consideration when choosing between single-stage or two-stage revision reconstruction [13].

Another method for restoring knee joint stability is primary ACL repair, which involves reattaching the ACL stump to its footprint on the femur. This technique dates back to the late 19th century, when A. Mayo-Robson performed an open ACL repair at the proximal attachment site in a 41-year-old male, achieving favorable clinical and functional results after six years of follow-up [14]. With advances in arthroscopic surgery and contemporary understanding of knee anatomy and biomechanics, primary ACL repair has reached a new level of precision and efficacy. However, this procedure has more stringent indications. Some authors recommend performing ACL repair for acute tears within three months of injury, citing the expression of ligament repair factors, whose levels significantly decrease after this period [15]. The most critical limitation, however, is the type of ACL injury — primary repair is only applicable for proximal ACL tears without fiber retraction, where their reposition is possible [16]. Nonetheless, according to some authors, such injuries occur in 15-40% of ACL injury cases [17, 18, 19].

Recent publications present conflicting data regarding the functional outcomes of primary ACL fixation, leading to cautious use of this technique among surgeons [20, 21]. As a result, most physicians prefer reconstruction using autografts for acute proximal ACL tears due to its more extensively studied and predictable nature.

The aim of the study is to compare the functional outcomes of patients who underwent arthroscopic repair of proximal anterior cruciate ligament tears using primary fixation and tendon autografting methods.

METHODS

Study design

A multicenter prospective randomized controlled comparative study is being conducted across three medical centers. Patient enrollment and evaluation of treatment outcomes began in 2020 and is ongoing (Figure 1).

The study included patients who underwent arthroscopic ACL reconstruction.

Inclusion criteria:

– patient age from 16 to 45 years;

– proximal ACL injury without fiber retraction, with possible repositioning according to Gächter types A, B, and E classification [22];

– chondromalacia of one compartment not exceeding grade III according to the Outerbridge classification [23];

– compliant patients available for follow-up and monitoring.

Exclusion criteria:

– patients with chronic ACL rupture (injury duration exceeding 3 months);

– body mass index (BMI) over 35;

– ligamentous injuries of the knee joint in

both limbs;

– concomitant injury to the medial or lateral collateral ligament;

– previous reconstructive operations on the knee ligamentous complex;

– non-compliant patients.

A total of 170 patients met the inclusion criteria and were divided into two groups: the repair group, in which ACL restoration was performed using the primary repair method (84 patients), and the autograft group, treated with tendon autograft reconstruction (86 patients).

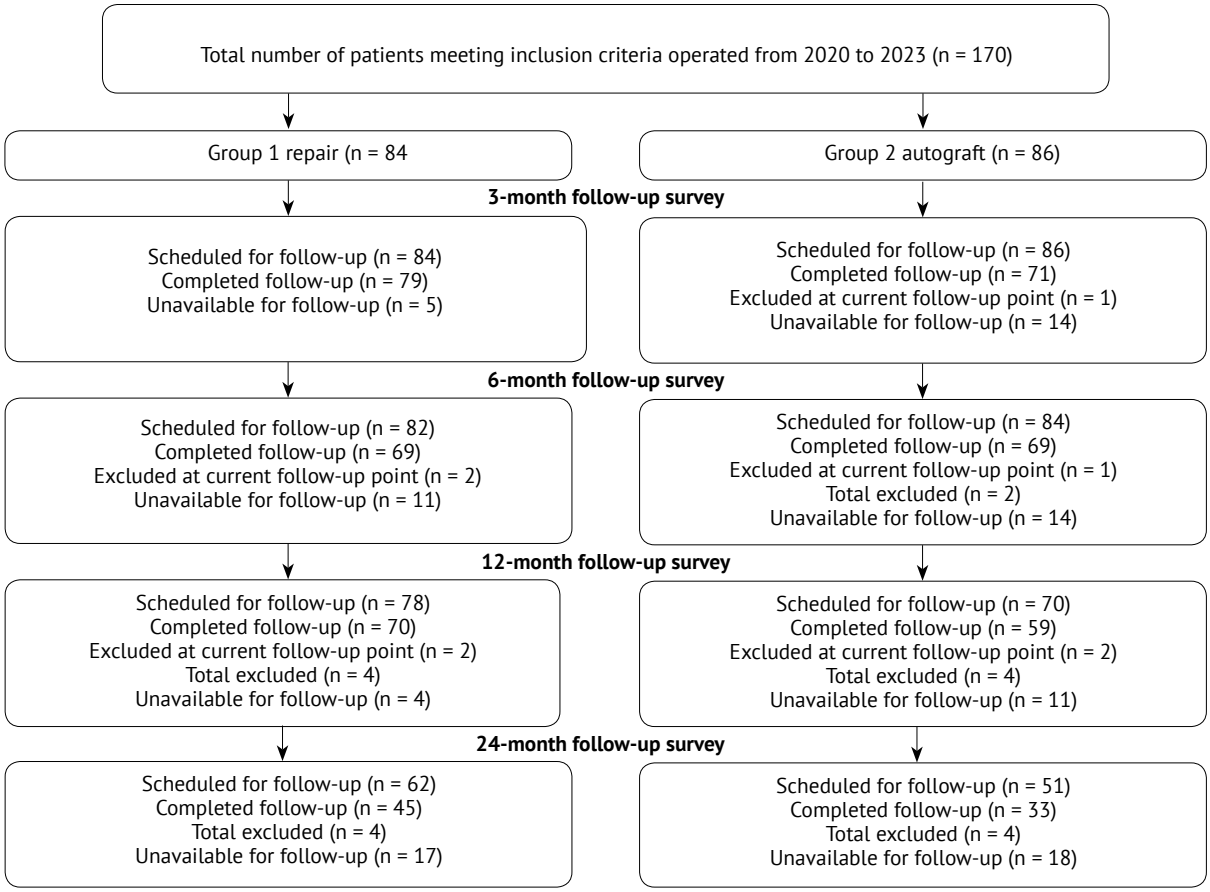

Figure 1. Study design flowchart

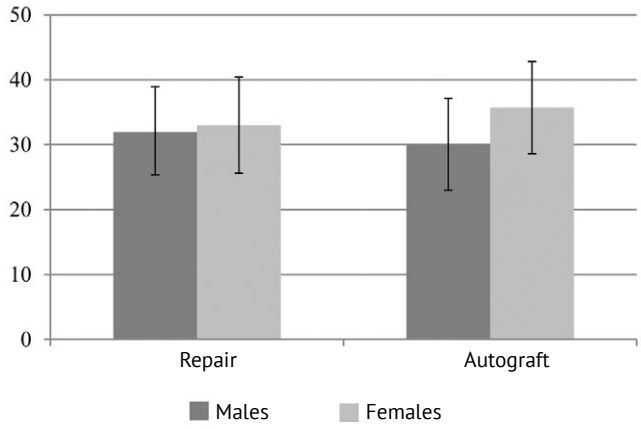

Figure 2. Distribution of patients by age in the groups

Patients

Both groups were predominantly male: in the repair group, 73.8±0.04% (62 patients) were male, while in the autograft group, 80.9±0.04% (67 patients) were male. Women accounted for 26.2±0.04% (22 patients) and 22.1±0.04% (19 patients) in the repair and autograft groups, respectively ($p>0.05$). The groups were also comparable by age ($p>0.05$) (Figure 2).

Clinical evaluation of anterior knee instability before surgery was performed using Lachman and anterior drawer tests. Magnetic resonance imaging (MRI) with a magnetic field strength of at least 1.5 was utilized for visualizing intra-articular knee structures. The final decision on

the feasibility of either surgical method was made intraoperatively following arthroscopic examination of the ACL and confirmation of the injury type's adherence to the study's inclusion criteria (Figure 3).

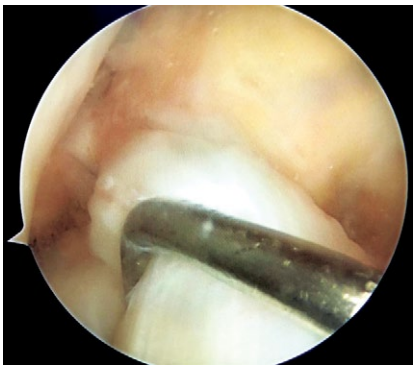

Figure 3. Arthroscopic image of the ACL injury of type A (Gächter classification)

Surgical technique

Arthroscopic primary ACL repair was performed using the technique described by G.S. DiFelice et al. [26], involving stitching of the ACL stump with free sutures, preparation of the footprint area until "pinpoint bleeding" appeared, threading the sutures through an anchor loop, inserting it into a pre-prepared bone tunnel, and final fixation after tensioning the sutures and repositioning the ACL stump at the footprint (Figure 4).

Reconstruction of the ACL with a tendon autograft was carried out using the standard technique, harvesting the semitendinosus and gracilis tendons. Femoral fixation of the graft was achieved using a button with adjustable loop size; tibial fixation was performed with a screw.

Figure 4. Arthroscopic image of the primary ACL repair

Postoperative period

Postoperative recommendations were consistent for all patients and included the use of crutches for 3 weeks, wearing a brace for 4 weeks, and limiting physical activity for 3 months. From the third week, knee flexion in the operated joint was allowed up to 30°, gradually increasing to 90° by the end of the first month.

Assessment methods

A subjective assessment of the kneefunktion was carriedjut preoperatively and at follow-up intervals of 3, 6, 12, and 24 months using IKDC 2000 [24] and Lysholm Knee Score [25] scales, with treatment outcomes assessed via phone interviews.

Dynamic MRI monitoring was not mandatory for all patients due to the wide geographic distribution of patients.

Statistical analysis

Statistical data processing was performed using Statistica v. 13.3 software (TIBCO Software Inc). The data were tested for normality using the Kolmogorov-Smirnov test and quantile-quantile plots. Depending on the distribution, quantitative data are presented as M±SD (M — mean value, SD — standard deviation) or as Me [IQR] (Me — median, IQR — interquartile range). Qualitative data are presented as P±σp (P — percentage, σp — standard deviation of the percentage). The Mann-Whitney U test was used to compare two independent groups with non-normally distributed data. Comparisons of dependent variables with non-normal distributions were conducted using the Wilcoxon signed-rank test. Differences were considered statistically significant at $p<0.05$.

RESULTS

In the repair group, the mean waiting period for surgery after injury was 64.5 [50.0; 74.5] days, while in the autograft group, it was 68.5 [55; 77] days ($p>0.05$). In both groups, the torn ACL was commonly attached to the posterior cruciate ligament, corresponding to type E according to the Gächter classification (Table 1).

Table 1

Patient distribution by the types of ACL injury according to the Gächter classification, *n* (P±σp)

Type of ACL injury	Repair (n = 84)	Autograft (n = 86)
A	34 (40.5±0,05)	30 (34.9±0.05)
B	5 (5.9±0.02)	4 (4.6±0.02)
E	45 (53.6±0.05)	52 (60.5±0.05)

p>0.05.

Patients undergoing ACL reconstruction with a tendon autograft had a longer surgery duration than those having primary repair: 40 [35; 48] vs 33 [25; 45] minutes (p<0.05). Non-absorbable synthetic 2 mm tape (32.2±0.05%) and No. 1 non-absorbable sutures (67.8±0.05%) were used as suturing material for primary repair, with fixation achieved through knotless anchor systems.

ACL reconstruction was consistently performed using semitendinosus and gracilis tendon autografts. The graft diameters were as follows: 33 cases (38.30±0.05%) had a diameter of 7.5 mm; 23 (26.70±0.04%) had 7 mm; 20 (23.20±0.04%) had 8 mm; 5 (5.80±0.02%) had 8.5 mm; 2 (2.30±0.02%) had 6.5 and 9 mm; and 1 (1.20±0.01%) had 6 mm. Seven patients (8.10±0.03%) required additional autograft augmentation with 2 mm Fiber Tape due to insufficient graft diameter: four cases involved 7 mm, while three cases involved 7.5, 6, and 6.5 mm diameters. In all ACL autograft reconstructions, TightRope adjustable button was used for femoral fixation, while either bioabsorbable or polyetheretherketone screws were used for the tibial fixation.

Among the repair group, 51.20±0.05% had concomitant meniscal injuries, compared to 59.30±0.05% in the autograft group (p>0.05) (Table 2). Meniscal resections were most common across both groups. When suturing the meniscus, the all-inside technique predominated (27 cases; 71.10±0.03%), followed by combined all-inside and outside-in (7 cases; 18.40±0.03%) and isolated outside-in technique (4 cases; 10.50±0.02%) (p<0.05) (Table 3).

In addition to concomitant meniscal injuries, each group included patients with chondral defects. In the repair group, their share was 15.50±0.04% (13 patients), while in the autograft group it was 10.50±0.03% (9 patients) (p>0.05).

Approximately half of the patients (46.03±0.06%) who underwent ACL reconstruction received strong analgesic therapy during their hospital stay, compared to only a quarter (25.35±0.05%) in the repair group (p<0.05).

Within two years postop, 6 patients in the repair group experienced re-injuries, presenting with complaints of joint swelling and instability. MRI

Table 2

Assessment of the menisci condition, *n* (P±σp)

Condition of the menisci	Repair (n = 84)	Autograft (n = 86)
Intact	41 (48.80±0.05)	35 (40.70±0.05)
A medial meniscus tear	33 (39.30±0.05)	39 (45.30±0.05)
A lateral meniscus tear	9 (10.70±0.03)	7 (8.20±0.03)
Injury of both menisci	1 (1.20±0.01)	5 (5.80±0.03)

p>0.05.

Table 3

Surgical approach for concomitant meniscal injuries, *n* (P±σp)

Group	Resection	Suture	p
Repair (n = 43)	26 (60.50±0.07%)	17 (39.50±0.07%)	<0.05
Autograft (n = 51)	30 (58.80±0.06%)	21 (41.2±0.06%)	>0.05

confirmed re-injury of the ACL in only 3 of these patients, who subsequently underwent tendon autografting. One patient had a medial meniscus tear requiring resection of the damaged part. In the autograft group, 2 patients experienced re-injuries; one required a repeated intervention due to a meniscal suture failure, leading to resection. The second patient underwent revision reconstruction due to graft damage. Additionally, 2 patients developed complications related to instability of the fixation screw, with one case caused by infection. Therefore, the share of primary repair patients requiring revision operation due to ACL re-injury was 3.50±0.02%, which was 2.5 times higher than in the reconstruction group, where the rate was 1.20±0.01%.

Functional state assessment before surgery and at all follow-up intervals using IKDC 2000 and Lysholm Knee Score questionnaires showed comparable results between groups ($p>0.05$) (Table 4).

Both groups demonstrated a statistically significant increase in IKDC 2000 and Lysholm Knee Score values when comparing preoperative status with outcomes at 3, 6, and 12 months ($p<0.05$). Pain syndrome, evaluated using IKDC 2000 pain subscale, decreased over the observation period in both groups. Scores for IKDC 2000 (pain) before surgery and one year postop showed statistically significant differences ($p<0.05$) in both the repair and the autograft groups.

Table 4

Functional state assessment using questionnaires before surgery and at follow-up intervals after surgery, Me [Q1; Q3]

Group	Interval	IKDC 2000	IKDC 2000 (pain)	Lysholm Knee Score
Repair	Before surgery (n = 84)	46.5 [37.3; 59.2]	5.0 [3.0; 6.0]	53.5 [42.5; 67.5]
	3 months (n = 79)	66.6 [57.5; 76.0]	2.0 [1.0; 4.0]	77.0 [66.0; 88.0]
	6 months (n = 70)	78.1 [65.5; 87.3]	2.0 [0.0; 4.0]	85.0 [74.0; 95.0]
	12 months (n = 70)	85.0 [75.8; 90.8]	1.0 [0.0; 3.0]	90.0 [83.0; 95.0]
	24 months (n = 45)	87.3 [82.7; 91.9]	0 [0.0; 2.0]	91.0 [87.0; 98.0]
Autograft	After surgery (n = 86)	52.0 [39.0; 58.7]	5.0 [3.0; 7.0]	63.0 [45.0; 71.0]
	3 months (n = 71)	67.8 [57.5; 77.0]	2.0 [0.0; 4.0]	76.0 [68.0; 90.0]
	6 months (n = 69)	77.0 [68.9; 84.0]	2.0 [0.0; 4.0]	84.0 [72.0; 93.0]
	12 months (n = 59)	83.9 [72.4; 90.8]	2.0 [0.0; 3.0]	89.0 [79.0; 98.0]
	24 months (n = 33)	90.8 [78.1; 94.2]	0 [0.0; 3.0]	91.0 [83.0; 98.0]

DISCUSSION

The idea of ACL refixation is not new. However, after an initial phase of enthusiasm and popularity for this procedure, the vast majority of surgeons moved away from its use, favoring arthroscopic reconstruction instead. This shift was due to unsatisfactory treatment outcomes. It is important to note that in most of the studies reporting poor results, outdated techniques were used, involving simple suturing of the torn ACL fragments or applying the procedure in cases with poor ligament stump quality or concomitant collateral ligament injuries [19, 21, 26]. With advances in surgical techniques, modern implant fixation systems, and the visualization of intra-articular injuries using improved MRI technology, arthroscopic primary ACL repair has seen a resurgence. Surgeons have since focused on identifying factors that might predict negative treatment outcomes [26, 27].

In our study, we excluded patients whose injury occurred more than 3 months before surgery, as it was traditionally believed that this procedure should be performed as soon as possible post-injury. H.D. Vermeijden et al. analysed outcomes for patients operated on between 15 and 285 days post-injury, finding similar clinical and

functional results at short- and mid-term follow-ups. The authors concluded that the most critical success factors for reinsertion are likely the quality of the remaining ligament fragment and its length, rather than the time elapsed before surgery [28]. Supporting this hypothesis, many researchers have noted that the type of ACL injury plays a crucial role in its refixation prognosis. Proximal tears near the femoral footprint demonstrate the greatest potential for success [26, 28, 29].

In our work, we used the ACL injury classification proposed by A. Gächter, based on arthroscopic findings [22]. According to this system, types A, B, and E injuries can be repaired using either tendon autografts or repair techniques. The literature also describes novel methods for addressing ACL tears in the middle and distal segments, incorporating fibrin clots and collagen matrices combined with various cell technologies, though such studies involve small patient groups [29, 30].

In our study, we limited patient age to 45 years, assuming that older age might affect clinical outcomes. However, G.S. DiFelice et al. reported comparable results in patients aged 17 to 57 years [26].

According to various authors, failure and recurrent instability rates after ACL repair range from 7 to 11%, with primary causes being re-injury and rehabilitation protocol violation [31, 32]. In our current study, these factors led to a 3.5% re-injury rate, slightly lower than the figures reported by foreign colleagues. It is undeniable that the recurrence of instability due to re-injury is typically higher in the repair group compared to tendon autografts [33, 34]. Many researchers affirm this, emphasizing, however, that revision operation in such cases is comparable to primary reconstruction in terms of surgical complexity and functional outcomes. This is not necessarily the case with revisions after ACL tendon autografts, which may require two-stage surgeries, thereby prolonging overall treatment duration and reducing functional outcomes [35, 36].

For many years, ACL reconstruction has been a well-established method for restoring knee stability, consistently delivering predictable and high functional outcomes [37]. However, numerous studies also show excellent functional results with primary ACL repair — exceeding 85% of the maximum scores according to commonly used scales. In our study, we achieved comparable results using IKDC 2000 and Lysholm Knee Score scales at the 12-month follow-up, with median scores of 85.0 [75.8; 90.8] and 90.0 [83.0; 98.0], respectively.

Undoubtedly, the final functional outcome depends not only on the stabilization method but also on the condition and surgical treatment of other knee joint structures, such as meniscus and articular cartilage. Our study groups were comparable in these parameters.

CONCLUSIONS

Primary anterior cruciate ligament repair, as a method for stabilizing the knee joint, still presents numerous limitations and cannot — and should not — replace arthroscopic reconstruction. However, with strict adherence to surgical indications and technique, this method demonstrates comparable functional outcomes and may be recommended for use.

DISCLAIMERS

Author contribution

Gerasimov S.A. — study concept and design, drafting and editing the manuscript.
Morozova E.A. — data acquisition, data analysis and interpretation, drafting the manuscript.
Naida D.A. — study concept and design, drafting the manuscript.
Kolmakov D.O. — study concept and design.
Zykin A.A. — study concept and design.
Khramtsova E.V. — literature search and review.
All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

Funding source. This study was not supported by any external sources of funding.

Disclosure competing interests. The authors declare that they have no competing interests.

Ethics approval. The study was approved by the local ethics committee of Privolzhsky Research Medical University, protocol No 11, 18.02.2020.

Consent for publication. The authors obtained written consent from patients to participate in the study and publish the results.

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