Research Article

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Comparative Analysis of the Results of Lateral Extra-Articular Tenodesis in Anatomical Anterograde Plasty of the Anterior Cruciate Ligament

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AIM OF STUDY To analyze the results of lateral extra-articular tenodesis (LET) of the semitendinosus muscle tendon (STMT) and iliotibial tract (ITT) in patients with severe anterior rotational instability of the knee joint during anatomical anterograde reconstruction of the anterior cruciate ligament (rACL) with a BTB graft.

MATERIAL AND METHODS We studied 138 patients with the Pivot shift test – 3+ and the Lachman test 2+ or 3+ degree after arthroscopic rACL with a BTB autograft. In 65 cases (47.1%) rACL was supplemented with LET of STMT (group 1), the remaining 73 patients (52.9%) – LET of ITT (group 2).

RESULTS According to IKDC-2000, KOSS and Lysholm-Tegner scores, the groups did not differ statistically. However, pain in the LET zone, LET failure with the appearance of the Pivot shift test – 1+, revision reconstructions – were more often observed in group 2 ($p<0.05$). Popliteal hematomas ($p<0.001$), longer operations ($p<0.01$) were more often observed in group 1.

CONCLUSION Lateral extra-articular tenodesis is a clinically effective addition to anatomical anterograde reconstruction of the anterior cruciate ligament with BTB autograft in patients with Pivot shift test 3+ and Lachman test 2+ or 3+. However, a more reliable option is lateral extra-articular tenodesis of the semitendinosus muscle tendon. At the same time, lateral extra-articular tenodesis of the iliotibial tract is a simpler, faster and more cost-effective technique, still demonstrating good indicators of knee joint stability.

Keywords: anterior cruciate ligament, LET, ITT, STMT, anterior instability, rotational instability

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ACL – anterior cruciate ligament
BMI – body mass index
BTB – bone-tendon-bone technique
ITT – iliotibial tract
LCL – lateral collateral ligament
LET – lateral extraarticular tenodesis
rACL – anterior cruciate ligament reconstruction
STMT – semitendinosus muscle tendon

INTRODUCTION

Anterior instability continues to be the most common cause of knee surgery [1]. Ruptures of the anterior cruciate ligament (ACL), the main stabilizer of the knee joint from anterior displacement, often occur in young, active patients interested in sports [2]. Long-term instability of the knee joint leads to its arthrosis [3]. Reconstruction of the ACL (rACL) has become a widespread operation, according to some data reaching 1.5–6.5% of cases among athletes per year [1, 2, 4]. However, even in those cases when rACL is performed taking into account all the anatomical features of the native ACL, the internal rotational stability of the knee joint cannot always satisfy the patient [5–8]. Anterior rotational instability of the knee joint is most often observed in patients after twisting injury, when, in addition to rupture of the ACL, the anterolateral extraarticular capsular-ligamentous structures of the knee joint can be damaged [9, 10].

Lateral extraarticular tenodesis (LET) in combination with anatomical rACL can improve the management of the internal rotational stability of the knee joint, as well as positively influence the survival of the ACL graft itself [9, 11, 12].

Many experts have offered various LET techniques [13]. The most popular for LET are transplants from the tendons of the semitendinosus (STMT) or tender muscles, as well as fragments of the iliotibial tract (ITT) [9, 14]. In the literature, there are studies evaluating the functional effectiveness of complex knee joint stabilization techniques (LET + rACL) in comparison with isolated (including anatomical) rACL; indications and contraindications for such operations have been determined [7, 15]. Technologies of rACL in combination with restoration of anterolateral capsular-ligamentous structures are currently gaining popularity among orthopedic traumatologists around the world [13, 16–19]. At the same time, there is still little information in the literature on the comparative analysis of various LET technologies, including those assessing the reasons for the unsuccessful use of a particular technology [19–21].

Purpose of the study: to carry out a comparative analysis of the results of the use of LET with grafts from STMT and from a non-free ITT flap in patients with severe anterior rotational instability of the knee joint during anatomical antegrade ACL reconstruction and highlight the clinically significant advantages and disadvantages of these techniques.

MATERIAL AND METHODS

The study analyzed the results of surgical treatment of 138 patients who underwent rACL in the period from 2016 to 2020 with a fragment of the central portion of the patellar ligament with bone blocks (bone-tendon-bone, BTB) in combination with LET. The age of the operated patients varied from 19 to 41 years (on average, 29.1 ± 3.4 years). The criteria for enrolling patients in the study were: complete rupture of the ACL, clinically confirmed (Lachman test 2+ or 3+) and intraoperatively, severe rotational instability of the knee joint (pivot-shift test 3+).

Patients with revealed injuries of the posterior cruciate or collateral ligaments of the knee joint, popliteal tendon, extended or deep defects of the intra-articular cartilage (chondromalacia of the 4th degree), and bone injuries were excluded from the study.

Patient complaints, knee function were assessed during a clinical study and using the Lysholm Knee Scoring Scale, KOOS, 2000 IKDC. In terms of radiation diagnostics, radiography of the knee joint was used in standard anteroposterior, lateral and axial projections, magnetic resonance imaging, and, if necessary, computed tomography.

All patients were operated on within 3 to 16 months from the moment of injury.

In 65 cases (47.1%) LET was performed with a graft from the STMT (group 1). 73 patients (52.9%) had a non-free ITT flap (group 2).

The groups were comparable in terms of age, gender, body mass index (BMI) of patients, terms from the moment of injury and its mechanisms, as well as the results of the scales used (Table 1).

Table 1

Characteristics of study groups before surgery

Enrollment criterion	1-я группа (*n*=65)	2-я группа (*n*=73)	*p*
Gender m/f	41/24	47/26	0,524 / 0,5219
Age	32±2,1	31±1,6	0,7329
Body mass index	25,8±0,8	26,5±0,3	0,1678
Mechanism of trauma sport/home	48/17	52/21	0,4977 / 0,4711
Period before operation	14,1±3,5	13,5±2,8	0,8213
Associated cartilage lesions	19	23	0,4868
Associated menisci lesions	48	44	0,2679
2000 *IKDC*	53,6±6,4	54,8±9,1	0,6739
KOSS	48,9±2,9	50,2±2,4	0,2241
Lysholm-Tegner score	57,4±11,4	59,1±10,6	0,7289

ACL reconstruction in both groups was performed taking into account the principles of anatomical positioning of bone canals and graft. A fragment of the central portion of the patellar ligament with bone blocks (BTB) was used as a plastic material. In order for the graft to fix in the femoral canal during its

antegrade passage, the tibial bone block was given a trapezoidal shape. After tension, the graft was fixed in the tibial canal with 1 interference screw.

For LET, in the projection of the lateral condyle of the femur, an additional access was formed about 4.5–5.5 cm long. The femoral canal was also drilled through it, orienting the entry point proximal to the lateral collateral ligament (LCL).

In the 1st group, the STMT prepared for LET was passed through a hole in the bone block of the VTT graft formed from the tibial tuberosity. The hole was formed with a drill with a diameter of 4.5 mm in the anteroposterior direction at the border of its middle and distal thirds. During antegrade placement of such a graft, the tibial bone block, together with the STMT, was fixed in the femoral canal. After fixation of the ACL graft in the tibial canal, the free ends of the STMT were inserted under the LCL and pulled through an additional through canal in the area of the Gerdy tubercle and fixed with ligatures to each other in the form of a closed loop (Fig. 1).

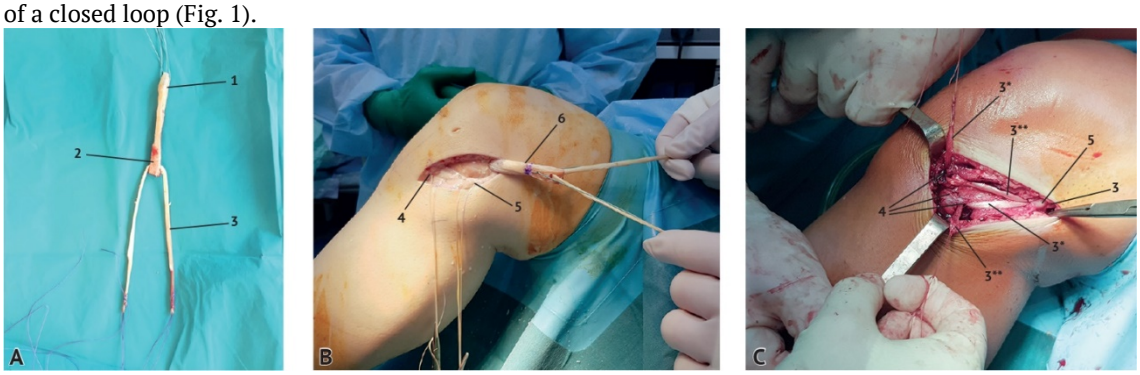
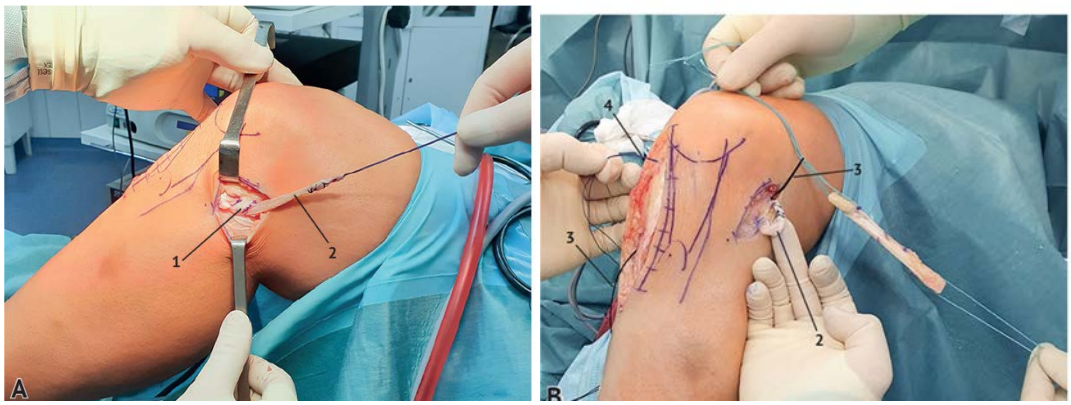


Fig. 1. Stages of the operation in patients of the 1st group: A — appearance of the combined BTB graft and the semitendinosus muscle tendon; B — anterograde introduction of the combined graft; C — introduction of free ends of the semitendinosus muscle tendon graft under the lateral collateral ligament and in the bony canal of the lateral condyle of the tibia. 1 — bone block of the patella of the BTB graft; 2 — bone block of the tibia of the BTB-graft; 3 — the tendon of the semitendinosus muscle, passed through the hole in the tibial bone block of the BTB graft; 3* — part of the tendon of the semitendinosus muscle, the end of which is brought out through the upper opening of the canal in the tibia; 3** — part of the tendon of the semitendinosus muscle, the end of which is brought out through the lower opening of the canal in the tibia; 4 — holes and anterior surface of the wall of the channel in the tibia, located in the projection of the Gerdy's tubercle; 5 — lateral collateral ligament; 6 — combined BTB graft and semitendinosus tendon

In group 2, a non-free fragment of the fascia lata of the thigh, about 1 cm wide and about 8–9 cm long, was used for LET while retaining its attachment site on the tibia. For the convenience of reconstruction, this graft was inserted into the femoral canal first, then the BTB graft was inserted, and the LET graft was fixed with a wedging trapezoidal bone block (Fig. 2). In both groups, LET grafts were stretched in the position of 30 ° flexion and neutral rotation in the knee joint.



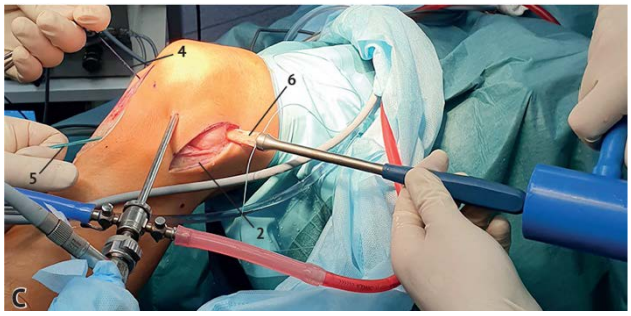


Fig. 2. Stages of surgery in patients of group 2: A — introduction a graft for lateral extra-articular tenodesis from the iliotibial tract (ITT) under the lateral collateral ligament; B — sequential anterograde introduction of grafts from ITT and BTB through the femoral canal; C — impaction fixation of ITT and BTB grafts in the femoral canal. 1 — lateral collateral ligament; 2 — non-free flap of ITT; 3 — conducting thread for the guiding thread of the BTB graft; 4 — guiding thread which is used for sewing the end of the non-free flap from the iliotibial tract; 5 — guiding thread for BTB-graft; 6 — tibial bone block of BTB-graft

The postoperative period, rehabilitation measures in both groups of patients were carried out in the same way as after isolated autoplasty of the ACL. The period of inpatient treatment for each group was 3.7 ± 2.4 days and 4.1 ± 1.6 days, and the period of rehabilitation treatment was 6.3 ± 1.3 months and 6.7 ± 0.9 months, respectively.

The observation period was 2 years, examinations were carried out every 3–3.5 months.

In addition to the condition of the knee joint, the duration of the operation, the duration of inpatient treatment, disability, and the regimen of returning to sports activity were studied.

Statistical processing was performed using the Statistical Package for the Social Sciences (SPSS), version 22 (SPSS Inc., USA). The descriptive statistics method was used for the general characteristics of the studied parameters. The test parameters in each sample for normal distribution were checked using the Kolmogorov – Smirnov test. To assess the statistical significance of the differences in the mean values of the analyzed parameters in the patients of the studied groups, the t-test for independent samples was used (in connection with the normal distribution of the studied parameters). Differences were considered statistically significant at two-sided $p < 0.05$. The results are presented as M ± m, where M is the mean, m is the standard deviation.

RESULTS

In the 1st group, the operation was performed on average after 14.1 months, and in the patients of the 2nd group - 13.5 months after the injury.

Signs of infectious inflammation inside the joint or in the area of postoperative wounds were not observed in any of the patients, and X-ray changes correlated with the results of clinical examinations.

The functional state of the knee joint according to integral scales turned out to be better in patients with LET STMT, although the difference in comparison with group 2 was not significant. In addition, in the 2nd group, muscle hernias were more often observed (4 (5.5%) and 1 case (1.5%)), and pain in the area of the BTB graft collection (3 (4.1%) and 2 cases (3.1%)), however, according to these criteria, the groups did not differ statistically from each other (Table 2).

Table 2

Characteristics of groups 2 years after surgery

Criterion for assessment	Group 1 (*n*=65)		Group 2 (*n*=73)		*p*
	n	%	*n*	%	
Pain in the LET area, %	2	3,1	11	15,1	<0,05
Popliteal hematoma %	16	24,6	0	0	<0,001
Muscular hernia in the LET area, %	1	1,5	4	5,5	0,2349
LET failure, %	1	1,5	11	15,1	<0,05
Pivot shift-test 1+ , %	0		6	8,2	<0,05
Pivot shift-test 2+ , %	1	1,5	5	6,8	0,1481
Pain in the knee joint, %	2	3,1	3	4,1	0,5597

Duration of surgery, min	115,6±8,1		81,2±8,4		<0,01
Revision rACL, %	1	1,5	8	11,0	<0,05
Revision LET, %	1	1,5	7	9,6	0,0567
2000 *IKDC*, mean	86,7±9,4		84,5±11,2		0,5267
KOSS, mean	89,1±5,1		87,8±7,5		0,6157
Lysholm-Tegner score, mean	87,9±6,3		86,1±4,8		0,4842

Notes: LET— lateral extra-articular tenodesis; rACL — anterior cruciate ligament reconstruction

13 patients (9.4%) complained of pain in the LET area, and more often this condition was observed in group 2 (11 (15.1%) and 2 (3.1%), respectively, p <0.05). At the same time, in the early postoperative period, 16 patients (24.6%) of the 1st group had extensive hematomas of the popliteal region, the posterior surface of the thigh and lower leg (p <0.001), which regressed within 12 to 21 days after topical application of anticoagulant ointments. In 11 patients (15.1%) of the 2nd group, signs of LET failure were determined after surgery (p <0.05). Clinically, rotational instability of the knee joint in the form of Pivot shift test 1+ was diagnosed in 6 patients (8.2%), and Pivot shift test 2+ - in 5 (6.8%). In 8 patients (11.0%) of the 2nd group and in 1 patient (1.5%) of the 1st group, revision plasty of the ACL with an BTB graft was performed, and in 7 patients (9.6%) of the 2nd group, simultaneously performed revision LET from STMT (p <0.05). Plastic material for these operations was taken from the contralateral limb.

At the same time, the time spent on the operation was statistically significantly different in the groups (115.6 ± 8.1 min, and 81.2 ± 8.4 min, respectively). This indicator singled out group 2 for the better (p <0.01).

It should be noted that statistically significant differences between the groups began to appear after 11 months or more after the operation, except for the LET failure indicator, which became noticeable in patients 5 months after the operation.

DISCUSSION

Persistent rotational instability after rACL is the most common cause of patient dissatisfaction with the results of surgery [5]. Even the technologies of anatomical rACL cannot always provide effective antero-internal rotational stability of the knee joint [3, 8]. LET is used as an additional factor that increases the efficiency of rACL and increases the stability of the knee joint [3, 10, 18]. Currently, many technologies have been offered for simultaneous rACL and LET [11, 17]. But in the modern literature, you can find a small number of articles comparing various LET techniques with each other and describing the complications associated with them.

In our study, in 13 people (9.4%), we observed pain syndrome in the area where LET was performed. The largest number of these patients belonged to the 2nd group of the study (p <0.05). In our opinion, there can be two reasons for this condition: 1) according to the operation technology, tension and fixation of LET from ITT in the femoral canal is performed before fixation of the ACL graft, and the absence of an intra-articular stabilizer can lead to some valgus overload and an increase in pressure on the lateral parts of the joint; 2) suturing of the fascia defect, especially if the graft was of significant size, can lead to excessive tension on the ITT. C. Batailler et al. (2018), studying patients after KJL2 (LET according to the technique described by Kennet Jones, using a fragment of ITT) and KJG (LET according to the technique described by Kennet Jones, using m. gracilis) reconstructions, noted that the pain syndrome in each of the groups was the same, appeared in 14.6% of patients and had no statistical difference [21]. In turn, Zafagnini et al. no statistical difference [21]. In turn, Zafagnini et al. noted pain in the LET zone after simultaneous intra- and extra-articular reconstruction in 12% of patients [14].

We observed LET failure only in 11 patients of group 2, which amounted to 15.1%. They showed an increase in anteroposterior rotation (Pivot shift tests 1+ and 2+) while maintaining anteroposterior stability of the knee joint. At the same time, repeated injury of the knee joint after surgery was the cause of such failure in only 4 of them (36.4%). In our opinion, this suggests that the rigidity of the LET ITT graft fixation is not always high and, under certain conditions, the flap can slip between the canal wall and the bone block of the BTB graft. Therefore, a sufficient part of the LET graft fragment should be located inside the femoral canal (at least 2 cm). The reason for the failure of LET from the STMT (1 (1.5%)) was the breaking of the lateral wall of the through canal formed in the region of the Gerdy tubercle. The failure of LET is also described by other specialists [22].

Postoperative hematomas were observed in both groups, however, in the popliteal region, they were more common among patients in group 1. We directly associate this condition with the collection of the STMT as a graft for LET. According to Grassi et al., This complication is observed in 1.9% of patients when the tendons of the semitendinosus and tender muscles are used as plastic material for ACL reconstruction [23].

The frequency of revision interventions in our study was 6.5%. According to a number of authors, reoperations in patients with rACL and LET have to be performed in 8.4–10.0% of patients [14, 16]. It should be noted that in our study most of the patients were under observation in the 2nd group. C. Batailler et al. (2018) showed that patients who underwent rACL simultaneously with LET from a fragment of the fascia lata of the thigh ($p < 0.05$) were less likely to need repeated surgeries [21].

In our study, this indicator was statistically insignificant, but was more often observed in patients of the 2nd group 1 (1.5%) and 7 (9.6%), respectively. In our opinion, this is due to the fact that LET from STMT has a larger size than the same graft from the tendon of the tender muscle. In addition, 2 graft bundles have a large overlapping area and, accordingly, allow better distribution of the stress load during internal rotation of the tibia than 1 fragment from the fascia lata graft.

Studying the time of performing the surgical intervention, we noted that the operations in patients of the 1st group turned out to be more time-consuming, since the LET technique from the STMT is more laborious and has a greater number of stages ($p < 0.01$). We have not met the study of this criterion in the world literature, although this factor is important in calculating the economic efficiency and choosing the indications for a particular LET option in patients with different sports activity.

CONCLUSION

As a result of the study, the following results were obtained.

The functional state of the knee joint for the examined patients in the selected groups turned out to be statistically insignificant, but nevertheless there was a tendency for higher indices in patients of the 1st group.

1. Pain syndrome after surgery was more significant in patients of the 2nd group.
2. Signs of failure of lateral extraarticular tenodesis were more often detected in patients of the 2nd group.
3. Among the complications in the 1st group, the formation of hematomas of the popliteal region and the thigh region was noted.
4. In group 2, muscle hernias were observed at the site of flap formation from the iliotibial tract.
5. The duration of the operation in the 1st group was statistically significantly longer.

FINDINGS

1. Reconstruction of the anterior cruciate ligament and lateral extra-articular tenodesis from the tendon of the semitendinosus muscle is often accompanied by subcutaneous hematomas of the popliteal region (16 cases (24.6%), $p < 0.001$), but this is a more effective method for restoring the anterior-internal rotational stability of the leg (in 64 cases (98.5%) studies, $p < 0.05$) than lateral extraarticular tenodesis from the iliotibial tract with the same technique of antegrade anatomical reconstruction of the anterior cruciate ligament with a graft from the patellar ligament.

2. Despite the fact that pain in the area of the external part of the knee joint in the early postoperative period is more common in patients after lateral extraarticular tenodesis from the iliotibial tract ($p < 0.05$), in 9.4% of cases, according to our study, it completely regresses by the end of the first year after surgery.

3. In a comparative aspect, the lateral extraarticular tenodesis from the semitendinosus tendon turned out to be more reliable ($p < 0.05$). In patients of this group, revision interventions were required only in 1.5% of cases ($p < 0.05$).

4. At the same time, lateral extraarticular tenodesis with a graft from the iliotibial tract has a number of advantages associated with a simpler, faster (81.2 ± 8.4 minutes) and economically more profitable technique ($p < 0.01$), characterized by the absence of hematoma of the popliteal region and demonstrates good knee joint stability.

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