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Mid-term Results of a Single-Stage Revision Anterior Cruciate Ligament Reconstruction: A Retrospective Analysis of 36 Cases

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Abstract

Background. Revision anterior cruciate ligament reconstruction is becoming more and more common in the knee surgery due to the annual increase in the number of primary anterior cruciate ligament reconstructions. Choosing the most suitable graft and determining the staging of the surgical treatment by preoperative assessment of the possibility of performing the most anatomical revision canals and their interposition with the primary canals are the main factors that influence treatment results.

Aim of the study — comparative assessment of the results of using hamstring tendon and peroneus longus tendon autografts in a one-stage revision reconstruction of the anterior cruciate ligament.

Methods. A retrospective analysis of the medical records of 36 patients who underwent revision anterior cruciate ligament reconstruction was performed. The patients were divided into two groups: in the patients of the study group (n = 19) a peroneus longus tendon (PLT) autograft was used, in the comparison group (n = 17) a hamstring tendon autograft (HT) was applied. Subjective and objective evaluation using the KOOS, IKDC, and Lysholm scales was performed, and also position of the central entry points of the primary and revision canals was determined. There were no statistically significant differences in the objective assessment of the knee joint stability. Significantly better results of subjective assessment of the knee function according to the Lysholm and KOOS scales were obtained in the PLT group ($p = 0.042$ and $p<0.001$, respectively). Position of revision canals corresponded to the standard values, but position of the femoral canal had a slight cranial and anterior displacement. It was also found that the PLT graft diameter was statistically significantly larger than the HT graft diameter ($p<0.001$).

Results. There were no statistically significant differences in the objective assessment of the knee stability. Significantly better results of subjective assessment of the knee function according to the Lysholm and KOOS scales were obtained in the PLT group ($p = 0.042$ and $p<0.001$, respectively). Position of revision canals corresponded to the standard values, but position of the femoral canal had a slight cranial and anterior displacement. It was also found that the PLT graft diameter was statistically significantly larger than the HT graft diameter ($p<0.001$).

Conclusions. One-stage revision anterior cruciate ligament reconstruction is a safe and effective surgical procedure providing satisfactory objective and subjective clinical results. Use of peroneus longus tendon autograft allows to obtain better results in comparison with the hamstring tendon autograft.

Keywords: knee joint, anterior cruciate ligament, revision anterior cruciate ligament reconstruction, arthroscopy.

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Среднесрочные результаты одноэтапной ревизионной реконструкции передней крестообразной связки: ретроспективный анализ 36 случаев

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Реферат

Актуальность. Ревизионная реконструкция передней крестообразной связки становится все более распространенным оперативным вмешательством на коленном суставе ввиду ежегодного увеличения количества выполненных ее первичных реконструкций. Выбор оптимального трансплантата и определение этапности хирургического лечения с помощью предоперационной оценки возможности проведения максимально анатомичных ревизионных каналов и их взаиморасположения с первичными каналами являются основными факторами, которые влияют на результаты лечения.

Цель исследования — сравнительная оценка результатов применения аутотрансплантатов из сухожилий подколенных сгибателей голени и длинной малоберцовой мышцы при одноэтапной ревизионной реконструкции передней крестообразной связки.

Материал и методы. Проведен ретроспективный анализ медицинской документации 36 пациентов, которым была выполнена ревизионная реконструкция передней крестообразной связки. Пациенты были разделены на две группы: у пациентов группы исследования (n = 19) использовался аутотрансплантат из сухожилия длинной малоберцовой мышцы (PLT), в группе сравнения (n = 17) — трансплантат из сухожилий подколенных сгибателей голени (HT). Проводилась субъективная и объективная оценка по шкалам KOOS, IKDC и Lysholm, а также определялось положение центральных точек входа в первичные и ревизионные каналы.

Результаты. Статистически значимых различий при объективной оценке стабильности коленного сустава не выявлено. Лучшие результаты субъективной оценки функции КС по шкалам Lysholm и KOOS получены в группе PLT (p = 0,042 и p<0,001 соответственно). Положение ревизионных каналов соответствовало нормативным значениям, однако положение бедренного канала имело незначительное смещение краниально и кпереди. Также выявлено, что диаметр трансплантата PLT оказался статистически значимо больше значений диаметра трансплантата HT (p<0,001).

Заключение. Одноэтапная ревизионная реконструкция передней крестообразной связки является безопасным и эффективным оперативным вмешательством, обеспечивающим удовлетворительные объективные и субъективные клинические результаты. Применение аутотрансплантата из сухожилия длинной малоберцовой мышцы позволяет получить лучшие результаты по сравнению с трансплантатом из сухожилий подколенных сгибателей голени.

Ключевые слова: коленный сустав, передняя крестообразная связка, ревизионная реконструкция передней крестообразной связки, артроскопия.

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BACKGROUND

Arthroscopic anterior cruciate ligament (ACL) reconstruction is one of the most common surgical interventions on the knee. The number of these surgeries is increasing annually due to the promotion of an active lifestyle among the population and the growing number of experienced surgeons able to perform this type of intervention. Modern surgical techniques allow to achieve good results in most cases, however, according to the scientific literature, the share of unsatisfactory outcomes of primary ACL reconstruction ranges from 5 to 20% [1, 2]. Accordingly, revision ACL reconstructions are becoming more and more common.

The complexity of revision surgery is determined by certain factors that directly or indirectly influence the treatment outcome. One of the most significant is the preoperative assessment of the possibility to form the most anatomical revision tunnels taking into account the position and the size of the primary tunnels and determining the stages of surgical treatment [3, 4, 5]. The choice of the optimal graft, the method of its preparation and fixation are also one of the underlying factors that influence the outcomes of revision surgery. It is known that autografts have advantages over the synthetic ones [6] or allografts [7, 8, 9], but in some situations, the use of the latter allows to solve non-standard problems arising when performing revision intervention [10].

Additional positive influence on the outcomes of revision ACL reconstructions is achieved by simultaneous extraarticular interventions — lateral extraarticular tenodesis [11, 12] and correction of excessive anterior tibial plateau inclination angle in the sagittal plane [13, 14]. However, these interventions increase the level of surgical aggression and the risk of various types of complications, therefore, they should be performed for strict indications and not universally.

Thus, the results of revision ACL reconstruction depend on many aspects, including graft selection, and the lack of a common opinion on this issue was the reason for performing a study to identify and confirm those or other significant factors affecting the outcome of surgical treatment.

Aim of the study is to perform a comparative assessment of the results of using hamstring tendon and peroneus longus tendon autografts in a one-stage revision reconstruction of the anterior cruciate ligament.

METHODS

Study design

This is a retrospective cohort comparative single-center non-randomized study. A retrospective analysis of medical records of 43 patients who underwent revision ACL reconstruction at Novosibirsk Research Institute of Traumatology and Orthopedics n.a. Ya.L. Tsivyan in the period from 2016 to 2019 was performed.

Inclusion criteria: a completed case of a one-stage revision ACL reconstruction performed during the reviewed period.

Non-inclusion criteria: multiligamentous knee injury, 2-3 stage of knee osteoarthritis, severe axial deformity of the knee, severe somatic pathology, repeated revision interventions.

Exclusion criteria: two-stage revision, contralateral knee injury, no contact with the patient.

Taking into account the inclusion, non-inclusion, and exclusion criteria, we analyzed 36 completed cases (Fig. 1). Patients were divided into two groups according to the type of tendon autograft used: patients in the PLT study group (n = 19) — a peroneus longus tendon (PLT) autograft was used, while in the HT comparison group (n = 17) — a hamstring tendon (HT) graft was used.

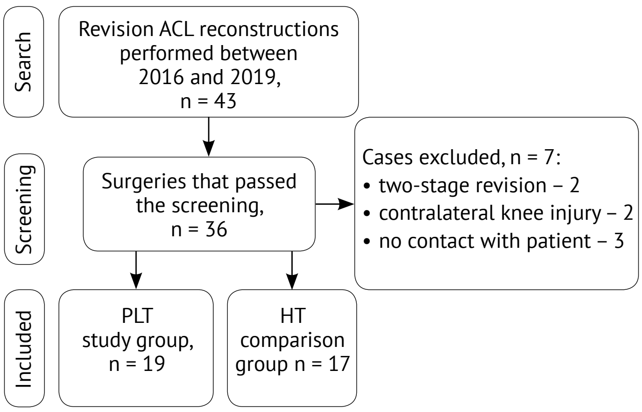

Fig. 1. Flowchart of the study design

Methods of outcome assessment

The patients were evaluated using specialized scoring systems for assessing knee function — the IKDC 2000, Lysholm and KOOS questionnaires. To assess the stability of the knee in both groups, physical examination according to the IKDC 2000 protocol (Lachman and pivot-shift tests) was performed before surgery and 12 months after the operation. In the PLT group, the functional state of the ankle joint was assessed using the AOFAS scale before and 12 months after surgery.

MSCT scans were evaluated before and after the surgical intervention. Diameter and position of the central entry points of the primary and revision bone tunnels were determined. The method of anatomical coordinate axes was used for the tibial tunnel and was calculated as a percentage (Fig. 2). The method described by M. Bernard et al. [15] was used to estimate the femoral tunnel entry points (Fig. 3). The standard coordinate values of the positions of the entry points into the bone tunnels were taken as the values corresponding to the well-known data on the topography of the attachment point of the native ACL to the tibia and femur [16].

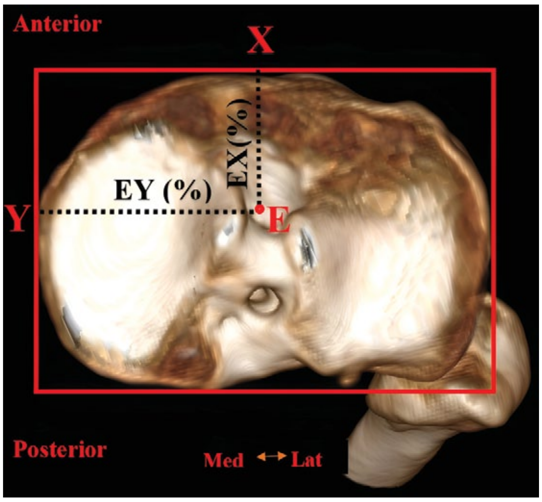

Fig. 2. Position of the central attachment point of the native ACL on the tibia (E);
Y — line drawn through the most prominent point of the medial edge of the tibial plateau;
X — line drawn through the extreme point of the anterior edge of the tibial plateau, perpendicular to the line Y;
EX — distance from the anterior edge of the tibial plateau (43.8%);
EY — distance from the medial edge of the tibial plateau (48.9%)

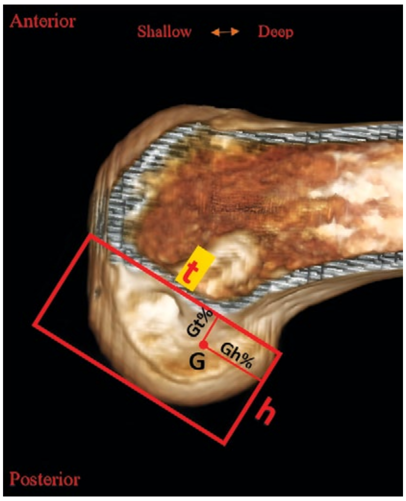

Fig. 3. Position of the central attachment point of the native ACL on the femur:
t — line corresponding to the Blumensaat's line;
h — line passing through the extreme point of the posterior edge of the lateral femoral condyle, perpendicular to the line t;
Gh (%) — distance from the deepest point of the medial edge of the lateral femoral condyle (29.9%);
Gt (%) — distance from the Blumensaat's line (30.1%)

When analyzing intraoperative data, the diameter of the revision graft, complications, and duration of surgical intervention were assessed.

Statistical analysis

Descriptive statistics of continuous variables were calculated as: median (Me) [first quartile Q1; third quartile Q3], mean ± standard deviation (M±SD), minimum-maximum values. For binary variables, the number of events, their frequency, and 95% confidence interval (95% CI) of frequency were determined using Wilson's formula. Comparisons of continuous variables between groups were performed by the Mann-Whitney U-test. The Spearman correlation coefficients were calculated to determine the strength of correlation between continuous variables. Binary variables were compared by Fisher's exact test. Differences between binary variables were assessed by calculating the odds ratio with 95% CI. Only two-tailed tests were used. The Benjamini-Hochbreg correction was applied in case of multiple comparisons. Statistical hypothesis testing was performed at a critical significance level of $p = 0.05$, i.e., a difference was considered statistically significant at $p<0.05$. Statistical analysis was performed in the integrated development environment (IDE) RStudio (version 2022.07.2 RStudio, Inc., USA) in R programming language v. 4.1.3 (2022-03-10 , Austria).

RESULTS

Mean follow-up was 27.5±11.9 months (range 12-48 months). General characteristics of the patients are presented in Table 1.

Data on the initial fixation method and primary graft and their distribution within the compared groups (HT and PLT) are presented in Table 2.

Table 1

Patients' characteristics

Parameter	Number (%), n = 43
Gender*: male female	 17 (39.5) 26 (60.5)
Age, years old*	34.4±8.7 (18–53)
Time of the follow-up, months*	27.5±11.9 (12–48)
BMI, kg/m²*	27.1±3.8 (19.4–41.4)
Time interval between surgeries, months*	83.1±71.5 (6–372)

* — M ± SD (min-max).

Characteristics of the primary tunnels in both groups

When analyzing the results of MSCT scans, a non-anatomic placement of initial tunnels was revealed in 19 cases (52.7%). Of these: 13 (36.1%) — femoral tunnel, 2 (5.6%) — tibial tunnel, 4 (11.1%) — both tunnels. Mean diameter of the primary tibial tunnel was 7.48±0.69 mm, femoral tunnel — 7.6±0.74 mm. Mean values of coordinates of position of the central entry points of the primary tunnels of the studied groups are presented in Table 3 and illustrated in Figures 4 and 5.

Analysis of the influence of the risk factors on the development of the initial graft failure

Damage to the initial graft in the absence of trauma in the medical history or its low-energy character was more frequent in case of non-anatomic placement of the bone tunnels ($p<0.001$). A statistically significant correlation was also found between the time of development of ACL graft failure and the age at the time of the primary surgery ($p = 0.041$). There was no statistically significant correlation between the time of the graft failure development and BMI ($p = 0.744$).

Table 2

Revision and primary grafts, initial fixation method in the groups, number (%)

Revision graft n = 36		Primary graft	Initial fixation method			
HT n = 17	PLT n = 19		extracortical	intratunnel	combined	cross-pin
0 (0.0)	7 (19.4)	ST-auto	7 (19.4)	0 (0.0)	0 (0.0)	0 (0.0)
0 (0.0)	10 (27.8)	HT-auto	0 (0.0)	1 (2.8)	3 (8.3)	6 (16.7)
3 (8.3)	1 (2.8)	BTB-auto	0 (0.0)	4 (11.1)	0 (0.0)	0 (0.0)
3 (8.3)	0 (0.0)	PLT-auto	0 (0.0)	0 (0.0)	3 (8.3)	0 (0.0)
10 (27.8)	0 (0.0)	Synthetic prosthesis	0 (0.0)	10 (27.8)	0 (0.0)	0 (0.0)
1 (2.8)	1 (2.8)	Allograft	0 (0.0)	2 (5.6)	0 (0.0)	0 (0.0)

ST-auto — semitendinosus tendon autograft; HT — hamstring tendon graft; BTB — patellar bone tendon block; PLT — peroneus longus tendon graft.

Table 3

Mean values of placement coordinates of central entry points of primary bone tunnels, M±SD (min-max)

Primary bone tunnel	Parameter	Norm	PLT, *n* = 19	HT, *n* = 17	p
Tibial	EX (%)	43.8±3.0	44.63±1.89 (40–47)	48.47±10.85 (30–71)	0.666
	EY (%)	48.9±3.0	47.79±2.20 (45–51)	46.82±10.96 (5–52)	0.081
Femoral	Gh (%)	29.9±3.0	47.11±15.48 (28–67)	45.12±14.72 (29–67)	0.962
	Gt (%)	30.1±3.0	19.26±9.84 (4–31)	28.94±14.94 (5–56)	0.122

Henceforward: EX (%) — distance from the anterior edge of the tibial plateau in percentage; EY (%) — distance from the medial edge of the tibial plateau in percentage; Gh (%) — distance from the deepest point of the medial margin of the lateral femoral condyle in percentage; Gt (%) — distance from the Blumensaat's line in percentage.

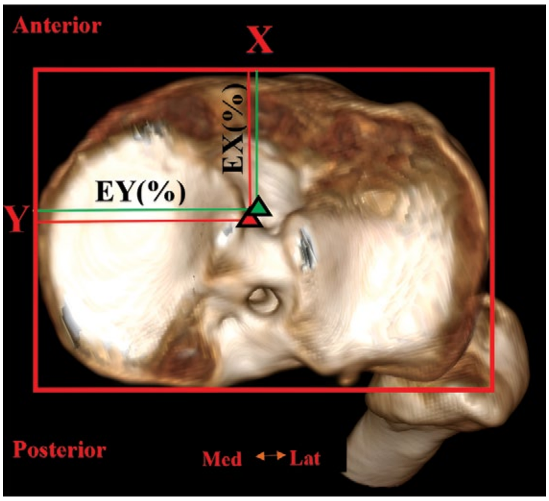

Fig. 4. Average position of the central entry points into the primary canals (marked in red) and revision canals (marked in green) of the tibial condyle

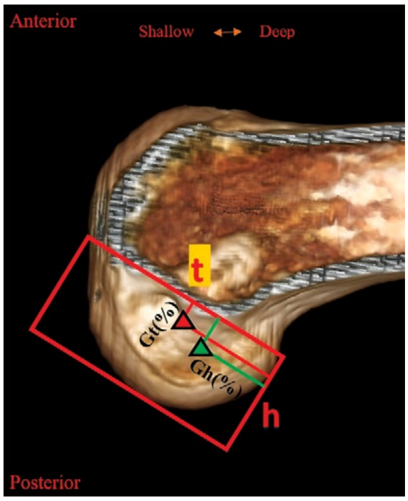

Fig. 5. Average position of the central entry points into the primary canals (marked in red) and revision canals (marked in green) of the femur

Assessment of the intraoperative data

Duration of revision intervention did not differ statistically in the studied groups; however, the PLT group had a lower mean value. The PLT revision autograft had a statistically significantly larger diameter than the HT autograft did (Table 4).

Table 4

Analysis of intraoperative data, M±SD (min-max)

Parameter	PLT, n = 19	HT, n = 17	p
Surgery duration, mins	83.95±27.92 (55–170)	94.12±38.7 (45–180)	0.494
Graft diameter, mm	8.61±0.49 (7.5–9.5)	7.44±0.35 (7–8)	<0.001
Diameter of revision tunnels, mm: tibial femoral	 8.42±0.72 (7.0–9.5) 8.45±0.69 (7.0–9.5)		>0.999

Analysis of the postoperative data

Analysis of the position of the central entry points of revision tunnels showed that there were no statistically significant differences between the groups, and the mean values of the coordinates of the central points were in anatomic positions. Mean values of the coordinates of position of the central entry points of revision tunnels of the studied groups are presented in Table 5 and illustrated in Figures 4 and 5.

Subjective and objective assessment of treatment outcomes

When assessing knee stability using the IKDC 2000 protocol and pivot-shift test before and after surgical intervention, no statistically significant differences between the groups were found (Table 6).

A comparative analysis of the results of assessment of subjective parameters by the KOOS and Lysholm scales 12 months after the revision intervention revealed statistically significantly higher values in the PLT group, but the results were comparable according to the IKDC scale (Table 7).

Functional state of the ankle joint and foot in the PLT group was assessed using the AOFAS scale. All 19 patients had comparable results preoperatively, 99.00±0.94 (97-100) and 12 months postoperatively, 99.21±0.71 (98-100) ($p = 0.919$).

Repeated graft failure or rupture, as well as postoperative complications that required repeated surgical revision were not revealed in both groups during the mentioned observation periods.

Table 5

Mean values of placement coordinates of central entry points of revision tunnels, M±SD (min-max)

Revision tunnel	Parameter	Norm	PLT, n = 19	HT, n = 17	p
Tibial	EX (%)	43.8±3.0	44.58±1.61 (41–47)	43.41±3.02 (39–48)	0.629
	EY (%)	48.9±3.0	48.42±2.59 (45–55)	48.71±1.93 (45–52)	0.469
Femoral	Gh (%)	29.9±3.0	31.89±2.73 (24–36)	32.18±3.40 (25–39)	0.835
	Gt (%)	30.1±3.0	30.79±4.2 (25–40)	30.53±3.61 (23–37)	0.861

Table 6

Objective knee stability assessment before and after surgery

Test	Total, n = 36		PLT, n = 19		HT, n = 17	
	before surgery	after surgery	before surgery	after surgery	before surgery	after surgery
IKDC 2000; Lachman test, A/B/C/D	0/0/22/14	16/20/0/0	0/0/10/9	6/13/0/0	0/0/12/5	10/7/0/0
Pivot-shift test, 0/1+/2+/3+	0/2/16/18	24/12/0/0	0/1/7/11	14/5/0/0	0/1/9/7	10/7/0/0

$p>0.999$.

Table 7

Comparative analysis of subjective assessment results of knee function, M±SD (min-max)

Scale	PLT, n = 19		HT, n = 17		p	
	before surgery	in 12 months	before surgery	in 12 months	before surgery	in 12 months
KOOS (total score)	48.58±7.61 (36–63)	82.95±3.84 (77–90)	47.29±9.60 (34–62)	73.71±3.64 (68–81)	0.558	<0.001
KOOS (pain)	41.68±10.32 (24–62)	90.26±5.41 (82–99)	39.76±13.35 (21–60)	79.53±6.64 (69–91)	0.485	<0.001
KOOS (symptoms)	60.74±5.61 (51–71)	84.58±7.6 (72–95)	59.18±7.23 (49–71)	77.18±5.79 (66–88)	0.465	0.013
KOOS (everyday activity)	69.53±5.09 (61–78)	89.05±5.19 (77–98)	68.59±6.22 (60–78)	79.47±3.74 (72–86)	0.515	<0.001
KOOS (sport activity)	42.11±10.49 (25–62)	84.11±5.64 (76–95)	40.65±13.18 (23–62)	76.47±7.81 (64–92)	0.456	0.004
KOOS (quality of life)	29.05±6.64 (18–40)	68.32±5.51 (55–80)	27.47±8.16 (16–39)	58.06±5.3 (46–66)	0.474	<0.001
Lysholm	60.32±11.35 (40–75)	81.21±5.17 (72–89)	55.24±10.65 (41–71)	77.35±4.49 (68–84)	0.158	0.042
IKDC 2000	52.37±7.65 (38–65)	80.58±4.86 (72–88)	51.53±8.09 (38–65)	77.24±4.98 (68–86)	0.600	0.065

DISCUSSION

Analysis of the results of modern studies allows us to determine that the non-anatomic placement of bone tunnel is one of the main technical errors that lead to the ACL graft failure [5, 17, 18]. In particular, J.A. Morgan et al. have found that the incorrect placement of the femoral tunnel leads to residual rotational instability of the femoral condyle with chronic injury to the ACL graft and the development of its failure [5]. Similar results were obtained when analyzing the material of our study: non-anatomic placement of the bone tunnel was observed in 19 cases (52.8%), with the most frequent isolated incorrect placement of the femoral tunnel, which was located vertically and anteriorly from the anatomic position. When assessing the nature of trauma in this category of patients, a statistically significant correlation ($p<0.001$) was revealed between the incorrect placement of the primary tunnel entries and the development of the graft failure in the absence of trauma in the medical history or in case of injury mechanism characterized by excessive load, which, other things being equal, could not lead to the rupture of the ACL or had a low-energy character. Thus, taking into account the negative influence of the incorrect placement of bone tunnels on the results of the primary ACL reconstruction, there is a necessity of their anatomical placement during revision intervention to reduce the risk of ACL revision graft failure.

The analysis of the dimensional characteristics of the bone tunnels during the revision intervention in our study showed that their average diameter was: 8.42±0.72 mm in the tibia and 8.45±0.69 mm in the femur. The obtained data show that the performance of a one-stage revision ACL reconstruction with anatomically placed tunnels in most cases is possible with their diameter up to 10 mm, which is also confirmed by the data of scientific literature [19, 20]. The size of the prepared graft is most often less than 10 mm, which may not allow adequate impaction into the canal due to the differences in diameters of the tunnel and the graft and lead, in turn, to the development of graft failure [21]. Nevertheless, in some studies, a one-stage revision was performed in anatomically placed tunnels with diameters ranging from 10 to 14 mm [22, 23]. In our opinion, this cannot be universally applicable for one-stage surgical treatment, despite the known methods of one-stage replacement of one of the secondary dilated tunnels with bone-tendon allografts [23, 24]. Meanwhile, preoperative assessment of the interposition of primary and planned tunnels plays an important role in reducing the risk of intraoperative complications. In particular, two cases of intraoperative fusion of primary and revision tunnels were observed in our study, which led to an increase in the duration of surgical intervention and forced to perform a two-stage operation. Thus, we can conclude that it is necessary to develop the most accurate methodology of preoperative planning based on mathematical calculations and correct selection of patients for one- or two-stage revision ACL reconstruction, especially taking into account the available scientific publications showing that the long-term results of one-stage and two-stage revision interventions are comparable [20].

The choice of a graft for revision ACL reconstruction is still a subject of debate in the surgical community. The results of modern studies suggest the advantages of using the patient's own tissues as a graft for ACL reconstruction [7, 25]. The most frequently encountered revision autografts in the scientific literature are hamstring tendon (HT) grafts, patellar bone tendon blocks (BTB), and the quadriceps tendon (QT) [9]. On the one hand, there are studies reporting comparable results of tendon grafts compared to bone-block grafts [26, 27]. On the other hand, QT and BTB autografts have some advantages, as under certain conditions they allow performing revision ACL reconstruction with one-stage bone grafting of the secondary dilated tunnel and expect predictable results [26]. Nevertheless, the available advantages, in our opinion, do not overlap the negative aspects that may result from the use of QT or BTB grafts. The disadvantages include: an increased risk of patella fracture with a graft with a bone block of more than 1 cm, decreased rehabilitation rates due to the fact that the quadriceps femoris muscle is one of the main active stabilizers of the knee and together with the patella ligament is a direct participant of the knee extensor apparatus, the problem of donor site soreness (pain in the anterior knee), the presence of contraindications for the use of this type of grafts in case of degenerative changes in the patellofemoral joint, as well as the relative difficulty of graft taking. In turn, allografts are devoid of the above disadvantages and due to the fact that they are currently subjected to more effective methods of sterilization, storage and transportation, they allow to safely avoid problems associated with the donor site, as well as make it possible to perform one-stage bone grafting of the secondary dilated tunnel and ACL reconstruction [10]. However, this type of graft is not available to everyone and, according to studies, has a higher risk of damage than autograft [7, 8].

In recent years, there has been an increase in the number of published studies analyzing the results of ACL reconstruction using PLT autograft [28, 29, 30, 31, 32]. In particular, K.Y. Phatama et al. in their experimental cadaveric study have found that PLT has better but comparable strength characteristics than HT graft ($p>0.05$), but compared to BTB and QT grafts, the peroneus longus tendon has significantly higher ($p<0.05$) tensile strength values [32]. T. Goyal et al. analyzed the use of PLT as a graft for ACL reconstruction, and on average after 2 years of follow-up all patients included in the study had good postoperative parameters according to the Lysholm and IKDC scales (85.03±7.2 and 80.7±6 points, respectively). Also, the authors did not record any cases of infectious complications and graft failure [28]. In another study F.D. Shi et al. performed a comparative evaluation of the results of PLT and HT grafts in primary ACL reconstruction. They obtained comparable postoperative results between the groups when assessed by the Lysholm functional scales (in PLT group 92.00±6.81; HT 93.00±5.22) and IKDC (in PLT group 90.13±3.01; HT 89.22±3.83) at an average follow-up of 24 months [30]. Similar results were obtained in our study: at an average of one year after surgical intervention, comparative analysis of subjective results on the IKDC scale showed comparable values in the PLT and HT groups (p = 0.065). However, the KOOS and Lysholm scores in the PLT group were statistically significantly higher than in the HT group (p<0.001 and p = 0.042, respectively).

According to the modern studies data, the use of PLT as an autograft for ACL reconstruction does not have a significant negative effect on the function of the foot and ankle joint [28, 29, 30, 31]. In particular, J. He et al. during the meta-analysis revealed statistically significant but not meaningful differences in the AOFAS scale between preoperative and postoperative scores (mean score decreased by 0.31; p = 0.01), and when assessed by the FADI scale, the results were comparable (mean difference of 0.02 points) [29]. The results obtained in our study also prove that there is no significant effect on foot and ankle function. Specifically, when analyzing the results of the AOFAS score, it was found that the preoperative and postoperative scores were comparable (p = 0.919).

The question of the influence of the graft diameter on the results of ACL reconstruction is quite often considered in modern studies. For example, in the study of L. Spragg et al. and in the article by T. Snaebjörnsson et al. is shown that the increase of the graft diameter by every 0.5 mm (from 7.0 to 10.0 mm) resulted in the reduction of the risk of revision by 0.82 times and 0.86 times, respectively [33, 34]. The above-mentioned study results are related to primary ACL reconstruction, but these findings are also applicable to revision intervention. In our opinion, the diameter of the revision autograft should exceed 8.0-8.5 mm, because, firstly, it is necessary to reduce the risk of repeated revision by reducing the influence of one of the risk factors, and secondly, this graft size in most cases allows to "overlap" the diameter of anatomically placed tunnel from the previous intervention. The analysis of literature data allowed us to determine that the PLT graft in most cases has a diameter of more than 8 mm [28, 29, 30, 31]. S. Rhatomy et al. during the comparative evaluation of the average values of PLT (8.8±0.7 mm; 8 to 10 mm) and HT (8.2±0.8 mm; 7 to 9 mm) graft diameters revealed statistically significant differences (p = 0.012) [31]. The results obtained in the work of S. Rhatomy et al. are confirmed by the findings of our study: the average diameter of PLT graft was 8.7 mm (from 7.5 to 9.5 mm), which was significantly greater than the average diameter of HT graft (7.6 mm; from 7 to 8 mm; p<0.001).

Limitations of the study

The present study has some limitations. Firstly, the results were analyzed retrospectively and, therefore, there was no randomization of patients. Secondly, we did not analyze the stability and range of motion in the ankle joint, as the obtained results and their reliability in the study of J. He et al. [29] were considered sufficient. Thirdly, the small number of patients included in the study is explained by the fact that to date there has not been a sufficient number of cases of revision ACL reconstruction where PLT graft was used. The positive aspects of our study are the analysis of the use of PLT autograft in the framework of revision intervention in comparison with the most popular HT graft. At the same time, the use of international evaluation scales (Lysholm, IKDC, KOOS) allows direct comparison with foreign studies. The study is of preventive nature due to expected increase in the number of revision ACL reconstructions.

CONCLUSIONS

One-stage revision ACL reconstruction is a safe and effective surgical intervention providing satisfactory objective and subjective clinical results. The use of PLT autograft allows to obtain better results than the use of HT autograft according to the KOOS and Lysholm scales. Consideration of all possible factors affecting the outcome of revision surgery may allow to obtain the results comparable to primary anterior cruciate ligament reconstructions. Further prospective studies with a larger number of patients are needed to confirm these results.

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