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Comparative analysis of five-year outcomes of anterior cruciate ligament tears repaired with different techniques

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Abstract

Introduction Primary repair of the anterior cruciate ligament (ACL) torn from the femur and the synovial membrane being intact can be an indication for two competing methods including dynamic intraligamentary stabilization (DIS) as the saving method and resection of the stump and primary autoplasty as a more traumatic option.

The purpose was to evaluate the five-year results of DIS in comparison with early ACL reconstruction of the knee joint.

Material and methods A review and statistical analysis of outcomes of 72 patients with ACL injuries (47 males and 25 females) were performed. The patients aged between 18 and 45 years (30.9 ± 8.5), with the length of time from injury ranging from 3 to 21 days (10.6 ± 5.0) and the Tegner activity score of 5 (1–9; 5.8 ± 0.9) prior to injury. DIS was performed for the first group of patients (n = 39) who arthroscopically were diagnosed with ACL torn off the femur with the synovial membrane preserved. Early ACL repair was performed for the controls (second group, n = 33).

Results VAS scored 1.4 ± 0.8 in group I and 1.9 ± 0.8 in group II at 6 months, p = 0.004. Patient satisfaction scored 8.0 ± 0.8 in group I and 7.4 ± 0.8 in group II at 12 months, p = 0.003. Tegner activity level scored 6.5 ± 0.9 in group I and 6.3 ± 0.8 in group II at 12 months, p = 0.014. The Lysholm knee score measured 91.1 ± 2.2 in group I and 88.6 ± 3.5 in group II at 12 months, p = 0.001. Five-year dynamic observation showed relapses of anterior-medial instability of the knee joint in 10 patients (13.9 %), with 4 patients in group I (10.3 %) and 6 patients in group II (18.2 %).

Discussion Outcomes of proximal ACL tears with intact synovium can be as good as with ACL repair. Removal of the torn cruciate ligament with the synovium being intact and grafting may be an unnecessary and aggressive approach.

Conclusion Dynamic intraligamentous stabilization as compared to early ACL repair shows a faster recovery of physical activity at a short term and less relapses of knee joint instability at a long term

Keywords: anterior cruciate ligament tear, dynamic intraligamentary stabilization, long-term results of ACL reconstruction

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INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction is the gold standard of surgical treatment for anteromedial instability in acute and chronic cases. The outcomes of the operation are nor always practical for the patients, since only 50–65 % of amateur athletes return to their pre-injury level of sports with the overall rate of poor results reaching 10 % [1–3]. There is growing evidence supporting efficacy of early ACL repairs for acute ACL tears [4–7]. Different results of primary ACL repair of ruptures and femoral avulsions were reported with preserved synovium and without fiber disintegration, so the indications for primary ACL repair have not been clearly defined [8–12]. Dynamic intraligamentous stabilization (DIS) is a method based on primary ACL suturing with increased contact force at the suture site using a polyethylene thread fixed to the femur with a button and a spring device in the proximal tibia [13, 14]. The construct protects the suture during healing and allows application of cyclic forces during early rehabilitation with the results being promising for proximal tears (within the proximal third of the ACL), in particular [5, 15]. Early results of these techniques were explored and presented in a number of publications [16–18].

The purpose was to evaluate the five-year results of DIS in comparison with early ACL reconstruction of the knee joint.

MATERIAL AND METHODS

The study was conducted at the Orenburg Regional Clinical Center for Surgery and Traumatology (ORCCST) between 2018 and 2023. Inclusion criteria included age over 18 years, acute injury (within the last 14 days), complete ruptures of the ACL, high level of motor activity prior to injury with the Tegner activity score not less than 5 (1–9). Exclusion criteria included acute or chronic infections, local or general muscle diseases, injury to collateral ligaments and nerves, knee osteoarthritis of any grade, osteoporosis, fractures of the knee and post-traumatic conditions. Professional athletes were not included in the study. If a participant wanted to leave or did not show up for the follow-up examination, he/she was excluded from the study.

Patients admitted to the hospital for an acute closed injury of the knee underwent a radiological examination to rule out bone pathology. Then MRI was performed within 10 days. Patients were offered to participate in the study if a complete ACL injury was detected. Early arthroscopic ACL reconstruction and debridement of other articular injuries were produced. The essence of the study was explained to the patients and they were informed that the final decision would be made during arthroscopic diagnosis of the injuries. The purpose of the study was explained to the patients and they were informed that the final decision can be made during arthroscopic diagnosis of the injuries: DIS could be performed with no contraindications identified. If that was not possible, ACL repair could be offered with hamstring autografts with impaired menisci to be either sutured or resected. All patients signed informed consent, the study was approved by the local expert board (LEK protocol No. 6 dated January 20, 2018).

A total of 77 patients were selected and included in the study, of which 5 (6.5 %) patients were excluded. Statistical analysis was produced for 72 patients (47 males and 25 females) with the mean age of 30.9 ± 8.5 years (range, 18 to 45 years). The left knee was involved in 25 patients, the right side injury was seen in 47 cases (left/right ratio of 1:1.9). The duration of injury in both groups ranged from 3 to 21 days. (10.6 ± 5.0). The mechanism of injury included falls(n = 26; 36.1 %), sports

activities (n = 46; 63.9 % (all amateur athletes)), alpine skiing (n = 16; 22.2 %), football (n = 13; 18.2 %), hockey (n = 6; 8.3 %), athletics (n = 6; 8.3 %), basketball (n = 5; 6.9 %). The mean height was 175.7 ± 8.0 cm, the mean weight measured 71.4 ± 8.1 kg, the mean body mass index (BMI) was 23.6 ± 3.0 kg/m^2, the Tegner activity score was not less than 5 (1–9) before injury with the mean of 5.8 ± 0.9. Comparison of the means between the groups showed no statistically significant differences (Table 1).

Table 1

Patient gender characteristics

Description		Patient			p*
		Group I	Group II	Total	
Quantity	abs.	39	33	72	0.891
	%	47.6	52.4	100	
Gender	M	25	23	47/	0.732
	F	14	10	25	
Involved side	R	25	17	42	0.287
	L	14	16	30	
Age (Me ± SD, years)		30.9 ± 8.2	31.0 ± 8.9	30.9 ± 8.5	0.961
Time from injury to surgery (Me ± SD, days)		10.7 ± 5.2	10.5 ± 4.7	10.6 ± 5.0	0.847
Height (Me ± SD, m)		1.75 ± 0.07	1.74 ± 0.08	1.75 ± 0.08	0.923
Weight (Me ± SD, kg)		71.0 ± 8.2	71.9 ± 8.0	71.4 ± 8.1	0.647
BMI (Me ± SD, kg/m^2)		23.4 ± 2.7	23.8 ± 3.3	23.6 ± 3.0	0.523
Tegner activity score		5.8 ± 0.9	5.9 ± 0.9	5.8 ± 0.9	0.895

*— t-test for equal means of independent samples in groups I and II

Standard knee arthroscopy was performed under spinal anesthesia using a tourniquet and two typical ports to examine ACL stumps. Examination of the ACL and grading a type A or B injury as classified by A. Ateschrang [16], dynamic involved intraligamentary stabilization (DIS) with Ligamys® fixator (Mathys Ltd. Bettlach Switzerland) using a typical technique were performed for the patients [17]. All the necessary diagnostic intra-articular manipulations were produced for Ateschrang type C injury with removal of the ACL stumps. An injury to the menisci (57 cases out of 72; medial: n = 39, lateral: n = 18) suggested a meniscal suture performed in the "red zone" (n = 23); resection of the torn portion was produced in 34 out of 57 cases. A 4 cm long incision was made in the projection of the adductor muscle tendons with a graft isolated, formed using two tendons folded in half (4-bundle autograft). The technique of ACL repair was typical with the femoral canal formed using the anteromedial approach. The femoral end was fixed with bioabsorbable Milagro Advance (DePuy) 6–10 × 23 mm screws and the tibia was fixed with Milagro Advance (DePuy) 6–10 × 30 mm screws [18]. Postoperative rehabilitation was similar for the patients of both groups.

The 100 mm visual analog scale (VAS) score, 10-point patient satisfaction scale (1 means not satisfied, 10 means very satisfied), the Lysholm and Tegner scores were used at 6 and 12 months. The anterior drawer test (ADT) was performed using a KT-1000 arthrometer (MEDmetric, San Diego, CA, USA) at 30° knee flexion annually for 5 years. The result was considered negative if the anterior displacement was no more than 5 mm and the Lachman test being negative in comparison with the normal knee. The measurements were performed three times, the mean was calculated and the result was entered

into the database. Recurrence of the anterior knee instability was considered in case of repeated injury based on clinical examination (with ADT greater than 5 mm in the anteroposterior direction), a positive Lachman test, MRI and the results of surgical arthroscopic treatment with annual examination (ADT greater than 5 mm and positive Lachman test) in the absence of injury.

For statistical analysis, the two-tailed Student's t-test was used for two independent samples with the *p*-value identified with the IBM SPSS Statistics 22 program. The Kaplan – Meier curve was used to determine the treatment failure (recurrence of anterior-medial knee instability) of single tears (DIS) and ACL repair of multiple ruptures. Differences between both groups were tested using the Log Rank (Mantel – Cox) test. A post hoc power analysis considering the sample size and the group difference measured 0.96 at $\alpha = 0.05$. The differences were considered statistically insignificant at $p > 0.05$.

RESULTS

The patients of both groups had pronounced pain early after surgery which necessitated multimodal analgesia. Patients of group I developed less pain at 6 months as compared to patients of group II (group I: 1.4 ± 0.8; group II: 1.9 ± 0.8, p = 0.004). The mean VAS score was similar with the groups at 12 months and later with no statistical difference detected: (1.1 ± 0.8) and (1.3 ± 1.0), $p = 0.340$.

Patient satisfaction scored 7.3 ± 1.3 in group I and 6.4 ± 1.3 in group II at 6 months with $p = 0.006$. Eight (20.5 %) patients scored their condition at 10, which was not noted in the control group. Patient satisfaction scored 8.0 ± 0.8 in group I and 7.4 ± 0.8 in group II at 12 months with $p = 0.003$.

The measurements echoed with the Tegner activity level test and showed decreased statistically significant values at 6 months as compared to preoperative values in both groups. There was a statistically significant difference of 25 % between the groups (p < 0.001) at 12 months and the parameters returned to those prior to injury and even higher with the difference being minimal between the groups but statistically significant scoring 6.5 ± 0.9 in group I and 6.3 ± 0.8 in group II at $p = 0.014$.

Lysholm score measured less than 90 in both groups at 6 months (group I: 89.9 ± 3.6; group II:(85.6 ± 4.2, $p = 0.001$) reaching a higher level at 12 months and measuring 91.1 ± 2.2 in the DIS group and 88.6 ± 3.5 in the ACL repair patients with a statistically significant difference at $p = 0.001$ (Table 2).

Table 2

Results of DIS and ACL repair

Показатели	Follow-up period					
	at 6 months			at 12 months		
	Group I (*n* = 39)	Group II (*n* = 33)	*p**	Group I (*n* = 39)	Group II (*n* = 33)	*p**
VAS	1.4 ± 0.8	1.9 ± 0.8	0.004	1.1 ± 0.8	1.3 ± 1.0	0.340
Patient satisfaction	7.3 ± 1.3	6.4 ± 1.3	0.006	8.0 ± 0.8	7.4 ± 0.8	0.003
Tegner	4.8 ± 1.1	3.6 ± 1.1	0.000	6.5 ± 0.9	6.3 ± 0.8	0.014
Lysholm	89.9 ± 3.6	85.6 ± 4.2	0.000	91.1 ± 2.2	88.6 ± 3.5	0.001
ADT (mm)	2.2 ± 0.9	2.5 ± 1.0	0.268	2.4 ± 0.8	2.6 ± 1.0	0.463

* — t-test for equal means of independent samples in groups I and II

The ADT measured not greater than 2–3 mm at all follow-up periods in both groups with no repeated injuries noted in patients at 12 months. Control examinations and five-year dynamic observation performed once every 12 months during 60 months showed relapses of anterior-medial instability of the knee detected in 10 patients (13.9 %), with four patients in group I (10.3 %). The patients denied re-injury. Six patients of group II developed recurrent anterior-medial knee instability (18.2 %) due to re-injury (n = 4; 12.1 %) and to no-cause in two cases (6.1 %) (Fig. 1).

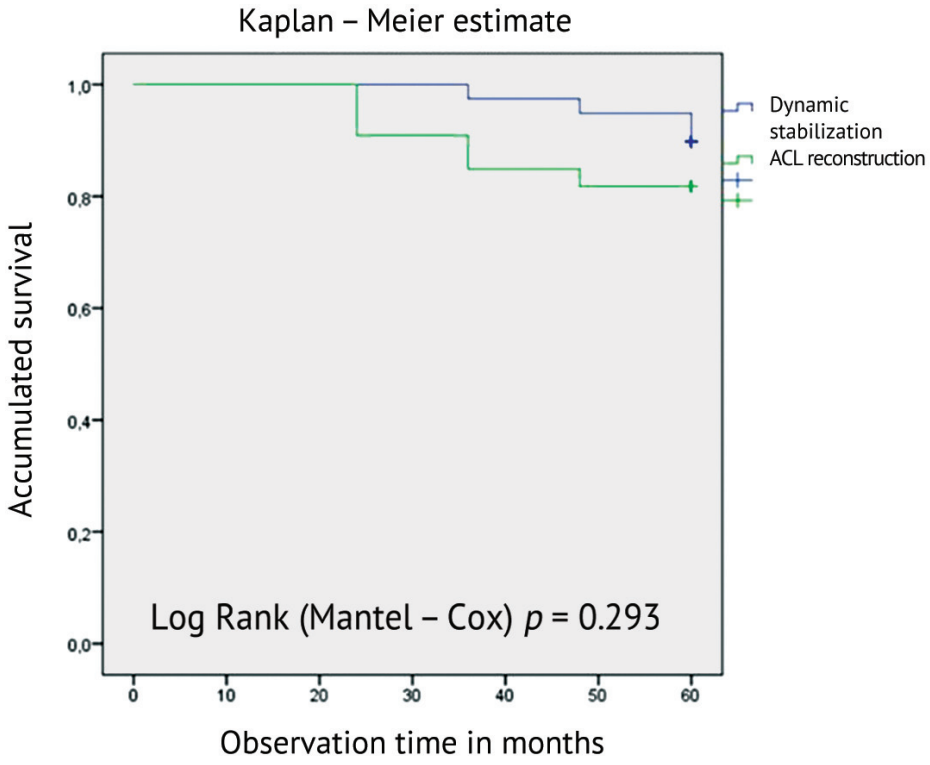

Fig. 1 Kaplan – Meier curve showing significant differences between the groups

Although there was no statistical significance for recurrent knee instability between groups (Log Rank (Mantel – Cox) p = 0.293), the relapse rate was higher in the ACL repair group with spontaneous ruptures without injury being more common in the DIS group.

DISCUSSION

Although a delayed ACL reconstruction approach was a dominant strategy for a long time there has been a renewed interest in the primary ACL suture, which requires discussion and revised indications for surgical interventions for acute ACL ruptures and proximal tears, in particular [8, 9, 15].

However, to justify indications for primary ACL repair, the results must be comparable to the gold standard of ACL repair. Schliemann et al. [11] performed a comparative prospective randomized and reported early functional results and changes in gait pattern after DIS during the first postoperative year. No significant differences between ACL and DIS groups were found for the functional scores (IKDC and Lysholm scales) at any time of the follow-up. [11]. The rate of recurrent instability in this study was 17.7 % within 2.5 years after DIS which was slightly higher compared with other studies.

Kohl et al. reported a re-rupture rate of 6 % and persistent instability in 4 % of 50 patients over two years of follow-up [5]. Henle et al. reported a rupture recurrence rate of 2.9 % and residual instability of 1.1 % [4]. In another study, Henle et al. reported reoperations after ACL reconstructions in 11 % of 96 cases, with a follow-up period of at least two years [14]. Meister et al. reported a relapse rate of 15 % at one year [12]. Osti et al. reported the overall relapse rate of 17.5 % [19]. The results of the series showed the overall failure rate of 17.7 % being higher as compared to ACL repair with the recurrence rate of 3 to 7 % of cases according to a meta-analysis [20].

The asymptomatic course of residual knee instability after ACL repair could be interpreted as a failure and identified as a relapse or a rupture [8, 20, 21, 22]. The condition was caused by the knee instability with the recurrence rate being higher.

Outcomes of DIS suggest that the result of proximal ACL tears with intact synovium may be as good as ACL repair and removal of a torn cruciate ligament with intact synovium and grafting may be an irrelevant and aggressive approach. A prerequisite for a good outcome may be associated with preserved blood supply by the arachnoid periligamentous capillaries in the synovium, which are known to provide blood supply of the ACL [23].

We recognize that the sample size and failure rate in our series were small to provide narrow confidence intervals. However, the cohort size was acceptable to address the primary research question and achieve sufficient power. It should be emphasized that all patients in the group underwent DIS based on an intraoperative decision, which excluded the patient's opinion making the final decision on the surgical method.

Despite these limitations, the results indicate that primary repair of the proximal ACL tears with preserved synovial integrity can be included in the decision-making algorithm for this cohort of patients. However, patient selection is critical. Previous studies have shown a higher risk of recurrence in younger patients — professional athletes, and in patients with a mid-substance ACL injuries [4, 15, 22, 24]. We believe that preservation of the synovial blood supply and the integrity of the ACL proximally torn from the femur can ensure recovery and prevent recurrence.

CONCLUSION

DIS compared with early ACL repair shows a faster recovery of the physical activity at a short term and less relapses of knee instability at a long term.

Conflict of interest *None of the authors has any potential conflict of interest.*

Funding *The authors received no specific funding for this work.*

Ethical review *The study was approved by the local expert board (protocol No. 6 LEK dated January 20, 2018).*

Informed consent *was given by all patients prior to inclusion in this study.*

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