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# Results of the Surgical Reconstruction of the Anterior Cruciate Ligament

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## ABSTRACT

*Results of the surgical reconstruction of the anterior cruciate ligament (ACL), using as a graft fourfold hamstring tendons (gracilis and semitendinosus) and middle third of the patellar ligament, were compared. In all patients that were participating in this study clinical examination and magnetic resonance showed ACL rupture, and apart from the choice of the graft, surgical technique was identical. We evaluated 112 patients with implemented patellar ligament graft and fourfold hamstring tendons graft six months after the procedure. Both groups were similar according to age, sex, activity level, knee instability level and rehabilitation program. The results showed that there was no significant difference between groups regarding Lysholm Knee score, IKDC 2000 score, activity level, musculature hypotrophy, and knee joint stability 6 months after the surgery. Anterior knee pain incidence is significantly higher in the group with patellar ligament graft (44% vs. 21%). Both groups had a significant musculature hypotrophy of the upper leg of the knee joint that was surgically treated, six months after the procedure. Both grafts showed good subjective and objective results.*

**Key words:** anterior cruciate ligament, reconstruction, patellar ligament, hamstring tendons

## Introduction

ACL rupture has a negative influence on the joint stability<sup>1</sup>, what results in everyday disturbances when performing daily and sports activities<sup>2-4</sup>, increases the risk of meniscus injury<sup>2,5,6</sup> and leads to early degenerative joint changes<sup>7-10</sup>. Many surgical techniques have been used for the ACL reconstruction, including prosthetic ligament, allograft, autograft, transplant with prosthetic support and reconstruction outside the joint<sup>11</sup>. For surgical reconstruction of ACL today is mostly used graft of the middle third of the patellar ligament with bone insertion and fourfold hamstring tendons (gracilis and semitendinosus)<sup>11</sup>. By using patellar ligament, graft risk of patellar fracture, patellofemoral pain and rupture of the patellar ligament increases<sup>12,13</sup>. By taking hamstring tendons graft, knee joint flexors are weakened, and adequate graft fixation in the bone has also been a problem for many years, which was solved by implementation of an interferential screw<sup>14,15</sup>. Structural strength of the fourfold hamstring musculature tendon graft measured during tension, amounted to 4590 N, whereas for the patellar ligament graft it amounted to 2977 N<sup>16,17</sup>. Ten-

don graft, as well as patellar ligament graft was compared prospectively and retrospectively. The studies have shown that there is no significant difference in overall results<sup>18-22</sup>. In most studies compared grafts were fixated in different ways, what leads to a significant difference in overall results. Results of arthroscopic reconstruction of ACL with autologous patellar ligament graft and fourfold hamstring tendons graft (gracilis and semitendinosus) were compared in this study. Both of them were fixated in the same way; on the upper leg with a method rigid-fix (resorptive pins) and on the lower leg with resorptive interferential screw. The same orthopaedic surgeon operated on all patients, using the same surgical technique, as well as postoperative rehabilitation.

## Materials and Methods

### *Patient selection*

112 patients with rupture of the anterior cruciate knee ligament using as a graft middle third of the pate-

llar ligament, width of 10 mm, and fourfold hamstring tendons, were operated from November, 2004 until the end of 2007.

The study included 112 patients, 54 (48.3%) of which with patellar ligament graft of average age of 28 ( $\pm 7.47$ ), and 58 (51.7%) with hamstring tendons graft of average age of 26 ( $\pm 7.94$ ).

The operation was performed on 31 (27.7%) female and 81 (72.3%) male patients. Average time period from the injury until the operation was 9 months. Indication for a surgical procedure was a subacute and chronic anterior cruciate ligament rupture discovered and proved by clinical examination and magnetic resonance results.

Patients that underwent the operation showed knee instability when performing daily and sports activities or they wanted to keep their level of activity as it was before the injury.

### *Surgical technique (arthroscopic)*

All surgical procedures were performed by the same surgical team. Patients underwent a spinal anesthesia and they got one-time preoperational dose of antibiotics. High anterolateral and low anteromedial portal (entrance) was used. The procedure started with cleaning a knee joint, which included removing stump of ACL, and taking care of adjoining lesions in the knee (menisci, cartilages). With patellar ligament graft, a 6–8 cm long longitudinal incision, from patellar apex to tibial tuberosity was used. Middle third of the patellar ligament, 10 mm wide, with bone insertion on patella of 25 mm and on tibia of 30 mm, was taken. Bony parts were then formed in a way that they lightly pass through a cylinder diameter of 10 mm. Both sides were fixated with stitches through openings in the bone. When taking hamstring musculature tendon graft a skin, 3 cm long, incision is used medially from tibial tuberosity and below tibial plateau. Fascia is cut and pes anserinus insertion is isolated. Hamstring tendons (gracilis and semitendinosus) were separated, then prepared and separated from proximal insertion by a special instrument. Distal insertion was separated with a knife, and tendons were then folded over the catgut to get a fourfold graft. Graft was then placed on a working cell under fibrous strain of 15 kp during the period of 10 minutes. Average width of fourfold tendons amounts to 8 mm. Canales on lower leg and upper leg were made arthroscopically with a bur, graft was implemented and fixated proximally with resorptive pins, and distally with resorptive interferential screw. Knee stability was tested with Lachman test, knee was washed out, drain was placed, and wound was closed. Average time of surgical procedure amounted to 75 minutes.

### *Rehabilitation*

Postoperative, all patients from both groups were on »accelerated« rehabilitation program. It included achieving full extension and function of the upper leg quadriceps from the first day after the operation. No immobilisation or orthopaedic aids were used. In the case of

swelling or pain, rehabilitation program was performed more slowly. Four weeks after the operation, patients were allowed to ride a bike, and after ten weeks they were allowed to jog slowly with constant strengthening of the upper leg muscles. Full burdening is allowed after six months if muscles of the operated leg are eutrophic, and muscle strength amounts to 90% in comparison to healthy leg.

### *Evaluation*

Average hospitalization lasted for 8 days, during which patients underwent a physical therapy prescribed by a physical therapist. Clinical evaluation included wound checking, removing of stitches after 12 days, regular check ups after 1, 3, and 6 months with measuring of movement scope and recording of all complications (swelling, pain, contracture, muscle hypotrophy, infection, instability). Muscle hypotrophy is determined as a difference in size of the upper leg between operated and healthy knee joint 10 cm proximally from the upper patellar pole. Pain of knee and back part of the upper leg was assessed subjectively by a patient and IKDC 2000 score. Patients also filled in a Lysholm knee score, as to record subjective symptoms. For clinical testing of stability of the knee joint ligaments, we used Lachman and Pivot-Shift test.

### **Results**

Out of 112 patients who participated in this study, we followed up regularly 108 (96%) of them, 52 (48%) of which were from the ligament graft group and 56 (52%) patients from the tendon graft group, during the period of six months. Average time period from the injury to the operation, in the group with patellar ligament graft was 10 months, and in the group with tendon graft 9 months. Distribution of patients according to sex and type of graft is given in Table 1 (Table 1).

In one patient from the patellar ligament graft and one from the tendon graft group a postoperative infection developed. Knee arthroscopy with a heavy lavage was performed one more time and free drainage was implemented. Antibiotics according to antibiogram were prescribed parenterally during 2 week period and then perorally during 4 week period. Afterwards, a slower pro-

**TABLE 1**  
DISTRIBUTION OF PATIENTS ACCORDING TO TYPE OF GRAFT AND SEX

Sex	Patellar ligament graft group	Tendon graft group	Total	p*
	N (%)	N (%)	N (%)	
Male	40 (74.1)	41 (70.7)	81 (72.3)	0.426
Female	14 (25.9)	17 (29.3)	31 (27.7)	
Total	54 (100)	58 (100)	112 (100)	

\* $\chi^2$ -test

gram of physical therapy was instituted, and they were excluded from further study results. In the period of 6 months after the operation, we lost one patient from each group from regular follow up. According to IKDC 2000 score, 55 (49.1%) patients had C and D level of activity, what means insufficient and bad, whereas B level of activity (good) had 1 (1.9%) patient from each group (Table 2). Average preoperative score according to IKDC 2000 questionnaire in the patellar ligament graft group was 63.6 ( $\pm 9.9$ ), and in the tendon ligament group 58.7 ( $\pm 10.6$ ). The patellar ligament graft group showed significantly higher amounts of preoperative score according to IKDC questionnaire (Mann Whitney test,  $p=0.003$ ). Average preoperative score according to Lysholm knee questionnaire was 56.2 ( $\pm 8.5$ ) in the patellar ligament graft group, and 54.8 ( $\pm 9.1$ ) in the tendon ligament group. There was no significant difference between groups. Adjoining injury (lesion) of medial meniscus was found in 53 (47.4%) patients. Lesions of lateral meniscus were found in 16 (14.3%) patients. In 5 (4.5%) patients lesions of both meniscuses were found. Medial meniscus was stitched in 3 (5.6%) patients of the patellar ligament group and 2 (3.4%) patients of the tendon graft group. Meniscus stitches were performed in arthroscopic technique known as »ALL-INSIDE«. Other patients underwent an arthroscopic partial resection of the injured part of meniscus. In 6 (11.2%) patients, due to greater damage of cartilage on femur condyles, in the patellar ligament graft group and 4 (6.9%) patients in the tendon graft group, arthroscopic cleaning of the damaged part of that microfracture was performed. In 3 (5.6%) patients of the patellar ligament group and 2 (3.4%) patients of the hamstring musculature tendon group a simultaneous damage of medial meniscus and cartilage was found (Figure 1). Thromboprophylaxis was performed in all patients, and not one case of deep venous thrombosis was recorded, as well as nerve structure lesions. Average time period which patients spent being hospitalized at the department was 8 days for both groups. In the period of six months after the operation graft rupture was not recorded. 4 knee arthroscopies were performed additionally (3 in the tendon graft group and 1 in the patellar ligament graft group). All arthroscopies were performed

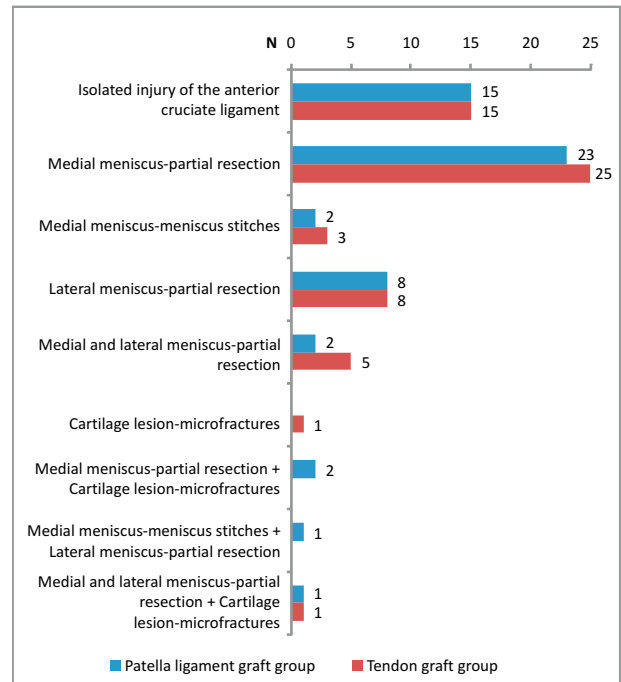


Fig. 1. Distribution of patients with intraoperatively treated lesions of meniscus and cartilages, according to graft groups.

due to rupture or repeated rupture of the medial meniscus. Lysholm knee score was designed for analysing specific symptoms regarding a knee function after the operation (limping, need for support, knee block, instability, swelling, pain and ability of climbing the stairs). Maximum score was 100. Preoperative and postoperative score showed a significant improvement in both groups 6 months after the procedure.

Average amount of the Lysholm score 6 months after the operation was 88.4 ( $\pm 6.4$ ) in the patellar ligament graft group in comparison to 85.3 ( $\pm 6.9$ ) in the tendon graft group. (Table 3, Figure 2). IKDC 2000 score included a combination of symptoms, functional state of the knee and sports activity level. Each category was presented as level A (excellent), B (good), C (sufficient), D

TABLE 2  
PREOPERATIONAL ACTIVITY LEVEL OF PATIENTS ACCORDING TO IKDC SCORE

IKDC score	Patellar ligament graft group	Tendon graft group	Total	p*
	N (%)	N (%)		
A (excellent)	0	0	0	0.848
B (good)	1 (1.9)	1 (1.7)	2 (1.8)	
C (sufficient)	28 (51.9)	27 (46.6)	55 (49.1)	
D (bad)	25 (46.3)	30 (51.7)	55 (49.1)	
Total	54 (100)	58 (100)	112 (100)	

\* $\chi^2$ -test

TABLE 3  
DISTRIBUTION OF PATIENTS ACCORDING TO POSTOPERATIVE LYSHOLM KNEE SCORE

Lysholm score	Patellar ligament graft group	Tendon graft group	Total	p*
	N (%)	N (%)		
A (excellent)	10 (19.2)	9 (16.4)	19 (17.8)	0.811
B (good)	34 (65.4)	36 (65.5)	70 (65.4)	
C (sufficient)	6 (11.5)	9 (16.4)	15 (14)	
D (bad)	2 (3.8)	1 (1.8)	3 (2.8)	
Total	52 (100)	55 (100)	107 (100)	

\* $\chi^2$ -test

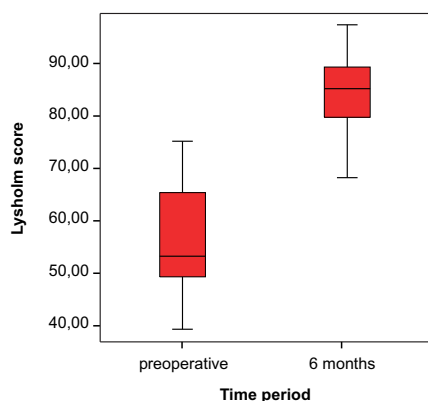


Fig. 2. Median of the lysholm knee score preoperatively and 6 months after the operation.

(bad). In the patellar ligament graft group, 6 months after the operation, level A and B had 40 out of 52 (77%) patients in comparison to 46 out of 56 (82%) in the tendon graft group (Table 4, Figure 3).

Knee extension was 5 degrees worse in one patient in the patellar ligament graft group, whereas all patients in the tendon graft group had a complete knee extension. 6

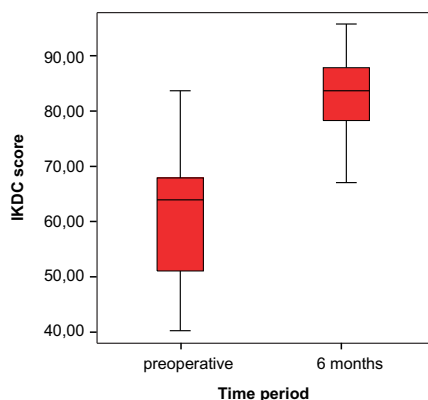


Fig. 3. Median of the IKDC 2000 score preoperatively and 6 months after the operation.

**TABLE 4**  
IKDC 2000 (INTERNATIONAL KNEE DOCUMENTATION COMMITTEE) SCORE 6 MONTHS AFTER THE OPERATION

IKDC score after 6 months	Graft group of the		Total N (%)	p*
	Patellar ligament graft group	Tendon graft group		
	N (%)	N (%)	N (%)	
A (excellent)	5 (9.6)	8 (14.3)	13 (12)	0.788
B (good)	30 (57.7)	29 (51.8)	59 (54.6)	
C (sufficient)	14 (26.9)	17 (30.4)	31 (28.7)	
D (bad)	3 (5.8)	2 (3.6)	5 (4.6)	
Total	52 (100)	56 (100)	108 (100)	

\* $\chi^2$ -test

**TABLE 5**  
CLINICAL STABILITY OF THE OPERATED KNEE JOINT 6 MONTHS AFTER THE OPERATION

Clinical stability of the knee	Graft group of the		Total N (%)	p	
	Patellar ligament	Tendon			
	N (%)	N (%)			
Lachman test	Negative	46 (88.5)	42 (75)	88 (81.5)	0.197*
	I level	5 (9.6)	12 (21.4)	17 (15.7)	
	II level	1 (1.9)	2 (3.6)	3 (2.8)	
	Total	52 (100)	56 (100)	108 (100)	
Pivot-Shift test	Positive	2 (3.8)	2 (3.6)	4 (3.7)	0.662†
	Negative	50 (96.2)	54 (96.4)	104 (96.3)	
	Total	52 (100)	56 (100)	108 (100)	

†Fisher's exact test; \*  $\chi^2$ -test

months after the operation, 87 (80.6%) patients described function of the surgically treated knee as excellent and good, 43 (82.6%) of which were from the patellar ligament graft group and 44 (78.6%) from the tendon graft group.

Anterior knee pain was presented in 23 (44.2%) patients from the patellar ligament graft group and 12 (21.4%) from the tendon graft group.

6 months after the operation 20 (18.5%) patients had a positive Lachman test. Clinical (manual) check up 6 months after the operation showed a positive Pivot-Shift test in 2 (3.8%) patients in the patellar ligament graft group and 2 (3.6%) patients in the tendon graft group (Table 5).

6 months after the operation, when patients after the rehabilitation should be able to completely burden operated knee, muscle hypotrophy of the upper leg was present in 38 (73.1%) patients of the patellar ligament graft group and 43 (76.8%) patients of the tendon graft group. In most of the patents from both groups that difference amounted to 10–20 mm. We have advised all patients to continue with rehabilitation with emphasis on muscle strengthening (Table 6).

**TABLE 6**  
DIFFERENCES IN MUSCLE HYPOTROPHY OF THE UPPER LEG BETWEEN GROUPS 6 MONTHS AFTER THE OPERATION

Muscle hypotrophy	Graft group of the		Total N (%)	P*
	Patellar ligament	Tendon		
	N (%)	N (%)		
<10 mm	14 (26.9)	13 (23.2)	27 (25)	0.751
10–20 mm	25 (48.1)	31 (55.4)	56 (51.9)	
>20 mm	13 (25)	12 (21.4)	25 (23.1)	
Total	52 (100)	56 (100)	108 (100)	

\* $\chi^2$ -test

## Discussion

ACL of the knee has a proprioceptive and a mechanical role; limits anterior movement of the lower leg in comparison to the upper leg, controls rotation of the lower leg, as well as knee abduction during flexion<sup>22,23</sup>. Traumatic rupture of ACL occurs during peak torsional forces during knee activities with tension of quadriceps muscles and flexion of 40 degrees, knee hypertraction, increased inner rotation of the lower leg, varus or valgus stress accompanied by torsion of collateral ligament<sup>24</sup>. Unstable knee leads to limited physical activity, what is a key indication for operation. According to one study, only 14% of patients with ACL rupture were able to perform earlier physical activities<sup>25</sup>. Noyes et al.<sup>26</sup> state that only 11% of conservatively treated patients can participate in physical activities, which require more strength, without limitations.

Aim of the surgical reconstruction was to establish a normal knee joint kinematics by eliminating instability and potential adjoining damages (of meniscus and cartilages). In the prospective study we have compared the most frequently used grafts for ACL reconstruction; middle third of the patellar ligament and fourfold hamstring tendons (gracilis and semitendinosus).

Except for grafts, other factors which determine clinical results were identical: operative team, graft fixation technique and rehabilitation program. It has been proven that in comparison to conservative treatment, there is a lower percentage of additional damages of meniscus and cartilages, as well as surgical interventions from 27%, in conservatively treated patients, to 3% in the arthroscopic reconstruction group<sup>27</sup>. Long-term studies show high incidence of degenerative changes in both groups<sup>28</sup>.

Studies which support operative reconstruction of ACL show high percentage of satisfying results with graft of the middle third of the patellar ligament, as well as tendon graft<sup>29–32</sup>.

Results of these studies show that implement of both grafts leads to satisfying knee stability in more than 95% of patients in the period of 2 years. Nevertheless, there are significant differences when grafts in postoperative knee stability and complications are compared. Most of the authors agree that knee stability is somewhat better in the patellar ligament graft group in the first year after the operation, and later on it is levelled<sup>33</sup>. Anterior knee pain is, according to most authors, significantly greater in patients with patellar ligament graft, as well as knee contracture in the first year after the operation<sup>34,35</sup>. Shaieb, et al.<sup>36</sup> state in their findings that instability after the operation is significantly higher in the tendon graft group, but difference lies mostly in instability degree. In this study there was no significant difference regarding postoperative joint stability between groups measured with Lachman and Pivot-Shift test. In almost all patients with postoperative clinical tests for the anterior knee joint instability, it was a minor instability of 1<sup>st</sup> grade, what did not significantly influence good subjective and objective results.

6 months after the operation anterior knee pain was present in 23 (44.2%) patients from the patellar ligament graft group and 12 (21.4%) patients from the tendon group. Significantly greater number from the patellar ligament graft group felt anterior knee pain 6 months ( $\chi^2$ -test,  $p=0.010$ ) after the procedure. Relationship between anterior knee pain and graft choice is not completely clear. Patients can feel knee joint pain for many etiological factors, such as: limited movements in the knee joint before the procedure, existing patellar chondromalacia, poor rehabilitation, pain on the place where graft was taken from, presence of the flexion contracture, etc.

Flexion contracture is determined as traction deficit of injured knee joint during maximal passive extension in comparison to the healthy knee joint. Historically, loss of full knee extension was a significant problem after cruciate ligament reconstruction with middle third of the patellar ligament. Pinczewski, et al.<sup>32</sup> state that 31% of patients in the patellar ligament graft group and 19% in the tendon graft group have a significant flexion contracture after the operation. Early immobilisation with emphasis on full passive extension reduced extension deficit significantly. 6 months after the procedure extension deficit was present in only one patient from the patellar ligament graft group. The study has shown that graft taking, i.e. »damage« of musculature tendons gracilis and semitendinosus, as well as middle third of the patellar ligament, did not cause extension loss in the knee joint, if aggressive rehabilitation treatment was implemented immediately after the procedure.

Postoperative Lysholm knee and IKDC 2000 score in comparison to preoperative showed significant improvement in both groups and there was no significant difference between them.

Limitations of this prospective study lie in the fact that patients with adjoining damages of meniscus and cartilages were added to those with isolated cruciate ligament rupture. Regarding the scope of the study, a longer time period was needed to present larger number of patients with isolated cruciate ligament rupture<sup>36</sup>.

## Conclusion

This study shows that surgical reconstruction of the anterior cruciate ligament, using as a graft middle third of the patellar ligament and fourfold hamstring tendons, leads to satisfactory stability of the knee joint. Most of the patients are again able to perform demanding physical activities after the proper physical therapy. Except for higher incidence of the anterior knee pain, 6 months after the procedure there was no significant difference between patients of both graft types. Choice of graft should be individual, depending on the patient<sup>37</sup>.

The author of this study prefers tendon graft, due to a smaller surgical incision and somewhat reduced postoperative knee pain and has been using it in 2/3 of surgical reconstructions of the anterior cruciate ligament.

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## REZULTATI KIRUŠKE REKONSTRUKCIJE PREDNJE UKRIŽENE SVEZE

### SAŽETAK

Uspoređivani su rezultati operacijske rekonstrukcije prednje ukrižene sveze koristeći kao presadak četverostruke tetive ishiokruralne muskulature (gracilisa i semitendinosusa) i srednju trećinu ligamenta patele. Svi ispitanici u ovoj studiji imali su dokazanu rupturu prednje ukrižene sveze kliničkim pregledom i nalazom magnetske rezonance, a osim izbora presatka, tehnika operacijskog zahvata bila je identična. Evaluirali smo 112 pacijenata s ugrađenim presatkom ligamenta patele i četverostrustrukim presatkom tetiva ishiokruralne muskulature kroz period od šest mjeseci nakon zahvata. Obje skupine bile su slične po dobi, spolu, nivou aktivnosti, stupnju nestabilnosti koljena i rehabilitacijskom programu. Rezultati pokazuju da nema značajne razlike među skupinama u odnosu na Lysholm knee upitnik, IKDC 2000 upitnik, nivo aktivnosti, hipotrofiju muskulature, te stabilnost zglobova koljena 6 mjeseci od operacijskog zahvata. Incidencija prednje koljenske boli značajno je veća u skupini s presatkom ligamenta patele (44% prema 21%). Obje skupine imale su značajnu hipotrofiju muskulature natkoljenice operiranog zglobova koljena, šest mjeseci nakon zahvata. Oba presadka pokazuju dobre subjektivne i objektivne rezultate.