Factors influencing the choice of graft type in ACL reconstruction: Allograft vs autograft

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Abstract

Background. Anterior cruciate ligament (ACL) reconstruction is the prevailing procedure in cases of ACL rupture.

Objectives. To analyze ACL reconstruction based on time and costs of the surgery, postoperative pain, postoperative complications, time it takes to return to work or other such physical activity, and cosmetic effects.

Material and methods. The retrospective analysis involved 62 patients who had undergone ACL reconstruction with the same results in clinical and functional assessment, which were then divided into 2 groups. In one group, an allograft was utilized, while in the other group – an autograft. The time it takes to perform the surgery, the cost, pain expected to be experienced, the possibility of postoperative complications, scarring, and the time needed for return to work were all considered and analyzed.

Results. The surgery time was 40.64 ± 4.23 min in group I in comparison to 52.48 ± 4.92 min in group II ($p < 0.05$). The cost of surgery was 32% higher in group I. Visual analogue scale (VAS) pain score in group I was from 36.45 ± 8.39 mm on the 3rd day to 15.16 ± 5.70 mm on the 28th day. In group II, it ranged from 60.67 ± 10.15 mm on the 3rd day ($p < 0.05$) to 18.67 ± 6.81 mm on the 28th day. The time of return to office work in group I was 6.96 ± 1.9 weeks and 9.27 ± 1.57 weeks in group II ($p < 0.05$). The time of return to physical work in group I was 19.85 ± 2.79 weeks, and 20 ± 3 weeks in group II. Postoperative scar and local complications were statistically less pronounced in group I.

Conclusions. Allografts achieve less postoperative pain, smaller local complications, shorter time necessary to return to work, and better cosmetic effect. However, an allograft is more expensive to perform.

Key words: anterior cruciate ligament, allograft, autograft, ACL reconstruction, knee arthroscopy

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Introduction

The reconstruction of the anterior cruciate ligament (ACL) of the knee joint is the standard procedure used in the treatment of complete ACL rupture for individuals desiring to return to high-level and vigorous physical activities,¹ and is advocated in order to prevent instability of the knee, further intra-articular disease and recurrent injury.^{2–4} The most frequently used grafts for reconstruction of ruptured ACL are: autologous grafts (semitendinosus (ST), gracilis tendon (GR), and combined semitendinosos and gracilis (STGR)), or allograft.^{5,6} Despite both grafts showing good results after ACL reconstruction, some authors suggest that graft selection should be based on an individual evaluation of patient demand. This suggestion is given because of potential advantages, such as less donor site morbidity or greater overall graft strength, particularly in allografts, due to the fact that the ST and STGR grafts have recently become more popular.^{7–10} Nevertheless, ST and STGR grafts, in contrast to allografts, are soft tissue grafts, which have a higher likelihood of slippage and loss of stability caused by slower healing and greater stress at the site of fixation.¹¹

Material and methods

The study was conducted in strict accordance with ethics guidelines and principles of the Declaration of Helsinki. Written informed consent forms were signed by all of the participants.

The retrospective analysis involved 61 patients which had undergone primary single-bundle ACL reconstruction with the same results in clinical and functional assessment, organized into 2 groups: one group utilizing allografts, the other group utilizing autografts. Sixty-two patients made up the initial sample. One patient stopped reporting for follow-up examinations. These patients had undergone ACL reconstruction, were operated on by the same 2 surgeons and the operation had been performed in 2014 and 2016. The inclusion criteria were as follows: primary unilateral intra-articular ACL reconstruction with the use of autologous ipsilateral STGR graft or allograft, and no additional injuries of the involved knee joint between the surgery and the 2nd measurement.

Surgical technique

The same surgical team operated on all the patients, using the same surgical technique, and either an allograft or autograft were used. It was fixed using an Endobutton (Smith–Nephew, Warsaw, USA) on the femur and an interference screw, ComposiTCP30 (Biomet, Warsaw, USA), on the tibia. After assessing the intra-articular structures (Fig. 1), the team started preparing the tibial canal. The tibial canal was prepared using the “outside-in”

technique. The aimer device was placed under the arthroscopic control, enabling the introduction of K-wire in the center of the tibial ACL attachment (Fig. 2) located in the intercondylar notch, 15 mm frontally to PCL. After the K-wire was introduced using a cannulated drill of 4.5 mm diameter, the tibial canal was drilled, and the team worked to leave the stump in the tibial attachment. Next, the K-wire was introduced into the tibial canal and, under arthroscopic control, was placed in the center of ACL femoral attachment on the inner area of the lateral femoral condyle using the “classic clock face” technique. After obtaining satisfactory placement for the procedure to continue, the K-wire was introduced into the femur through the cortical bone and the soft tissues over the skin of the thigh. Next, the canal was drilled with a drill 4.5 cm in diameter, allowing the introduction of the Endobutton. A measurement of the length of the femoral canal was taken using a scaled device (Fig. 3). Prepared this way into the canals, the wire was introduced with a loop made of a strong thread, through which the threads were pulled. The threads led the graft suspended on the Endobutton loop. After introducing the graft to both canals (Fig. 4), the assistant, while pulling the threads protruding beyond the canal, inspected graft stability in the femoral canal. Under arthroscopic control and with the extended graft, the knee joint was flexed by 90° to make certain the graft tape had settled properly.

Fig. 1. Arthroscopic image. Left knee joint. A ruptured right ACL

Fig. 2. Left knee joint. The K-wire coming out of the center of the stump, which is an evidence of a proper introduction of the wire into the tibial footprint

Fig. 3. Arthroscopic image. Left knee joint. Measuring the femoral canal

Fig. 4. Arthroscopic image. Left knee joint. The introduced graft

Clinical and functional assessment was made using Lysholm scale and International Knee Documentation Committee (IKDC) 2000 scale. Next, parameters analyzed in the postoperative period were as follows:

- Visual Analogue Scale (VAS) was applied on days 3, 7, 14, and 28 (VAS is a scaled ruler from 0 to 100 mm with an accuracy of 1 mm); complications were noted (hematomas at the collection site and intra-articular hematomas, skin sensation disturbances, pain in and around the back of the thigh).

- Check-up at 3 and 6 months after surgery: complications noted (skin sensation disturbance, pain in the back of the thigh).

- Control examination 18 months after surgery: complications reported (skin sensation disturbances, pain in and around the back of the thigh); measurement of the extent from one end to the other end of the postoperative scar on the tibia.

Statistical analysis

IBM SPSS Statistics v. 20 software (IBM Corp., Armonk, USA) was used in order to perform the statistical analysis. The arithmetic mean ($\bar{x}$) and standard deviation (SD) of the patients' age, the timescale between the surgery and measurements for the study groups were calculated. Data distributions for the pain values were evaluated for normality using the Shapiro–Wilk test.¹² The Wilcoxon test was employed for the intra-group to compare pain

values between the operated and non-operated knees, and between the preoperative and postoperative values. Differences in values were considered significant if $p < 0.05$.

Results

No statistical differences between groups were found in clinical and functional assessment on Lysholm scale ($p = 0.119$) and IKDC 2000 scale (0.992).

Results of pain assessment

The daily pain felt in the operated limb in group I can be interpreted as a mild pain, being that they were at maximum on the 3rd postoperative day $\bar{x} = 36.45 \pm 8.39$ mm. A comparative inspection of the results of the assessment of the extremity of daily pain of the operated limb in group I exhibited statistically significant differences ($p \leq 0.001$) between the results acquired successively on 3, 7, 14, and 28 postoperative days (Fig. 5).

The intensity of daily pain felt from the operated limb in group I was statistically significantly smaller ($p \leq 0.001$) on postoperative day 7 ($\bar{x} = 25.16 \pm 6.77$ mm) than on postoperative day 3 ($\bar{x} = 36.45 \pm 8.39$ mm). Pain also statistically significantly decreased ($p \leq 0.001$) on the 14th postoperative day ($\bar{x} = 17.74 \pm 6.17$ mm) compared to the 7th postoperative day. In turn, the intensity of pain sensations of the operated limb on the 28th postoperative day ($\bar{x} = 15.16 \pm 5.70$ mm) was comparable to the pain felt on the 14th day after surgery ($p = 0.448$). The relationships between individual results are noted in Table 1.

The pain felt in the operated limb in group II on the 3rd postoperative day was of moderate nature ($\bar{x} = 60.67 \pm 10.15$ mm). In the following postoperative days, the values did not exceed $\bar{x} = 43.67$ mm, so they can be considered as mild pain. Comparative analysis of the results of the assessment of the intensity of daily

Fig. 5. Results of the assessment of the intensity of daily pain experienced in the operated limb in groups I and II on subsequent postoperative days

Table 1. Comparative analysis of results obtained in assessing the intensity of daily pain using VAS in the operated limb in group I and II between individual postoperative days

Postoperative day	VAS							
	day 3		day 7		day 14		day 28	
	group I	group II	group I	group II	group I	group II	group I	group II
Day 3	–	–	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001
Day 7	≤0.001	≤0.001	–	–	≤0.001	≤0.001	≤0.001	≤0.001
Day 14	≤0.001	≤0.001	≤0.001	≤0.001	–	–	0.448	≤0.001
Day 28	≤0.001	≤0.001	≤0.001	≤0.001	0.448	≤0.001	–	–

Values expressed as p (level of statistical significance); VAS – visual analogue scale.

pain of the operated limb in group II, similarly to group I, showed statistically significant differences ($p \leq 0.001$) between the results obtained successively on 3, 7, 14, and 28 postoperative days (Fig. 5).

The intensity of daily pain of the operated limb in group II statistically significantly ($p \leq 0.001$) decreased on the 7th day after the operation ($x = 43.67 \pm 8.90$ mm) in comparison to the 3rd day after surgery ($x = 60.67 \pm 10.15$ mm). Between the 7th and 14th days following the operation ($x = 30.33 \pm 6.69$ mm), the intensity of pain also decreased statistically significantly ($p \leq 0.001$). Pain felt in the operated limb on the 28th day post-operation ($x = 18.67 \pm 6.81$ mm) was significantly ($p \leq 0.001$) less intense than on the 14th day after surgery. The results are shown in Table 2.

Comparison of the results of the assessment of the intensity of daily pain experienced in the operated limb showed that in group I, the level of said pain was statistically significantly lower than in group II (from $p \leq 0.001$ to $p = 0.033$). A comparative analysis of the results obtained in both examined groups is presented in Fig. 6.

Results of the return to work evaluation

The patients from group I statistically significantly ($p \leq 0.001$) returned to office work faster ($x = 7.00 \pm 1.93$ weeks) than to physical work ($x = 19.86 \pm 2.79$ weeks). In group II,

Fig. 6. Comparison between the research groups for pain intensity results in the operated limb on individual days post-operation **Fig. 7.** Comparison of time taken to return to office work and to physical work in both groups

patients also statistically significantly ($p \leq 0.001$) returned to office work faster ($x = 9.24 \pm 1.61$ weeks) than to physical work ($x = 20.00 \pm 3.00$ weeks) (Fig. 7).

Patients from group I statistically significantly ($p \leq 0.001$) returned to office work faster than patients from group II. The time taken to return to physical work was comparable in both groups ($p = 0.924$) (Fig. 7).

Local postoperative complications

Skin hypoesthesia did not occur in any of the patients in group I (Table 2). In contrast, it occurred in 17 patients in group II, constituting 57% of patients in group II. Symptoms of skin hypoesthesia resolved in less than 3 months after reconstruction of the ACL in 59% of the patients (Table 2). Symptoms of skin hypoesthesia resolved within 3–6 months of surgery in 29% of the patients. In the remaining 12% of the patients with symptoms of skin hypoesthesia, the symptoms resolved more than 6 months after the reconstruction of the ACL.

None of the patients in group I complained of pain in the posterior thigh of the operated limb (Table 2). However, 21 patients from group II reported this symptom, which constituted 70% of the patients from group II. Thigh pain subsided in less than 3 months of reconstruction of the ACL in 81% of the patients (Table 2). This symptom

Table 2. Analysis of the occurrence of skin hypoesthesia symptoms and analysis of pain in the posterior thigh of the operated limb and its remission in group I and group II

Group	Occurrence of symptoms	Remission of symptoms		
		<3 months after surgery	3–6 months after surgery	>6 months after surgery
Skin hypoesthesia in the operated limb, n				
Group I	0	0	0	0
Group II	17	10	5	2
Pain in the posterior thigh of operated limb, n				
Group I	0	0	0	0
Group II	21	17	3	1

Values expressed as n (number of patients in test group).

resolved within 3–6 months of surgery in 14% of the patients. In the remaining 5% of patients, pain in the posterior thigh of the operated limb persisted for more than 6 months after surgery.

Four patients from group II had hematoma at the graft site, which made up 13% of group II. Three out of 4 patients with hematoma received conservative treatment, and 1 patient out of 4 hematoma required surgical intervention.

Discussion

Numerous reports show differing opinions on the choice of an acceptable term of surgical treatment, option of graft and graft fixation approach, bone canal preparation method, or the selection of postoperative approach to rehabilitation^{8–12}; however, there are only a few scientific papers regarding cost and patient comfort. Some of them can be compiled as duration and costs of surgery, postoperative pain, postoperative complications, time taken to return to work, and cosmetic effects.

The analysis of the cost of surgery shows that the allograft procedure generates a 32% higher cost compared to the autograft procedure. This, of course, is related to the cost of the graft, because the costs of the implants are the same, and the difference in the time of surgery does not cause financial savings that can offset this expense. This coincides with the observations of other authors.^{13,14} However, the difference in the cost of the procedure is greater in this work than in the works of other authors. In the work of Cole et al., this difference was 18%,¹⁵ and according to Nagda et al., the use of the allograft increased the cost of the procedure by only 11%.¹⁶ This is associated with the large number of tissue banks, especially in the USA, implying greater availability and lower transplant prices. This is a field for a broader discussion regarding transplantology in Poland.

The type of transplant did not affect postoperative management. In both groups, walking on crutches and using the orthosis device for 3 weeks was recommended. In medical literature, differences have not been encountered in postoperative management and rehabilitation due to the use of the allograft.^{17–19}

On days 3, 7, 14, and 28, postoperative pain intensity in patients was monitored in both groups using VAS. Comparing both groups, it is clear that in the material, statistically significantly smaller pain occurred in patients operated on using the allograft. This is in agreement with the studies of other authors who consider significantly less postoperative pain as an advantage of using allografts.^{20,21}

In all patients in both groups, there were no inflammatory septic complications or arthrofibrosis. This confirms the safety of using allografts in cooperation with certified tissue banks.²² Other researchers also point out the lack of difference in the incidence of inflammatory complications using allo- and autographs in the primary reconstruction of ACL.²³

The most frequently observed local complications concerning the operated limb among patients were skin hypoesthesia, posterior thigh pain and hematomas at the attachment site. Skin hypoesthesia is associated with damage to the skin branch of the femoral nerve. Among patients in the allograft group, skin hypoesthesia was rare and resolved in the first 3 months after surgery. Much more often, the symptom of skin hypoesthesia was reported by patients after primary ACL reconstruction using an autograft. The time until cessation of symptoms in these patients was much longer. This problem is related to the incision performed for graft harvesting and is also indicated by other researchers.²⁴ It should be noted that this symptom did not affect the function of the knee of the examined patients after reconstruction of ACL; it was only a discomfort for them. Other authors also confirm the frequent occurrence of this symptom without affecting knee joint function after ACL reconstruction.²⁵ The incidence of this discomfort among patients in the autograft group was an unwelcome surprise. This confirmed the opinions of other researchers that the incidence of damage to the skin branch of the femoral nerve when performing vertical cutting for hamstring is high; it decreases when ST is taken and increases when ST and GR are taken.²⁴ The risk of damage is also reduced by an oblique incision when accessing hamstrings.²⁶

Posterior thigh pain in the early postoperative period occurred in the autograft group in most patients. Due

to the fact that no such symptom was observed in any patient in the allograft group, it should be assumed that this pain is associated with hamstring tendon collection. There have been no instances in literature of any other researchers assessing the occurrence of this symptom in the early postoperative period. In most patients, this symptom resolved within 3 months after surgery, which may confirm the hamstring "regeneration" phenomenon described by other authors.²⁷ However, other researchers noted the fat degeneration of hamstrings, improper regeneration and weakening of flexor strength in the operated limb.²⁸ These phenomena may explain the occurrence of pain in the back of the thigh of the operated limb, persisting over 3 months after surgery in 4 patients operated on using an autograft.

Lower limb hematomas only occurred in patients from the autograft group and were associated with bleeding from the hamstring site. In 1 patient, the hematoma required surgical intervention and re-hospitalization. No studies in medical literature have been found analyzing the occurrence of hematomas at the site of taking hamstring tendon harvest.

According to the analysis of our material, local complications related to the operated limb such as skin hypoaesthesia, posterior thigh pain and hematomas at the donor site concerned only patients operated on using autografts. Their absence in the allograft group is one of the undoubted advantages of using allografts. These observations are consistent with the published analyses of other authors.^{20,29}

There are interesting results concerning time taken to return to work assessed for operated patients. In the group of patients with allografts, the time taken to return to office work was shorter than in the group of patients with autografts. This is because there is less pain in the postoperative period and no local complications in the form of hematomas and pain in the back of the thigh in the group of allografts. In the case of manual labor, the time necessary to return to work was comparable in both groups. No literature was found that compared the time needed to return to work in relation to the graft used. The time taken for patients from the autograft group to return to work coincided with the observations of Groot et al.³⁰

Regarding the length of the postoperative scar in the lower leg, the scar was significantly shorter in patients from the allograft group. In our opinion, this has both a better cosmetic effect, which is especially important for women, and is associated with fewer local complications. This coincides with the observations of other researchers.^{20,29}

The main limitation is the short-term follow-up. In the future, studies involving long-term follow-up with patients that have undergone fully supervised physiotherapeutic procedures and a comprehensive clinical and functional evaluation should be considered.

At this moment, there are numerous studies being conducted focusing on highlighting genetic predisposition

to cruciate ligament injuries. Research on the application of stem cells, plasma rich in platelets and xenografts are also breaking new ground. These present trends in the evolution of ACL surgery will pave the way for a far more individualized method of surgical treatment.

Conclusions

The choice of the graft impacts duration and costs of surgery, postoperative pain, local complications, time necessary to return to work, and cosmetic effect. An allograft reduces the duration of lower surgery, postoperative discomfort and pain, local complications and the time required to return to work, as well as increases cosmetic effect. However, the cost is higher.

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