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Comparison of results of ACL reconstruction using LARS method and autogenous ST/GR graft

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Purpose: The objective of the study was assessment of the function of the knee joint after ACL reconstruction using the LARS method and autogenous graft. The study was of a retrospective character and included 96 patients who had undergone reconstruction of the torn ACL. The study was conducted within 36–48 months after surgery. *Methods*: In order to compare the results of the ACL reconstruction performed with 2 types of grafts, the following instruments were used: Lysholm Knee Scoring Scale, SF 36v2 questionnaire for assessment of health-related quality of life, and Biodex System 4 for isokinetic muscle testing. *Results*: No differences in the evaluation of the quality of life measured using SF 36v2 questionnaire were observed between the LARS and ST GR groups. Using the Lysholm Scale, the distribution of knee function scores was compared according to the type of surgery. There are no grounds to confirm the differences in the distribution of knee function scores considering the type of graft ($p = 0.756$). Isokinetic test showed a significant weakening of muscle strength in the operated limb, compared to the strength of the healthy limb. *Conclusions*: The type of graft used for ACL reconstruction does not exert an effect on the quality of life of patients or the level of their knee joint function. Extensor and flexor muscles strength of the knee joint was lower in the operated limb, irrespective of the type of graft used. Weak relationships were observed between the level of knee joint function and extensor muscle strength of this joint.

Key words: *knee, ACL reconstruction, LARS, knee function, artroscopy*

1. Introduction

High effectiveness of ACL reconstruction in the mechanical stabilization of the knee joint encouraged the seeking of increasingly better surgical techniques. The goal of these techniques is to increase mechanical endurance of the graft, the site and method of its fixation – shortening the time of surgery, and maximum acceleration of the rehabilitation process. For the patients, the time elapsed to the restoration of the function of the joint is most important. Synthetic materials provide such possibilities [17]. These materials have been introduced as replacement of biological human tissue since the beginning of the 1970s. For the production of synthetic ligaments were used, among others, teflon, polypropylene, carbon fibre, polyester composites or Gore Tex [21], [28]. The assessment of the knee joint function in patients in whom the above-mentioned materials were applied was unsatisfactory. The main post-operative complications were inflammatory states of the synovial membrane, filings in the articular cavity as well as tear of the graft [21], [24].

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2. Material and methods

2.1. Participants

The study was of a retrospective character and included 96 patients who had undergone reconstruction of the torn anterior cruciate ligament, and was conducted within the period of 36–48 months after surgery. The study group were 44 patients operated on using the LARS method, whereas the control group were 52 patients who had undergone reconstruction using autogenous ST/ GR graft.

Excluded from the study were patients aged over 50, those who had undergone the reconstruction of more than one ligament, those in whom currently occurred an injury concerning one of the joints of the healthy or operated limb, as well as patients who had undergone a revision reconstruction.

The criteria considered as neutral for the study were concomitant surgeries of suturing or removal of the meniscal performed during the primary ACL reconstruction.

Both groups were compared according to age and gender. In the examined population, the number of males was considerably higher that that of females (76; 79.2% and 20; 20.8%). The selection of such a group was due to the limited number of patients operated on using the LARS method. Among patients in the study group there were 37 males (84.1%) and 7 females (15.9%), whereas in the control group – 39 males (75.0%) and 13 females (25.0%). The results obtained by patients aged 27–50 were analyzed (mean age approx. 36). Patients who had undergone reconstruction with autogenous graft ($\bar{x}$ = 34.6; Me = 33.5; s = 7.3; min = 27; max = 50) were younger by approx. 4 years, on average, than those operated on using the LARS method ($\bar{x}$ = 38.8; Me = 39.0; s = 8.0; min = 27; max = 50).

The duration of rehabilitation was significantly longer (p = 0.0235) in the group operated on with autogenic graft. Over 20% of the group was rehabilitated >16 weeks. 7 patients (13.5%) were subjected only to physical therapy, 42 patients (80.8%) apart from physical therapy had individual sessions with a therapist. The remaining 3 subjects (5.7%) did not have any rehabilitation at all. All patients operated with LARS had rehabilitation, which lasted a maximum of 16 weeks. Similarly to the previous group, 13.6% of the subjects underwent only physical therapy, and the rest (86.4%) had individual therapy supplemented with physical therapy.

According to the guidelines from the literature and depending on the existing structural and functional deficits and indications, the post-surgery rehabilitation program consisted of protocol including the PRICE principle (in the initial period), progressive weight-bearing walking, progressive range of motion (ROM) exercise, progressive strengthening exercise of the knee muscles, stretching exercises, proprioception exercises and stabilization of the knee, reeducation of gait as well as the educational program focused on the potential post-surgical complications and limitations [18], [22].

2.2. Methods

The following research instruments were applied:

1) Lysholm Knee Scoring Scale – for assessment of the knee function. The results may be interpreted according to the scale presented below by defining the knee function as: excellent: 90–100 scores, very good: 80–89 scores, good: 70–79 scores, fair: 60–69 scores, and poor: < 60 scores.
2) Quality of life questionnaire SF 36v2 – consisting of 36 items divided into 8 domains: PF – physical functioning, RP – role physical, BP – bodily pain, GH – general health, VT – vitality, SF – social functioning, RE – role emotional, MH – mental health; maximum number of scores – 100, the higher the number of scores the better the quality of life. The license No QM026506 to use the questionnaire SF_36 v. 2.0 was obtained from OptumInsight Life Sciences, Inc.
3) Biodex 4 System for isokinetic muscle testing. Measurements for the purpose of the study were performed at angular velocity of 60 s; 3 trials were undertaken, 5 repetitions each. The following velocity and strength parameters of the examined knee joint extensor and flexor muscles were evaluated: peak torque – reflects maximum strength of the examined group of muscles, and peak torque to body weight (peak torque/bw) – enables precise determination of the strength capability of muscles, considering various body weight of patients.

Statistical analysis

Statistical calculations were performed using the software Statistica. In order to compare pain complaints and classification of the function of the knee according to standards in various groups chi-square test for independence was applied, while the distribution of isokinetic parameters and the results of the Lysholm Scale, according to type of surgery, were compared by means of Mann–Whitney *U*-test. The significance of the differences between results of isokinetic tests for the healthy and afflicted limb were assessed using the Wilcoxon

signed rank test. The relationships between isokinetic parameters and the result according to the Lysholm Scale were assessed by means of Spearman rank correlation coefficient. The values $p < 0.05$ were considered statistically significant [26].

3. Results

Comparison of knee function according to Lysholm Knee Scoring Scale in patients from both groups

Comparison of evaluations of knee function depending on the type of surgery was performed using the Lysholm Knee Scoring Scale. Patients from the LARS group obtained the following results: poor function – 2 patients (4.5%), fair – 1 patient (2.3%), good – 6 patients (13.6%), very good – 16 (36.4%), and excellent – 19 (43.2%). Persons from the control group obtained the following results: poor – 3 (5.8%), fair – 1 (1.9%), good – 3 (5.8%), very good – 19 (36.5%), and excellent – 26 (50.0%). There are no grounds for the confirmation of differences in the distribution of evaluations of knee function between the two groups ($p = 0.7555$).

Comparison of pain complaints according to Lysholm Knee Scoring Scale in patients from both groups

The pain incidence was compared in both groups based on Lysholm scale. No pain was found in 38.5% of the subjects from the group of patients operated on using autogenous graft, and 34.1% in the group operated on with LARS. There were no statistically significant differences between the two groups (Table 1).

Table 1. Comparison of pain in both groups

Pain in Lysholm scale	Group ($p = 0.6413$)		Total
	Autogenous graft	LARS	
No pain	20 (38.5%)	15 (34.1%)	35
Light pain on heavy loads	22 (42.3%)	22 (50.0%)	44
Significant pain during giving-way	5 (9.6%)	4 (9.1%)	9
Significant pain on heavy loads	3 (5.8%)	2 (4.5%)	5
Significant pain during or after > 2 km walk	2 (3.8%)	0 (0.0%)	2
Significant pain during or after < 2 km walk	0 (0.0%)	1 (2.3%)	1
Total	52	44	96

p – test probability value calculated using the chi-squared test of independence.

Comparison of the quality of life of respondents from both groups

The majority of patients examined expressed the most negative evaluations of the quality of life in the domains of general health ($\bar{x} = 62.5$ scores) and mental helth ($\bar{x} = 70.4$ scores). The most positive evaluations concerned role limitations – both due to physical and emotional problems ($\bar{x} > 95$ scores). The quality of life of patients was also compared according to the type of surgical procedure. No statistically significant differences in the level of the quality of life measures were observed, whereas for 3 components the differences were close to statistical significance. The quality of life was slightly better among patients who were operated on using the LARS method, compared to those who had undergone surgery with the use of autogenous graft with respect to: social functioning ($\bar{x} = 92.9$ vs. $\bar{x} = 87.0$), the domains of mental health ($\bar{x} = 79.6$ vs. $\bar{x} = 74.9$), and overall health-related quality of life ($\bar{x} = 86.3$ vs. $\bar{x} = 81.5$).

Comparison of the results of isokinetic testing in both groups

The presence of a systematic difference may be noted between the values of both isokinetic parameters assessed for the operated and non-operated limb, both in the LARS and ST/GR groups. The values obtained for operated limbs were clearly lower than those for the healthy limbs.

However, no statistically significant differences were found with respect to con-con 60°/sec peak torque and con-con 60°/sec peak torque/bw for extensors and flexors of the operated and non-operated knee joints in the 2 groups compared. Statistically significant differences were found only between various types of surgery in the values of con-con 60°/sec peak torque/bw measurements in the case of flexors of the operated limb ($p = 0.0191$). Lower values of this measure were obtained only by patients who had undergone surgery using the LARS method (Table 2).

Comparison of isokinetic assessment between operated and healthy limb in both groups

Considering the assessment of peak torque for knee flexors, the difference between operated and non-operated limb was – 5.7 in the ST/GR group, and 12.7 in the LARS group, on average; similarly, while assessing the parameter peak torque/bw, the obtained results were: in the ST/GR group – 7.2, and in the LARS group – 13.8, on average. Thus, in both cases, the difference was higher after using the

Table 2. Results of isokinetic testing of the parameters con-con 60°/s peak torque and con-con 60°/sec peak torque/bw for extensors and flexors in both groups

con-con 60°/sec peak torque	Group						p^A
	ST/GR			LARS			
	$\bar{x}$	Me	s	$\bar{x}$	Me	s	
Non-operated side con-con 60°/sec flexors peak torque	80.5	82.6	24.6	78.1	77.3	35.8	0.4572
Non-operated side con-con 60°/sec extensor peak torque	168.7	176.3	59.3	161.2	159.8	60.3	0.4935
Operated side con-con 60°/sec flexors peak torque	74.9	72.8	28.8	65.4	66.3	24.1	0.1100
Operated side con-con 60°/sec extensor peak torque	150.0	158.3	59.5	148.5	141.4	61.0	0.1824
con-con 60°/sec peak torque/bw	Group						p^A
	ST/GR			LARS			
	$\bar{x}$	Me	s	$\bar{x}$	Me	s	
Non-operated side con-con 60°/sec flexors peak torque/bw	101.8	106.0	25.1	92.7	89.7	41.8	0.0709
Non-operated side con-con 60°/sec extensor peak torque/bw	211.5	221.6	58.7	193.2	200.5	64.1	0.1350
Operated side con-con 60°/sec flexors peak torque/bw	**94.6**	**95.6**	**30.7**	**78.9**	**80.3**	**28.7**	**0.0191**
Operated side con-con 60°/sec extensor peak torque/bw	187.1	196.4	62.1	179.4	173.1	70.5	0.3616

p^A – Mann–Whitney *U*-test.

LARS method. At the same time, for both parameters, the differences between operated and non-operated limb were statistically significant only in the LARS group.

While analyzing mean results obtained for the operated and non-operated knee joint extensors, higher and statistically significant differences in both parameters were found in the ST/GR group – 18.7 and – 24.4, respectively. In the case of the LARS group the difference in the peak torque measure was lower than in the ST/GR group – 12.7; however, it was also statistically significant. While evaluating the other parameter – peak torque/bw in this group, no statistically significant differences were observed (Table 3).

Table 3. Comparison of the results of isokinetic tests of extensors and flexors obtained for operated and non-operated limbs

con/con 60	Operated vs. healthy limb		
	ST/GR	LARS	Total
Flexors peak torque	–5.7 (p = 0.0535)	–12.7 (p = 0.0030)	–8.9 (p = 0.0005)
Extensors peak torque	–18.7 (p = 0.0005)	–12.7 (p = 0.0419)	–16.0 (p = 0.0001)
Flexors peak torque/bw	–7.2 (p = 0.0728)	–13.8 (p = 0.0088)	–10.2 (p = 0.0014)
Extensors peak torque/bw	–24.4 (p = 0.0003)	–13.8 (p = 0.0588)	–19.5 (p = 0.0001)

p – Wilcoxon signed rank test.

Relationships between the results of self-reported knee joint function and results of isokinetic testing of extensor and flexor muscles of the operated knee joint

No clear correlations were observed between isokinetic test results con/con 60°/sec, and the Lysholm Scale values. The exceptions were weak, and there were significant positive correlations between extensors strength and Lysholm Scale values (R = 0.36) in the group operated on using the LARS method and in the total population examined (R = 0.22) (Table 4).

Table 4. Isokinetic assessment and results according to Lysholm Scale in both groups

con-con 60 test	Group		
	ST/GR	LARS	TOTAL
	Lysholm Scale		
Operated limb			
flexors peak torque	0.12 (p = 0.4067)	**0.25 (p = 0.0958)**	0.19 (p = 0.0617)
extensors peak torque	0.12 (p = 0.4049)	**0.36 (p = 0.0154*)**	**0.22 (p = 0.0320*)**
flexors peak torque/bw	0.20 (p = 0.1659)	0.09 (p = 0.5490)	0.18 (p = 0.0871)
extensors peak torque/bw	**0.27 (p = 0.0544)**	0.21 (p = 0.1662)	**0.22 (p = 0.0310)**

R – Spearman rank correlation coefficient.

4. Discussion

In the relevant literature, the reports concerning assessment of the knee joint muscle strength and function and the quality of life of patients after the ACL reconstruction using the LARS method are relatively scarce. The presented study included 44 patients who received the LARS graft and 52 patients with autogenous graft ST/GR. The group of patients who were operated on using the LARS method, despite being slightly smaller due to the number of surgeries performed in the Specialist Hospital in Rudna Mała, does not differ in this respect from reports by other researchers. The results presented in literature by Huang describe 43 cases [11], Gäbler – 26 [7], and Lavoie – 47 [14]; however, the study by Gao et al. [8] is worth mentioning, which covered 159 patients operated on using the LARS method and conducted in 4 centres.

In the presented study, the Lysholm Knee Scoring Scale was applied for the assessment of knee function. No statistically significant difference in the assessment of knee function was observed between both groups examined. The mean number of scores obtained by patients with the LARS ligament graft was 85.5 scores (very good result), similar to the ST/GR group – mean score 88. In the group of patients with the LARS ligament graft there were 2 patients who obtained the result on the level below 60 scores (poor result), and 3 such cases in the ST/GR group.

The result obtained in the study by Lee et al. [15] conducted in a group of 112 patients who had undergone autogenous graft, was close to that obtained in own study, and remained on the level of 85.2 scores during a 5-year period of observation. Barenius et al. [2] conducted a long-term study in the same group of patients, and the results obtained after 2, as well as 8 years were on the mean level of 88 scores. Sebastiani [23] examined 31 patients who had undergone ACL reconstruction using LARS. The study was conducted at least 10 years after the reconstruction. The mean score according to the Lysholm Scale obtained by this group of patients was 96.6 (excellent result); similarly, a nearly 3-year observation by Huang [11], describing 43 cases of patients who had undergone ACL reconstruction using LARS, presented mean results on the level of 95.6 scores (excellent result). The results by Sebastiani and Huang show that not only the time elapsed from surgery, but also other factors exert an effect on the assessment of the knee joint function performed by means of the Lysholm Scale in patients treated using the LARS method. The study by Gao in a group of 159 patients who received a LARS graft indicated the results according to the Lysholm scale on the level of 94.5 scores. High results obtained in knee function assessment in own study are very close to those obtained by other researchers [2], [11], [23]. It is noteworthy that in the examined groups there were single results on a poor level. Parchi et al. [20] also observed 2 patients from among 26 operated on using the LARS method, who obtained poor result according to the function scale KOOS, within the mean time of 8 years after the surgery. In the study by Shervegar et al., conducted on a group of 50 patients who had undergone anterior cruciate ligament reconstruction with hamstring tendons, within the period up to 4 years after the surgery, 5 patients obtained poor result according to the Lysholm Scale – below 65 scores [25].

In the study of health-related quality of life by means of SF36v2, the patients evaluated their quality of life in very positive terms, on the mean level for both groups – 83.9/100 scores. The most positive evaluations were expressed with respect to subscales concerning role limitation due to physical and emotional problems – over 90 scores. The most negative evaluations were obtained in the categories: general health (62.5 scores) and mental helth (71.1 scores). No statistically significant differences were observed between the examined groups of patients. Patients operated on using the LARS method obtained slightly higher results with respect to the domains of social functioning, mental health, and overall quality of life. Barenius [2], during an 8-year period of observation in patients after autogenous graft, presented the result according to the SF 36v2 scale – 75 scores (the lowest result in the domain of vitality – 67 scores). These results are close to the results of own study, despite a considerable difference in time when they were conducted. Busja et al. [3], in the study conducted 2 years after ACL reconstruction using the ST/GR graft presented results on the mean level of 83.4 scores. This result is nearly identical as that obtained in own study. The patients examined by these researchers expressed the most negative evaluations concerning own vitality – on the level 71 scores, and pain – 75.2 scores. In literature, no reports have been found pertaining to the quality of life measured using SF 36v2 questionnaire in the group of patients operated on using the LARS method. Falconer et al. [6] evaluated the quality of life of patients using the ACL-QOL questionnaire 2 years after ACL reconstruction with ST/GR – control group (27 individuals), and with ST/GR graft and LARS ligament graft – LARS group (61 patients). No significant differences were found between groups: $\bar{x}$ = 80.00 (control group) and $\bar{x}$ = 80.16 (LARS

group). Machotka et al. [16] conducted a literature review concerning the results obtained after ACL reconstruction using the LARS method. Out of 20 articles published between 2000–2010 in 8 databases, only 4 satisfied their criteria of inclusion into analyses. A high level of satisfaction with life after surgery in these patients was the only compatible result reported in the analyzed study.

Fully restored muscle strength is very important for the normal functioning of the knee joint after ACL reconstruction. Similar to the study by Baltaci et al., Chen J. et al., Królikowska et al, in order to reliably determine strength capabilities of muscles, in the examined group of patients isokinetic parameters were analyzed – peak torque [Nm] and peak torque/bw [%] at velocity of 60°/sec [1], [4], [13].

In own study, the muscle strength values obtained during con/con training mode were considerably lower than in the healthy limb. Similar observations have been presented by authors of reports where ACL reconstruction was performed using both autogenous graft [10], and the LARS ligament [2].

Patients with LARS ligament obtained lower results of flexor and extensor muscles strength in both limbs, compared to those who received autogenous graft; however, these differences were statistically insignificant, with the exception of flexors strength in the operated limb. Considering low values of flexor muscles strength in both groups of patients, muscle group strength was analyzed between the healthy and operated limbs. Knapik et al. [12] considered that the imbalance between the limbs exceeding 15% increases the risk of occurrence of the knee joint injury by almost 3 times. According to this classification, a greater imbalance was observed in the patients from the LARS group (over 70%) than in those from the ST/GR group (48%). Thomas et al. [27], in their study, did not observe a similar weakening of the flexor muscles strength between the healthy and the operated limbs in the examined patients. However, there are reports indicating a deficit of muscle strength exceeding 15% between flexors of the healthy and operated limb 2–3 years after the ACL reconstruction surgery [10].

The results concerning knee joint extensor muscles in the examined group of patients are also unsatisfactory. Nearly 44% of the patients in the study had a strength deficit of over 20% between extensors in the healthy and operated limbs. Similar results were presented by other researchers: Thomas – 6 months after surgery [27], De Jong – within the period of 12 months [5], and Hiestra – 3 years after ACL reconstruction [10].

In the current study, a very weak positive correlation was found between the Lysholm Scale and extensors strength in the operated limb in the total population examined. A positive correlation was also discovered for the parameter of extensor muscles in the operated limb; however, only in patients who had undergone reconstruction using the LARS method. Nevertheless, Oh et al. [19] did not observe any correlation between the results of isokinetic tests and assessment by means of the Lysholm Scale at month 6 after ACL reconstruction.

In the literature, very different results have been reported concerning the assessment of flexor and extensor muscles strength. This may result from differences in the rehabilitation programmes in which the patients participate. It is noteworthy that the weakening in the strength of these muscles is frequent, despite rehabilitation strategies aimed at their strengthening. Chronic weakening of knee extensors and flexors may be due to persistent incorrect walking patterns, impaired proprioception or arthrogenic muscle inhibition [9]. It should be remembered that the lack of normal muscle strength may become one of the causes of secondary ACL injury.

In the light of the presented results, it may be presumed that the examined groups of patients present good results of treatment. However, it is not possible to indicate one type of surgery which would guarantee obtaining clinically better outcomes. The selection of the type of surgery should be considered individually, according to, among others, time elapsed from injury, time devoted to the return to sports activity, and financial capabilities of the operated patients (lack of the cost reimbursement of surgery using the LARS method).

5. Conclusions

1. The type of graft used for ACL reconstruction does not exert an effect on the quality of life of patients or the level of their knee joint function.
2. Extensor and flexor muscles strength of the knee joint is lower in the operated limb, irrespective of the type of graft used.
3. Weak relationships are observed between the level of knee joint function and extensor muscle strength of this joint.

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