

Evaluation of muscle strength and knee joint movements after arthroscopic reconstruction of the anterior cruciate ligament

(Ocena siły mięśni i ruchów stawu kolanowego po artroskopowej rekonstrukcji więzadła krzyżowego przedniego)

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Abstract – Introduction. Due to the functional importance of the knee joint, and at the same time the growing number of injuries, it is necessary to continually search for optimal treatment methods both for, surgery and post-operative rehabilitation.

The aim of the study. The study aims to evaluate the strength of muscles and movements in the knee joint, in post-arthroscopic operation patients by portal one, and two-bundle anterior cruciate ligament (ACL) reconstruction.

Materials and Methods. The study involved 94 patients who were divided into a group of 1 - 49 people after a single-bundle reconstruction, and a group of 2 - 45 patients after a two-bundle reconstruction. Prospective studies according to a uniform evaluation sheet were conducted after 4 (study 1), 6 (study 2) and 12 (study 3) weeks after the surgery.

Results. In the assessment of a passive and active range of flexion of the knee joint, patients from group 1 achieved statistically significantly better results in study 4 and 6 weeks after surgery. The average muscle strength of the thigh stretch was obtained in all patients after 12 weeks. A statistically significant difference was found in the study of thigh flexor muscle strength after 12 weeks, with better results in group 1 patients.

Conclusions. Patients who were operated using the double-bundle method (group 2) had worse results in the majority of parameters assessed, despite better knee joint stability. In the rehabilitation program, special attention should be paid to the reduction of edema and pain, which will probably lead to better results in this group.

Key words - knee joint, ACL, physiotherapy.

Streszczenie – Wstęp. Ze względu na funkcjonalne znaczenie stawu kolanowego, a równocześnie rosnącą liczbę urazów konieczne jest ciągle poszukiwanie optymalnych metod leczenia zarówno operacyjnego, jak i pooperacyjnej rehabilitacji.

Cel badań. Celem pracy jest ocena siły mięśni i ruchów w stawie kolanowym u pacjentów po artroskopowej przez portalowej jedno i dwupęczkowej rekonstrukcji ACL.

Materiał i metodyka. Badaniami objęto 94 pacjentów, których podzielono na grupę 1 - 49 osób po rekonstrukcji jednopęczkowej i grupę 2 - 45 pacjentów po rekonstrukcji dwupęczkowej.

Prospektywne badania wg jednolitego arkusza oceny przeprowadzono po 4 (badanie 1), 6 (badanie 2) i 12 (badanie 3) tygodniach od zabiegu.

Wyniki. W ocenie biernego i czynnego zakresu ruchu zginania stawu kolanowego pacjenci z grupy 1 uzyskali istotnie statystycznie lepsze wyniki w badaniu po 4 i 6 tygodniach od zabiegu. U wszystkich badanych pacjentów po 12 tygodniach uzyskano prawidłową siłę mięśni prostowników uda. Istotną statystycznie różnicę wykazano w badaniu siły mięśni zginaczy uda wykonanym po 12 tygodniach, gdzie lepsze wyniki uzyskali pacjenci z grupy 1.

Wnioski. Pacjenci operowani metodą dwupęczkową (grupy 2) mieli gorsze wyniki w większości ocenianych parametrów, pomimo lepszej stabilności stawu kolanowego. W programie usprawniania należałoby zwrócić szczególną uwagę na zmniejszenie obrzęku i dolegliwości bólowych, co prawdopodobnie pozwoli uzyskać lepsze wyniki w tej grupie.

Słowa kluczowe – staw kolanowy, ACL, fizjoterapia.

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I. INTRODUCTION

The knee joint is adapted to transfer significant loads of different orientations, mainly under the conditions of compression under the influence of gravity; it fulfills two main tasks in the biomechanics of the lower limb in a human body. First of all, it is maintaining stability in the joint extension. Its second task is to maintain mobility in the bend during the performance of such activities as, for example: running on rough terrain, where it is also essential to maintain proper foot orientation. In most situations, the knee joint functions as a joint with one degree of freedom for the bending and stretch movement in the sagittal plane around the transverse axis. The second degree of movement freedom occurs at the bent knee joint and is associated with rotation around the longitudinal axis of the lower leg [1].

The connection of the femur with the tibia bone stabilizes the knee ligaments of the knee. The strength of the ligaments is vast, but they are not very flexible. The tension of individual fibers depends on the position of the knee joint and is variable when performing various movements [2-7].

ACL damage is most often caused by practicing various sports disciplines, such as contact sports, e.g., team games or the so-called contactless sports (e.g., skiing, tennis). Damage caused as a result of the knee joint injuries, not only causes significant impairment of the entire limb function and leads to the appearance of subsequent degenerative changes, but also disturbances of receptor sensation, which in turn, may increase the risk of re-injury [4]. One of the most frequently damaged structures of the knee joint is the anterior cruciate ligament (ACL). In the United States alone in 2000, about 175000 ACL reconstructions were carried out, which cost about \$2 billion [8].

The surgery indication is the degree of joint dysfunction resulting from damaged structures. Lack of symptoms of instability resulting from damage is not an absolute indication for surgical treatment. Generally accepted criteria for a reconstruction, apart from an ACL injury, are the full ex-

tent of knee joint movement, in particular, the extension, correct muscle strength ensuring good muscular control of the joint, no contraindications.

With regard to the rehabilitation procedure after the operation, it can be said, that many centers dealing with ACL reconstruction have their own developed program. However, it is based on the same principles, and the most important goal is to achieve the full function of the joint without losing its stability. The rehabilitation programs particularly distinguish the methods aiming at regaining the efficiency of the knee extension, strength and muscular control of the joint as well as the analgesic effect. The various models of the procedure after reconstruction (more or less intense), the aims of the different phases of rehabilitation are determined. Most of the authors agree that the patient will get a full ability to stretch, as soon as possible (1-2 weeks after the procedure). The differences most often concern the range of bending movements in the knee joint during the various phases of rehabilitation. The commonly used methods include: closed and open kinematic chain exercises, isometric, active, active with resistance, proprioception exercises, and mobilizations. Physiotherapy treatments and elastic therapeutic taping are used as treatments to improve the procedure [9, 10].

The study aims to evaluate the muscles strength and movements in the knee joint in arthroscopic patients by the single and double-bundle portal ACL reconstruction using the ST, G method.

II. MATERIALS AND METHODS

Materials

The study involved 94 (34 women and 60 men, mean aged 36.06 years) patients who were operated due to ACL injury.

Patients were divided into two groups based on the type of surgical reconstruction of the anterior cruciate ligament: group 1 - 49 patients (17 women and 32 men, average age $x = 36.5$ years) after a single-bundle ACL reconstruction, group 2 - 45 people (17 women and 28 men, average age $x = 35.6$ years) who undergone two-bundle ACL reconstruction.

The period from the moment of ligament damage to surgery was about 4 months.

Exclusion criteria were the coexistence of damage to another ligament of the knee above the second degree, the trauma of another joint or the other lower limb, postoperative complications affecting the rehabilitation process and

the interruption of the rehabilitation program due to the patient's causes.

Methodology

The tests were carried out after 4 (study 1), 6 (study 2) and 12 (study 3) weeks after the surgery. The collected information related to personal data, type of injury, the method of reconstruction, disease and additional injuries that may affect the test result, the start and the completion time of the physiotherapy program, measurement of muscle strength acting on the knee joint, range of knee joint motion, pain severity.

The clinical assessment of muscle strength acting on the knee joint used in the study was based on the Zembate methodology. [11]

In the strength description, the Lovetta scale was used [12]. In the post-operative procedure, in the operating theater the patient was provided with an orthosis stabilizing the knee joint in the delivery, then a physiotherapeutic protocol consisting of the V phases was started. [13,14]

Patients were evaluated for muscle strength of both lower limbs. From the results of the above assessment, the decision was made on the patient running the running training. The patient was not allowed to undertake running training if the difference in strength and / or strength endurance between the lower limb operated and the unoperated was more than 30%. The patient was not allowed to return to sport-directed activities if the difference in strength and / or strength endurance between the operative and the non-operated lower limb was more than 20%.

Collected results regarding the assessment of the range of muscle movements and strength, knee joint stability were subjected to statistical analysis using the R 3.0 program.

III. RESULTS

During 1 study (after 21 days of surgery), 2 (after one month) and 3 (after 3 months), the range of knee movement bending of the operated knee was assessed using a digital inclinometer.

In study 1 no statistically significant differences were found (an average range of passive motion in group 1 - 89.7, in group 2 - 89.4, active range in group 1 - 88.5, in group 2 - 87.2), in opposed to study 2 (p <0.001) and 5 (p <0.05). Statistically significant differences were obtained both in the assessment of the range of passive and active motion. Larger bending ranges were achieved by patients

from group 1, in study 3 by an average of 4.7o in the case of passive motion and 4.3o in active movement, and 4.9o in passive motion and 6.2o in active movement in study 6. (table 1).

Table 1. Results of the assessment of the range of passive and active movement of the knee bend in both groups

Study		Group 1		Group 2		Level of relevance p
		average	SD	average	SD	
Study 1	Passive motion (°)	89,7	1,6	89,4	1,9	0,353
	Active motion (°)	88,5	3,7	87,2	5,6	0,366
Study 2	Passive motion (°)	124,0	4,7	119,3	3,6	<0,001
	Active motion(°)	120,0	6,8	115,7	7,4	<0,001
Study 3	Passive motion (°)	149,3	8,8	144,4	8,1	<0,05
	Active motion(°)	140,2	8,7	134,0	8,9	<0,05

Measurement of the range of passive flexion in the knee joint performed in study 1 showed that 2 people (4%) from group 1 and 4 (8.9%) from group 2 did not reach the value of 90 ° (min = 80 °, max = 90 °). There were no differences between the study groups in both passive and active movement study. In the active movement, the majority of patients (83.7% in group 1 and 77.8% in group 2) reached 90 °, with minutes for group 1 = 75 °, and for group 2 minutes = 70 °; max for both groups = 90 °.

Measurement of the range of motion of passive flexion in the knee joint showed that 57.1% of patients from group 1 reached the value of 125 ° (min = 110 °, max = 135 °). In group 2 the results were worse, the majority of patients (71.1%) achieved 120 ° bends (min = 105 °, max = 125 °). In the active movement, almost half of the patients from group 1 (46.9%) achieved the bending value in the range of 125 ° (min = 100 °, max = 130 °). In group 2, the majority of patients (68.9%) achieved bending values in the range of 120 ° (min = 95 °, max = 120 °).

Similarly, statistical significance was found in the study after 3 months. In the passive motion measurement in group 1, the highest number of patients achieved 160 ° (28.6%), slightly less (24.5%) 150 °, and 22.4% 140 ° (min = 130 °, max = 160 °). In group 2, an inferior result was obtained. Thus, 24.4% of patients had 150 ° passive flexion in the knee joint, 22.2% 145 °, while the maximum value reached only 6.7% of people (min = 125 °, max = 160 °). In the measurement of active movement in group 1, 30.6% of patients achieved an active flexion of the knee

joint in the 150 ° range, but also a significant group (28.6%) only 130 ° (min = 125 °, max = 150 °). In group 2, 24.4% of patients had 145 ° active flexion and 22.2% 135 ° (min = 115 °, max = 145 °).

The study of muscular strength acting on the knee joint according to the Lovett scale was performed after one month (study 2) and after three months (study 3) from surgery. In the study, three months after surgery, normal thigh extensor muscle strength was obtained in all patients in both groups and thigh flexors in group 1 (5 in the Lovett scale). In group 2, 80% of patients achieved normal thigh flexor strength, and 20% were slightly smaller (4 on the Lovett scale). There were no significant differences between the studied groups of patients. Only the flexor muscle strength of the thighs examined after 3 months after the surgery turned out to be statistically significant (Table 2). During the study 2, the calf muscle strength was additionally measured by evaluating it in the Lovett scale. In both groups, similar results were achieved, in group 1 the average muscle strength was 3.8 (SD = 0.4), in the group 2 x = 3.6 (SD = 0.5). There were no statistically significant differences between the examined groups of patients.

Table 2. Results of the study after one month (study 2) and after three months (study 3) according to the Lovett test and the strength of the quadriceps muscles of the thigh, bicep thigh, semi-sinew and semilepotent muscles in both groups of patients

Study		Group 1		Group 2		Level of relevance p-value
		average	SD	average	SD	
Study 2	Quadriceps femoris muscle	2,8	0,4	2,6	0,5	0,069
	Biceps femoris muscle semitendinosus, semimembranosus	2,8	0,4	2,6	0,5	0,069
Study 3	Quadriceps femoris muscle	5,0	0,0	5,0	0,0	-
	Biceps femoris muscle semitendinosus, semimembranosus	5,0	0,0	4,8	0,4	0,001

IV.DISCUSSION

Based on the conducted studies, it was found that in the vast majority of patients the patients obtained normal range of motion and muscle strength in 6 study after 3 months.

Thus, a period of 3 months after surgical treatment of anterior-posterior knee instability (reconstruction of ACL by arthroscopy with portal transplants of tendon muscles and slender muscles) with proper rehabilitation is sufficient to regain the proper function of the knee joint. It is determined by the restoration of good passive mechanical stabilization and proper dynamic neuromuscular interactions between receptors and effectors. Of course in this process, an extremely important element is a proper rehabilitation, the program should include comprehensive elements of exercises, including proprioception training.

It would be desirable to adopt and implement tailored and harmonized protocols for patients that would be adapted to individual criteria in order to quickly return to sports activities. In an article by Shelbourne *et al.* patients who achieved full range of motion as early as possible, had a much lower frequency of degenerative changes compared to people who had bending and straightening limitations. Retrospective studies were conducted within 10 years after surgery [15].

According to data from Biau *et al.* 67% -76% of patients undergoing ACL reconstruction return to the level of sports activities before the injury [16].

Reconstruction of ACL should occur within 12 months of injury to avoid further damage to the meniscus and cartilage. A delayed surgical intervention of more than one year is associated with a significant increase in secondary damage to the intra-articular structures of the knee and, as a result, it may lead to arthrosis. [17]

Eitzen *et al.* [18] showed that the strength of quadriceps measured before surgery influences the clinical results after reconstruction. Therefore, the authors suggest that at least 80% of the initial quadriceps muscle strength should be achieved before surgery. In order to achieve the correct function of the knee joint and its full capacity, it is also important to restore the correct balance of muscle strength of the rectifiers and flexors of the knee joint.

Unfortunately, after the reconstruction, the mechanoreceptors do not regenerate completely, therefore early and regular proprioception training is a very important part of rehabilitation throughout its lifetime, as well as after its completion. Introduction in the early period of rehabilitation is to significantly support and shorten the process of rehabilitation, enable the elimination of increased tension of soft tissues, improve blood and lymph circulation, additionally antithrombotic, anti-oedematous action and facilitate the absorption of hematomas and accelerate repair processes.

Physiotherapy is essential after ACL reconstruction and its goal is to achieve good functional results so that you can continue the activity started before the injury. Kruse *et*

al. [19] and Saka *et al.* [9] determined that early postoperative activity in the form of exercises improving the range of mobility, strengthening muscle strength is important for the early return to the functioning of the knee. In physiotherapy programs, some authors recommend treatments in the field of physical therapy, such as, for example, magnetic field, cryotherapy or electrotherapy. The use of neuromuscular stimulation by means of currents is important in preventing thigh muscle atrophy after surgery. Kruse *et al.* and Beynon *et al.* [19, 20] demonstrated that accelerated rehabilitation after surgery has no negative effect on the functioning of the patient after ACL reconstruction after two years of the procedure. In a study conducted by Fukuda *et al.* [21] it was shown that the early start of exercise in open kinetic chain activities influenced faster recovery and reconstruction of the strength of the quadriceps muscle of the thigh than their subsequent introduction.

Dragicevic-Cvjetkovic *et al.* [22] in their work described the impact of rehabilitation on the mass of the thigh muscles. The authors found a beneficial effect of "aggressive" and "accelerated" postoperative rehabilitation on the thigh muscle circumference. Bonikowski *et al.* Obtained a very good subjective assessment according to the IKDC 2000 scale for the studied groups in 81%. In the case of Lynsholma, this concerned 82% of patients.

Physiotherapy after ACL reconstruction requires individual approach to each patient and includes in the detailed program the improvement of his age, work, type / characteristics of sports before injury and expected after treatment, type of injury and extent of knee injuries, as well as other factors related to general health status [23].

V. CONCLUSIONS

- In the assessment of passive and active range of flexion of the knee joint, patients from group 1 achieved statistically significantly better results in the study after 4 and 6 weeks after surgery.
- In all the examined patients, after 12 weeks, the normal thigh extensor muscle strength was obtained. A statistically significant difference was demonstrated in the study of thigh flexor muscle strength after 12 weeks, with better results obtained by patients from group 1.

VI. REFERENCES

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