

Original Article

Physical Rehabilitation of patients who underwent the reconstruction of anterior cruciate ligament with arthroscopic surgical interventions

ANDREY RUSANOV¹, LYUDMILA KRAVCHUK², OLGA RUSANOVA³, ZINCHENKO VITALY⁴, SKOMOROKHA OLGA⁵

^{1,4}Institute of traumatology and orthopedics of the National Academy of Medical Sciences of Ukraine, UKRAINE

^{2,3,5}National University of Physical Education and Sports of Ukraine, UKRAINE

Published online: October 31, 2018

(Accepted for publication September 18, 2018)

DOI:10.7752/jpes.2018.s4279

Abstract. *Purpose:* The article observes the issues of grounding, elaborating and studying the effectiveness of the complex physical rehabilitation program among patients who have undergone the reconstruction of anterior cruciate ligament with arthroscopic surgical interventions. The reason for the program was the use of workout modules performed on a stabilographic platform, remedial gymnastics, therapeutic massage with the elements of passive workout, aimed to increase the movements' amplitude in the injured joint and to achieve the postisometric relaxation, mechanotherapy on the joints workout machine and keeping to the orthopedic routine.

Materials: According to the proposed program, 21 patients (the main group of patients) underwent rehabilitation after ACL reconstruction. 31 patients received the traditional program of physical rehabilitation. The results registered on the previous study stage showed the lack of statistically meaningful discrepancies in the studied indicators and the age among the patients of the control and the main groups. . All patients (52 people) underwent the rehabilitation treatment in the rehabilitation department of ITO NAMS of Ukraine and were operated in the hospitals of the institute. The femoral end of the transplant was fixed with the help of "Rigid-fix" or "Cross-pin" systems, and the tibial end – using "Biointrafix" or "Biosure-synk" systems. Medication were applied according to the prescriptions.

Results: The results, registered on the preliminary stage of research, showed no statistically meaningful discrepancies between the examined indicators and the age of the patients among the control group and the main group. As a result of the proposed complex rehabilitation program applied, one can observe the decrease ($p < 0,05$) in number of unsatisfactory results from 38,09 % in the preoperative period to the full absence of unsatisfactory results in the late postoperative period according to the scale by J. Lysholm, J. Gillquist (1982) among patients of the main group. The percentage of unsatisfactory results among patients of the control group has not reliably changed ($p > 0,05$).

Key words: physical rehabilitation, trauma, anterior cruciate ligament, knee joint, recovery treatment.

Introduction.

Due to the complexity of its anatomical structure and its biomechanics, knee joint (KJ) among all other big joints is damaged the most often and has a high risk of posttraumatic complications. Over 70% of musculoskeletal injuries stand particularly for knee joint (Kuznetsov I.A., 2011).

The results of the theoretical analysis made in the process of the research show the stable growing in number of ACL injuries – up to 80-85 cases out of 100 000 persons, especially among young people (Abdelkafy A., 2007).

Arthroscopic operative interventions are of big importance for developing treatment methods for ACL injuries, and the most progressive method to recover its function by now is its reconstruction (Bogatov V.B., 2011). Such surgeries allow not only to keep the normal biomechanics of knee joint, but also to prevent the early development of posttraumatic gonarthrosis (Chemiris A. Y., Davydenko A. V., 2001; Andriychuk O.Ya., 2013). In this case, the number of operative interventions regarding the ACL plastic surgery makes up 34 out of 100 000 persons (Kuznetsov I.A., 2011).

The effectiveness of physical rehabilitation depends on the proper estimation of functional disorders, which need correction after the arthroscopic surgery provided (Zazirnyi I. M., 2014; Zamorsky T., Zakharov O., Nikanorov O., 2014). The most of the functional disorders are connected both with the preoperative injuries of the knee joint structure and with the reaction of the body itself to the surgery, the further restriction of movements and with the peculiarities of reparative processes in the postoperative period (Kostrub A.A., Roy I.V., Kotyuk V.V., Zasadniuk I.A., 2015).

According to the data from the professional literature, this is exactly the sequence of stages in incorporating the transplant into the bone tunnels and its remodeling (ligamentization), which is the basis for

differentiating the stages of physical rehabilitation, divided into weeks, which forms the priority tasks for the recovery treatment of patients with ACL injuries, waiting to be solved: avoiding overloading of the transplant, early strengthening of the lower limb muscles to provide the dynamic stability in the joint and to decrease the pressure in the transplant; progressive growth of the axial loading and movement workout in the joint; joint swelling and infiltration control; muscle control rearranging (Pauzenberger L., Syre S., Schurz M., 2013).

In this connection, the development of new and upgraded rehabilitation programs for patients with ACL injuries who underwent the arthroscopic operative interventions is still very relevant.

Methodology of research.

Participants

In the process of the research, we have systematized and consolidated data from 52 medical histories of the patients who addressed ITO NAMS during the period of 2013-2016. The patients (52 people) without temporary contraindications for arthroscopic operative intervention were examined using instrumental methods of research. The examination was made within different periods of recovery treatment.

21 patients (main group) underwent rehabilitation according to the proposed program after ACL reconstruction; 31 patients kept to the traditional program of physical rehabilitation. The results, registered on the preliminary stage of research, showed no statistically meaningful discrepancies between the examined indicators and the age of the patients among the control group and the main group.

All the patients (52 people) underwent the rehabilitation treatment in the rehabilitation department of ITO NAMS of Ukraine and were operated in the hospitals of the institute. The femoral end of the transplant was fixed with the help of "Rigid-fix" or "Cross-pin" systems, and the tibial end – using "Biointrafix" or "Biosure-synk" systems. Medication was applied according to the prescriptions.

Procedure

To achieve the set target in this work the following methods were used: theoretical analysis of data from the scientific and methodological literature, pedagogical, clinical (examination, anamnesis collection), instrumental methods of research (anthropometric measurements, goniometry, dynamometry, electromyography, stabilography) and methods of mathematical data processing.

All the materials for this work were obtained during studies based on the State Enterprise "Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences in Ukraine (ITO NAMS)". The algorithm of the complex diagnostics for acute ACL injuries, created in ITO NAMS of Ukraine, was applied to the patients having corresponding claims; this algorithm implied clinic-functional and X-ray examination, ultrasound examination and MRT.

All the hospitalized patients underwent the following measures: definition of patients' claims and anamnesis collection; clinical examination, palpation; examination of the injured joint functioning, evaluation of instability level, presence of block, synovitis, infiltration, muscular atrophy, etc.; the joint was immobilized with the help of a semi-rigid brace (if necessary); X-ray examination, ultrasound of knee joint; MRT (if possible). The received data were recorded into the patients' medical history.

During clinical examination and anamnesis collection all patients were asked about the reason of turning to the rehabilitation department, about the intensity of pain syndrome (patients were tested according to the "Visual-analogue scale of pain"); their claims on pain syndrome while active movements, passive movements and stasis; instability of KJ, which was measured by the following tests: Lachman test, drawer test, furthermore, the quantitative measurements of instability were made according to criteria of American Association of Arthroscopy. The patients were also diagnosed for the functional condition of KJ (by scoring scale of J. Lysholm, J. Gillquist (1982)), and for the indicator of movement function of KJ, which was obtained with the help of scale IKDC-2000 (International Knee Documentation Committee). The results of anthropometric measurements and goniometry of the injured and intact limbs were also registered in the patients' medical history.

Statistical Analysis

Empirical materials were processed with the mathematical statistics methods. To assess the significance of the difference, in the presence of a normal distribution of the results of the studies, the Student's t-test (for independent or for dependent groups) was used, and for the indicators with the distribution which was different from the normal one, there were used the Mann-Whitney U test (for independent groups) and Wilcoxon T test (for dependent groups).

Results of Research

It was registered on the preliminary stage of research, that among all reasons for addressing the rehabilitation department the sports traumas prevailed – 55,7%, the second place was taken by domestic injuries – 27,9%, among 13 patients (16,4%) the injury mechanism was not defined, which could be explained by the late age of the injury or by inability of the patient to recall the moment and characteristics of the trauma.

The research of the specifics of the limbs functional condition among the examined patients having ACL KJ injuries showed pain sensations at the level of $5,07 \pm 0,99$ points ($\bar{x} \pm S$), with the maximum rate of 10

points, among all 100% of patients. Claims for feeling pain at the moment of active movements were observed among 91,1% of patients, while passive movements – among 75,9% of patients, in stasis – among 44,3% of patients.

It has been proved, that consequences of KJ injury are significant, movement function is decreased and symptoms largely appear, which was evident from the indicators of the movement function of KJ, obtained with the scale IKDC-2000 (International Knee Documentation Committee), which were on the level of $46,07 \pm 1,71$ % ($\bar{x} \pm S$). The indicators of movement range when bending the injured limb in its knee joint were quite low – with the normal movement range equal to 140° , among patients with ACL KJ injuries it showed $102,91 \pm 4,41^\circ$ ($\bar{x} \pm S$), which is $37,09^\circ$ less than norm and corresponds to 73,5 % of the normal movement range ($p < 0,05$).

Because of the KJ function deficiency, contracture in the damaged joint, pain sensations, muscle hypotrophy in the injured limb, the patients manifested the decrease of muscle strength in the injured limb comparing to the intact limb ($p < 0,05$) while making the following movements: bending in knee joint – up to 36,43% and straightening – up to 32,13 %.

Following the results of superficial electromyography examination the estimation of the bioelectrical activity of rectus femoris muscle among patients with ACL of KJ injuries was provided. Thus, comparative index of the average amplitude of the sides (injured and intact) for the indicators of vastus intermedius showed $1,15 \pm 0,29$ conventional units ($\bar{x} \pm S$), musculus rectus femoris - $1,28 \pm 0,23$ conventional units ($\bar{x} \pm S$), which indicates the decrease of bioelectrical activity of the rectus femoris muscle of the injured limb.

During the primary examination of the changes in support reactions, which were defined while performing a balance test on the platform «Gamma Platform», patients demonstrated the body weight shift to the intact limb and the asymmetry of load distribution in lower limbs (by difference in loading time (dominant) of intact and injured limb – $30,65 \pm 12,78$ % ($\bar{x} \pm S$)). The average rate of the dominant loading time (%) for the injured and intact limbs made up - $34,4 \pm 2,67$ % ($\bar{x} \pm S$) and $63,48 \pm 2,59$ % ($\bar{x} \pm S$) accordingly.

Thus, the analysis of the results obtained during the research of the specifics of the limbs functional condition among the examined patients having ACL KJ injuries, allowed to outline the main complex of tasks, which should be solved in the process of rehabilitation program development.

Having studied the specifics of the lower limbs functional conditions among patients, we have described and developed the physical rehabilitation program for the patients after the ACL reconstruction with arthroscopic operative interventions.

The program consisted of five periods of preoperative, early postoperative, late postoperative, functional periods and a period of higher physical activity. The basis of the program was the use of workout modules on the platform «Gamma Platform», remedial gymnastics and massage with the elements of passive workout to increase the movement amplitude in the injured joint and postisometric relaxation, mechanotherapy on the joints workout machine and keeping to the orthopedic routine.

The specific feature of the developed program of physical rehabilitation for the patients with injured ACL, comparing to the traditional program, was, particularly, (except the early postoperative rehabilitation period) the use of workout modules “Boat”, “Ball swing”, “Sorting balls”, “Trampoline jumping”, “Jump rope”, “Combined” on the platform «Gamma Platform», which enhanced the elimination of loading asymmetry between intact and injured limbs and the faster recovery of the functional abilities of the operated joint.

52 patients underwent the course of recovery treatment at the Institute of traumatology and orthopedics of the National Academy of Medical Sciences of Ukraine. To define the effectiveness of the rehabilitation program two groups of patients were formed – the main group, which followed the presented authors’ program ($n = 21$), and the control group ($n = 31$), who underwent the recovery treatment course including remedial gymnastics, classical massage and physical therapy methods according to the hospital program. Outcoming (preoperative) indicators for the studied parameters among the patients of the groups didn’t have statistically meaningful discrepancies ($p < 0,05$). The study of the results, their comparison to the outcoming data (registered during preoperative period (from 1 to 4 weeks before operative intervention)), and their evaluation was made before the discharge from the hospital during the early postoperative period (up to 2 weeks after operative intervention), during the late postoperative period (from 3 to 16 weeks after operative intervention) and functional (from 17 to 20 weeks after operative intervention) periods of recovery treatment.

There was a comparative analysis of indicators, characterizing the injured limb functional condition, applied in the process recovery treatment. Along with this, the dynamics of both average and individual results was analyzed.

Estimation of the KJ functional condition during the recovery treatment in the preoperative period, early and late postoperative period was made using the questionnaire by J. Lysholm, J. Gillquist (1982), using the corresponding scale with points. After the total final calculation of the points the result was considered “unsatisfactory” – > 64 points, “satisfactory” – 65-83 points, «good» – 84-94 points, or “very good” – 95-100 points. The given questionnaire is a form of subjective evaluation of knee joint and is aimed to evaluate

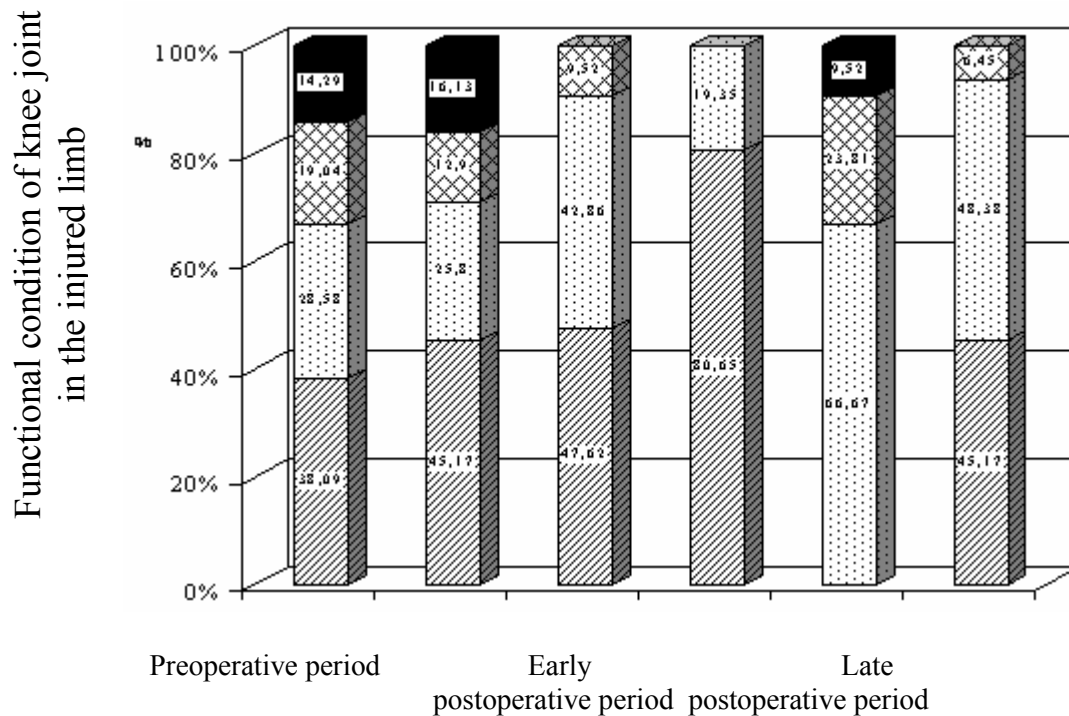
instability in the knee joint while performing activities necessary for everyday life.

Studying the given indicators in the late postoperative period was of the most interest, as patients can walk without the help of crutches, fully extending the operated limb, and even use stairs.

The analysis of data, received with the questionnaire in the late postoperative period among patients of the main group (MG), proved the absence of unsatisfactory results by individual rates, satisfactory result was observed among 66,67% of patients, good – 23,81% of patients and very good – 9,52% of patients in MG. Among the control group (CG) patients 45,17% of them had unsatisfactory result less than 64 points, 48,38% showed satisfactory result, and 6,45% of patients had good result (pic.1).

The results improvement after the rehabilitation course had place in both groups. The number of patients with good result has increased 2.33 times in MG, and 1.87 times in CG. There is no “very good” mark in CG, at the same time there are 9,52% of such patients having this result in MG.

As a result of implementing the proposed rehabilitation program, we have achieved the decrease ($p < 0,05$) in number of unsatisfactory results from 38,09% before the surgery to the complete absence of unsatisfactory results in the late postoperative period according to the scale by Lysholm J., Gillquist J (1982) among patients of the main group. The percentage of unsatisfactory results among patients of CG didn't change reliably ($p < 0,05$) by individual rates, low estimation of patients' own abilities, as it turned out during the questioning and the conversation, was mostly connected to the constant limping, lower ability to lean on the operated limb, inability to sit down to the full and use stairs in the everyday life.



Pic.1 Individual markers dynamics showing the functional condition of KJ in the injured limb according to the data from the questionnaire by Lysholm J., Gillquist J. Among patients on MG and CG:

- “very good”;
- “good”;
- “satisfactory”;
- “unsatisfactory”

Discussion.

The anterior cruciate ligament (ACL) is a band of tough tissue inside the knee that helps stabilise the knee during movement. Rupture of the ACL is a common injury during some sporting activities, such as football and skiing (Kuznetsov I.A., 2000, Debieux P., Franciozi CES, Lenza M., Tamaoki M.J., Magnussen R.A., Faloppa F., Belloti J.C. , 2016) .

Arthroscopic reconstruction for anterior cruciate ligament rupture is a common orthopaedic procedure. One area of controversy is whether the method of double - bundle reconstruction, which represents the 'more anatomical' approach, gives improved outcomes compared with the more traditional single - bundle reconstruction (Rezende F.C., Moraes V.Y., Franciozi CES, Debieux P, Luzo M.V., Belloti J.C., 2017).

Thus, due to the introduction of new less invasive methods of the injured ACL operative reconstruction and the ability of the early axial loading and movement function recovery in the injured limb, it became necessary to further develop and improve the methods of physical rehabilitation, particularly the possibility to use recovery physical exercises and to train proprioception (Nikanorov A.K., 2014, 2015; Roy I.V., Strafun S. S., Kostrub O. O., 2015; Samokhin A.V., 2017).

Cooper R L, Taylor N F, Feller J A. (2005) investigated the effect of proprioceptive and balance exercise on outcomes following injury and surgical reconstruction of the anterior cruciate ligament (ACL). Five studies of high quality that offered empirical evidence by comparing one rehabilitation program to another were included in this review. There is some evidence that proprioceptive and balance exercise improves outcomes in individuals with ACL-deficient knees. Improvements in joint position sense, muscle strength, perceived knee joint function, and hop testing were reported following proprioceptive and balance exercise. Only one included study investigated proprioceptive exercise following ACL reconstruction. Benefits were noted in the proprioceptive group for measures of strength and proprioception; however, no benefits were noted for any measures of activity. No detrimental effects--such as increased passive joint laxity or decrease in strength--were noted when compared with standard rehabilitation programs for both ACL-deficient and ACL-reconstructed individuals. Further research is required to determine if proprioceptive and balance exercise improves long-term outcomes such as return to sport (Nikanorov A.K., 2014, 2015).

Conclusions.

As a result of the proposed complex rehabilitation program implementing, we have achieved the decrease ($p < 0,05$) in number of unsatisfactory results from 38,09% before the surgery to the complete absence of unsatisfactory results in the late postoperative period according to the scale by Lysholm J., Gillquist J (1982) among patients of the main group. The percentage of unsatisfactory results among patients of CG didn't change reliably ($p < 0,05$).

Provided research proves the effectiveness of the developed complex physical rehabilitation program and shows clear evidence of its advantage comparing to the traditional program of a hospital. The data, obtained during the pedagogical experiment, demonstrate that the use of the authors' program within preoperative, early postoperative, late postoperative, functional periods of recovery treatment after ACL reconstruction with arthroscopic operative surgeries allows to achieve better results among MG patients, comparing to CG patients.

References.

- Abdelkafy A., Aigner N., Zada M. [et al.] (2007). Two to nineteen years follow-up of arthroscopic meniscal repair using the outside-in technique: a retrospective study. *Arch. Orthop. Trauma Surg.* Vol. 127 (4). P. 245-252.
- Andriychuk O.Ya. (2013) Theoretical and methodological foundations of physical rehabilitation of patients with gonorrhea: author's abstract. dis ... d. Phys. Ed. and sport : special 24.00.03 "Physical rehabilitation" .L., 42 p.
- Bogatov V.B. (2011) Arthroscopic surgical treatment of traumatic knee injuries in children (experimental-clinical research): author's abstract. dis ... Dr. medical Sciences: special 14.01.15 "Traumatology and Orthopedics". Saratov, 35 p.
- Chemiris A. Y., Davydenko A. V. (2011). Physical rehabilitation of patients with damage to the anterior cruciate ligament of the knee joint. *Chronicle of traumatol. and orthopedics.* No. 1-2. P.271-271.
- Cooper R L, Taylor N F, Feller J A. (2005) A systematic review of the effect of proprioceptive and balance exercises on people with an injured or reconstructed anterior cruciate ligament. *Research in Sports Medicine*; 13(2): P.163-178.
- Debieux P., Franciozi CES, Lenza M., Tamaoki M.J., Magnussen R.A., Faloppa F., Belloti J.C. (2016). Bioabsorbable versus metallic interference screws for graft fixation in anterior cruciate ligament reconstruction. *Cochrane Database of Systematic Reviews* 2016, Issue 7. Art. No.: CD009772. DOI: 10.1002/14651858.CD009772.pub2.
- Kostrub A.A., Roy I.V., Kotyuk V.V., Zasadniuk I.A. [and others] (2015). Rehabilitation after arthroscopic operations at athletes. K.. 272 p.
- Kuznetsov I.A. (2000). Options for endoscopic surgery for damage to the anterior cruciate ligament of the knee joint. 5 (19). P. 117-122.
- Kuznetsov I.A. (2000). Arthroscopic knee St. Petersburg. 45 p.
- Kuznetsov I.A. (2000). Options for surgical treatment for damage to the anterior cruciate ligament of the knee: manual for doctors. St. Petersburg. 20 p.

- Kuznetsov I.A., Shapiro K.I., Selin A.V. (2001). Clinico-statistical characteristic of patients with knee injury. *Man and his health: materials of the VI Congress of the Russian Federation*. SPb. P. 94-95.
- Nikanorov A.K. (2015). Physical rehabilitation of athletes with damage to the anterior cruciate ligament of the knee joint (on an example of playing sports). Kyiv. 304 p.
- Nikanorov O. K. (2015). The problem of injuries in the game types of sports and the prospects of using physical means of rehabilitation. *Sport. medicine*. Kyiv. 1-2. P. 61-65.
- Nikanorov O.K. (2014). Application of means of physical rehabilitation for athletes of playing sports after reconstruction of the anterior transmitted ligament (on the example of research of the tone of the quadriceps of the thigh). *The theory and method of physics. education and sports*. 1. P. 61-65.
- Pauzenberger L., Syre S., Schurz M. (2013). "Ligamentization" in hamstring tendon grafts after anterior cruciate ligament reconstruction: a systematic review of the literature and a glimpse into the future. *Arthroscopy*. Vol. 29. P. 1712-1721.
- Rezende F.C., Moraes V.Y., Franciozi CES, Debieux P, Luzo M.V., Belloti J.C. (2017). One - incision versus two - incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults. *Cochrane Database of Systematic Reviews* 2017, Issue 12. Art. No.: CD010875. DOI: 10.1002/14651858.CD010875.pub2.
- Roy I.V., Strafun S. S., Kostrub O. O. [and others]. (2015). Method of rehabilitation of patients after arthroscopic reconstruction of anterior cruciate ligament in the early postoperative period: method. Recommendations. K.: "Etna-1". 28 p.
- Samokhin A.V. (2017). Application of electromyostimulation and therapeutic gymnastics in patients with hypothyroidism of the quadriceps of the thigh in the early postoperative period after arthroscopic reconstruction of the anterior cruciate ligament. *Molodizhny Scientific Bulletin*. Lutsk. 27. P. 146 - 152.
- Zamorsky T., Zakharov O., Nikanorov O. (2014) Taping the lining in the process of rehabilitation of patients after reconstructing the anterior transmitted ligament. *Phys. Culture, Sport and Health of the Nation*. K., 2014. 16. P. 214-218.
- Zazirnyi I. M. (2014) Contemporary conflicting views on rehabilitation after the reconstruction of anterior cruciate ligament (review of literature). Part II. *Bulletin of Orthopedics, Traumatology and Prosthetics*. 3. P. 75-79.