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Impact of Magnetic Field and Deep Oscillation in the Complex Rehabilitation after Arthroscopic Reconstruction of the Anterior Cruciate Ligament (A Comparative Study)

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Article Info

Article History:

Received: 02 March, 2020

Accepted: 14 March, 2020

Published: 19 March, 2020

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Abstract

Introduction: The importance of anterior cruciate ligament (ACL) for knee stability and gait is recognized. After ACL rupture with subsequent arthroscopic reconstruction the rehabilitation is obligatory. The goal of current study was to realize a comparative evaluation of the efficacy of five different rehabilitation programs after ACL-reconstruction.

Material and Methods: During one month, we treated a total of 115 patients after ACL reconstruction (divided into five groups). All patients received physiotherapy (active exercises), cry therapy (ice massage), gait training, ergotherapy and patient education. Patients of first group (gr-1) received only these procedures. For patients of the second group (gr-2) local applications of a non-steroidal anti-inflammatory drug (NSAID) were included. In group 3 (gr-3) we added low frequency low intensity Magnetic field; in group 4 (gr-4) we added another preformed modality - Deep Oscillation. Patients of the group 5 (gr-5) received both preformed modalities: Magnetic field and Deep Oscillation. Patients were controlled before, during, at the end of the PRM course and one month later - using a battery of subjective and objective methods: tests and scales for pain, range of motion, knee stability and gait. Statistical analysis was performed with SPSS package (ANOVA and Wilcoxon).

Analysis of Results: Demonstrates the efficacy of physiotherapy and cry therapy on mobility of the knee joint and gait velocity. Efficacy of PRM on pain was most important in groups with preformed modalities. The oedema was significantly reduced in gr-4. The knee stability and the length of the step were most significantly enhanced in group 5.

Discussion and Conclusion: Authors consider that different natural and preformed physical modalities must be sinergically combined for amelioration of the efficacy of rehabilitation in patients after ACL reconstruction. Physiotherapy and cryotherapy are useful for the knee mobility and stability. Deep Oscillation and Magnetic field decrease the pain and oedema.

Keywords: Anterior cruciate ligament; Deep oscillation; Knee joint; Magnetic field; Physiotherapy; Rehabilitation

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Introduction

The World Report on Disability defines the goals of rehabilitation: prevention of the loss of function; slowing the rate of loss of function; improvement or restoration of function; compensation for lost function; maintenance of current function [1]. Gait is an important element of the everyday life functionality of our patients in rehabilitation practice, and is crucial for their independence in activities of daily living, respectively for their autonomy.

The importance of anterior cruciate ligament (ACL) for knee constancy and gait is recognized [2-4]. ACL is an important

stabilizer of the knee, providing almost 85 % of the joint stability to forward force (especially in some aggressive twisting and jumping sports, as skiing and basketball). The common orthopedic surgical intervention is the reconstruction, performed as soon as possible after the traumatic injury [2]. After the orthopedic surgery, a period of rehabilitation must begin and the consultation with a medical doctor – specialist in Physical and Rehabilitation Medicine (PRM) is required [5-8]. In all traumatic knee conditions with a knee surgery, the PRM Algorithm traditionally includes functional evaluation of the knee mobility and stability, and a complex PRM programme of care, including natural and preformed physical modalities. The pre-defined PRM

protocol includes only physiotherapy (PT) combined with cryotherapy [9-14]. Our objective is to suggest a complex PRM-algorithm of care of these patients, based on detailed literature review and on our own clinical practice. We propose a synergic combination of different physical modalities: physiotherapy, cryotherapy, and some preformed physical factors: Deep Oscillation and low intensity low frequency magnetic field. The goal of current study was to realize a comparative evaluation of the efficacy of application of five different PRM programmes of care after arthroscopic reconstruction of ACL.

Design of the study, Materials and Methods

Study design

Our controlled prospective randomized double-blind investigation was effectuated during last years (April 2012-February 2020) on a total of 115 patients, divided into 5 groups (23 patients for each one).

Outcome measures

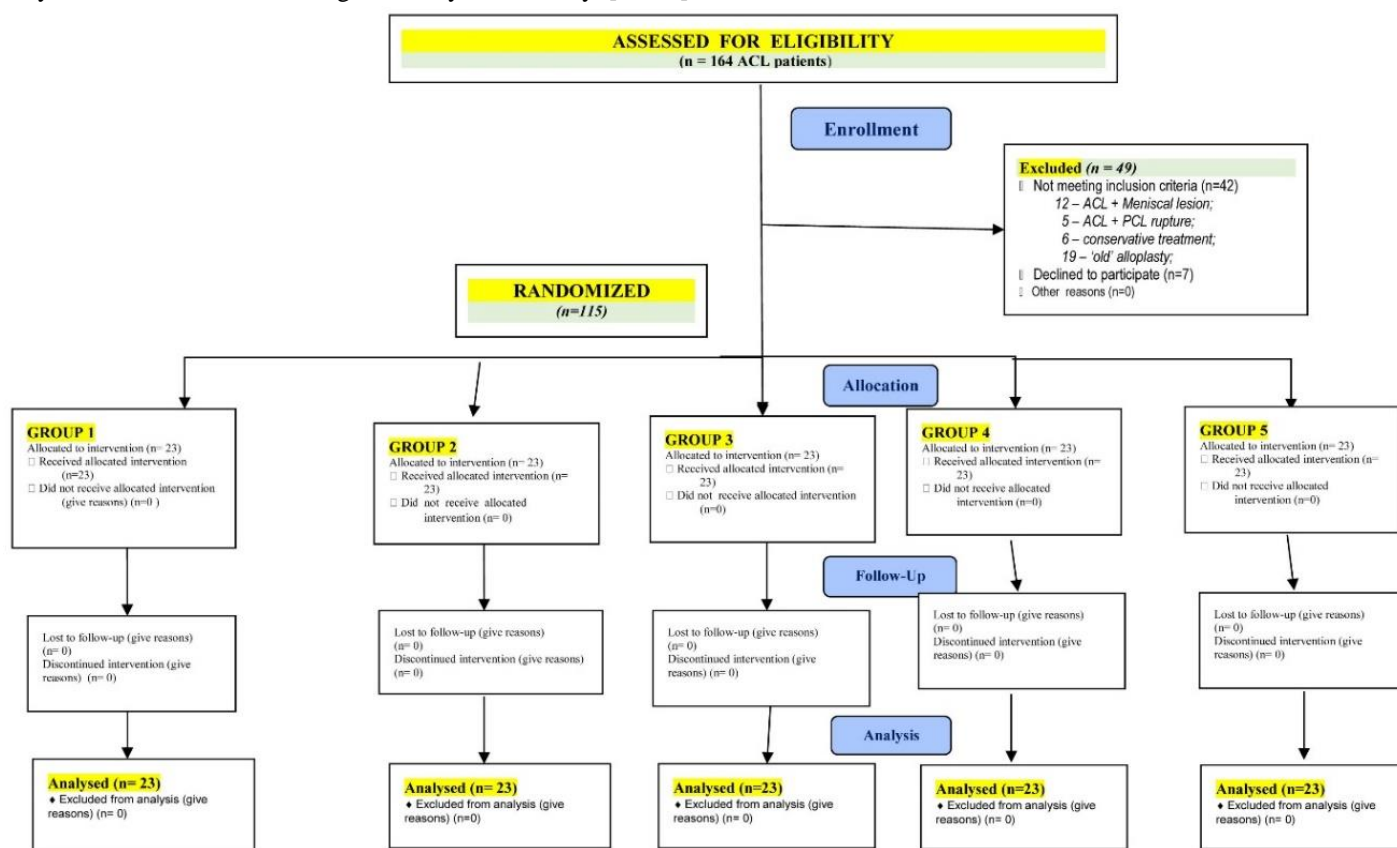
During the period of the study we checked all operated patients, hospitalized in our PRM Clinic / Department. A detailed clinical and functional examination was performed for every patient, including history of the disease, date and cause of the ACL rupture, date of the ACL arthroscopic reconstruction, post-op day number; presence of pain; oedema and restriction of the knee range of motion (ROM); functional status, pathokinesiologial analysis, manual muscle test, goniometry, centimetry [15-18].

Special attention was paid to pain evaluation, presence of muscular or articular contractures; clinical signs and symptoms of ACL rupture; gait and activities limitations.

Eligibility criteria for participants

After detailed analysis of potential participants and with the objective to assure data uniformity, we decided to put strong inclusion and exclusion criteria, as follows: Inclusion criteria: All patients with ACL rupture and after an arthroscopic reconstruction, effectuated during last week (1-7 days), with signs and symptoms of the ACL trauma (pain, oedema, ROM limitation). Exclusion criteria: We excluded patients with ACL rupture without subsequent operation, patients with other traumatic lesions of the same knee joint, as rupture of the posterior cruciate ligament or meniscal lesion, undergoing more complicate operation; or 'old' ACL ruptures (reconstructions executed more than 1 week ago).

According the CONSORT (Consolidated Standards of Reporting Trials) 2010 statement [19]. We present patients' distribution and flow (Flow diagram). All patients were investigated according to an examination Protocol - before (B.Th.), during (Day 10) and after (A.Th.) therapy, and one month after the end of the rehabilitation (1 month later - follow-up). All patients received a complex PRM program of 4 weeks (20 procedures). All patients present at the beginning of the study, finished the rehabilitation, and were investigated before, during and after treatment.



Material

All 115 patients were with a post-traumatic ACL rupture and underwent an arthroscopic reconstruction, effectuated during last week. The distribution of patients is presented in figures 1 and 2 (by sex - Figure 1; by age – Figure 2).

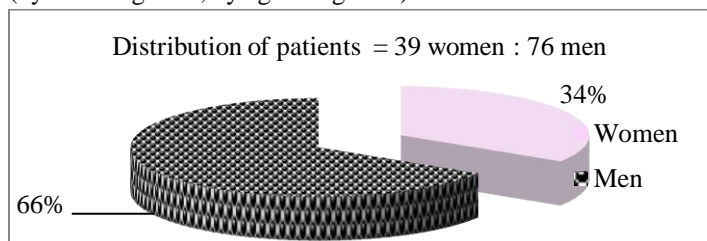


Figure 1: Distribution of patients (M:W).

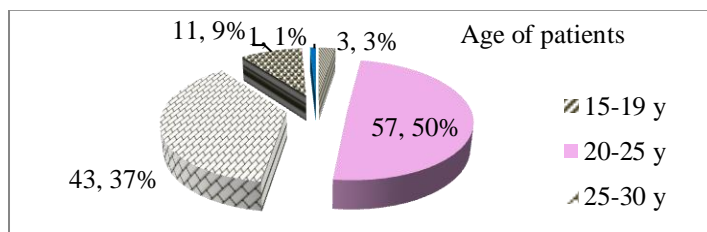


Figure 2: Distribution of patients (age).

Methods

All 115 patients after ACL reconstruction (divided into five groups) received a complex rehabilitation programme of one month.

- All patients received physiotherapy (active exercises), cry therapy (ice massage), ergo therapy (occupational therapy) and patient education.
- Patients of the first group (gr-1) received only these procedures.
- For patients of the second group (gr-2) local applications of a non-steroidal anti-inflammatory drug (NSAID ointment or crème) were included.
- In group 3 (gr-3) we added low frequency low intensity Magnetic field (MF);
- In group 4 (gr-4) we added another preformed modality - Deep Oscillation (DO).
- Patients of the group 5 (gr-5) received both preformed modalities: MF and DO.

Patients were controlled before, during, at the end of the PRM course and one month later - using a battery of subjective and objective methods: tests and scales for pain, range of motion, knee stability and gait. Statistical analysis was performed with SPSS package, using ANOVA and Wilcoxon methods ($p < 0.05$).

Rehabilitation programme

The objective of the rehabilitation was reconstitution of ROM and prevention of loss of muscle strength. For this, during the

first days after the traumatic lesion and the operation (post-op), we applied: partial immobilization and the RICE-protocol (Rest-Ice-Compression-Elevation). The standardized knee immobilization is through an *orthosis* (with possibility of fixation and regulation of the flexion / extension). From the 2nd post-op day we began with cryotherapy and range-of-motion (ROM) exercises. From the post-op day 5 we included an extended PT-programme (ROM, strengthening exercises), ergotherapy (ET - gait training, activities) and procedures with preformed modalities (magnetic field and deep oscillation). The PT-complex included obligatory analytic exercises, especially for Quadriceps Femoris /QF/ and for Gluteus medius muscles [4,20]. At the beginning, we use passive mobilizations /under the level of pain perception/, after - isometric exercises; gradually we include isotonic exercises, with a progressive increase of the applied resistance during exercises. The Gait Training was realized with gradually rise of the weight bearing /WB/ (from non-weight bearing to 50 % and to full WB) and progressive transition from crutches and cane to gait without technical aids. As Ergotherapy (Occupational therapy) we introduce gradually different everyday activities, including sports: stationary bicycle, swimming, etc. From the group of preformed physical modalities we applied: Low frequency pulsed magnetic field (MF with parameters: 16 000 A / m, 10-20 min.) – for the knee joint; Deep Oscillation (DO with parameters: 5-7 μ A, 15-30 minutes; two frequencies: 10-20 Hz & 140-200 Hz) – for the knee joint [21,22].

Ethical aspects

The investigation was conducted with consideration for the protection of patients, as outlined in the Declaration of Helsinki (1964), and was approved by the appropriate institutional review boards and ethic commissions. All patients gave written informed consent before undergoing any examination or study procedure.

Details of organization of the study, randomization and blinding

A simple randomization was used. Patients were sequentially numbered and randomized into five treatment groups of 23 each one. According recommendations [23,24]. The investigation was realized by a multi-professional team; including: a medical doctor – specialist in Physical and rehabilitation medicine (PRM) and in Neurology. The physical therapy complex was performed by two physical therapists, with sub-specialization in the fields of Neurological and Orthopedic Rehabilitation. The statistical analysis was performed by a specialist in Information Technologies. The medical doctor provided the exams of patients (before, during and after treatment) without information concerning the rehabilitation complex. The physical therapists oriented every first patient to gr 1, every second patient – to gr 2, etc. The mathematician had not information about patients' personal data and PRM complex; he had only investigations' results. The details of the series were revealed to investigators

after the end of the study.

Results

For us, the primary endpoint was change in pain intensity, knee functionality and gait stability. Secondary efficacy endpoints included changes in the level of functional limitations and in the quality of life of patients. The comparative analysis of results demonstrates the efficacy of rehabilitation in all cases, so due to physiotherapy and cryotherapy. Pain and oedema were most significantly reduced in groups 4 & 5 (with DO). The knee ROM and knee stability was most significantly improved in groups 3 & 5 (with MF). Efficacy of PRM on length of the step was most significant in groups 3, 4 & 5 (all groups with preformed modalities). All results are better for patients of gr-5, so the complex rehabilitation is most useful for our patients.

Analysis and Discussion

The comparative analysis of results demonstrates the efficacy of physiotherapy and cryotherapy on mobility of the knee joint and gait stability. We observed a significant reduction of pain and oedema in groups 4 & 5 (with DO). The knee ROM was most significantly improved in groups 3 & 5 (with MF). Efficacy of PRM on length of the step was most significant in groups 3, 4 & 5 (all groups with preformed modalities). All observed results were better after the local application of NSAIDs' ointment or crème, and after the addition of a preformed physical factor.

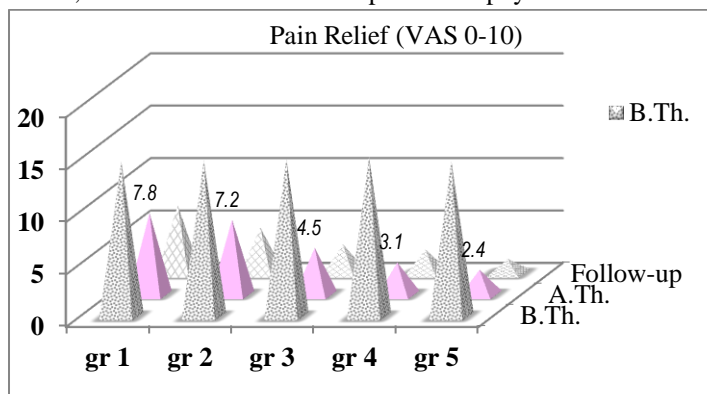


Figure 3: Pain relief (VAS 0-20; no pain, to worst pain).

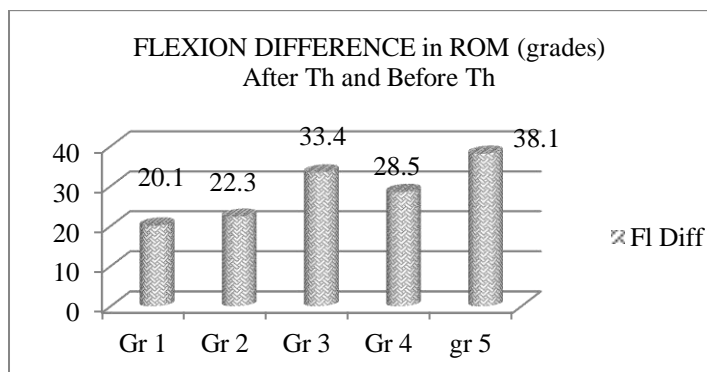


Figure 4: Flexion differences.

Physical analgesia or the anti-pain effect of physical

modalities

The reduction of pain sensation is visualized by the Visual analogue scale (VAS 0-10), presented in Figure 3. The analgesic effect is significant in all groups (comparison before and after therapy), but is most expressed (significance < 0.05) in groups 3, 4 and 5 (combination of natural and preformed physical modalities). A very interesting fact is that the inclusion of preformed modalities (especially DO), has an important analgesic effect, and this effect has a long duration, including one month after the end of rehabilitation (significance during comparisons B.Th. and A.Th.; and B.Th. and one month later follow-up). By our opinion the anti-pain effect of physical modalities is very important, with a high level of efficacy [22-25]. Physical analgesia has not adverse effects and side consequences, and may be applied in combination with other therapeutic factors (promoting medication's analgesic effect).

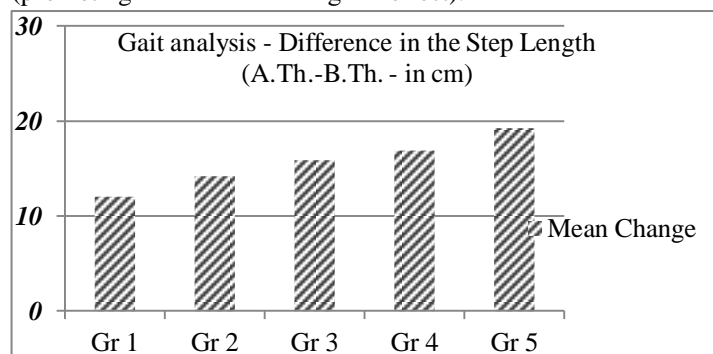


Figure 5: Gait analysis – step length.

Pain and oedema

Pain and oedema are most significantly reduced in gr-3 and gr-5, due to the Deep Oscillation therapy and the influence of the electrostatic field on tissues in profundity, explained with the Johnsen–Rahbek effect [26,27]. Probably, these effects are consequences of the stimulation of circulation and the block of peripheral sensitization.

Range of motion and Gait stabilization

The reconstitution of the range of motion (ROM) of the knee joint is very important goal of the rehabilitation [28]. In our patients, the ROM (especially the flexion) is most increased in gr-3 (MF). Probably the magnetic field stimulates the metabolism and has a trophic effect on the joint tissues, enhancing its mobility. The step length is probably influenced directly and indirectly by the increase of joint mobility, and the reduction of pain and oedema. In all cases, we observed a growth of the step length and the gait stability and velocity (steps per minute). Patients' opinion and satisfaction of the rehabilitation was very important for us. Younger sportive subjects with a more active life need the gait stability and velocity in their everyday activities and they are the better critics of the complex PRM programme after surgical reconstruction of ACL [29].

Rehabilitation Team

For effective management the presence of a multi-professional therapeutic and rehabilitation team is obligatory. Different models of organization of the teamwork of the staff are applied: interdisciplinary (complex care of the patient from different scientific and professional disciplines); multi-disciplinary (role of every professional is completely independent from the others); transdisciplinary (everyone helps the work of the others; role and functions are distributed). We consider that the clinical practice imposes the necessity of transition from a multi-disciplinary to a transdisciplinary model of teamwork, with a clear definition of the fields of competence and the responsibility of the team members. In Bulgarian rehabilitation practice traditionally a lot of specialists are included: medical doctors – specialists in Orthopedics and Traumatology and in Physical and Rehabilitation Medicine (PRM); nurses; bachelors and masters in Physical Therapy (Kinesiotherapy – according the Bulgarian nomenclature).

Limitations of our Study

Our study was carried out on a relatively small group of patients, with ACL rupture and anterior reconstruction. So, now we are sure that the proposed rehabilitation programme, including DO and MF, will be beneficent for this type of patients, but we haven't (at the moment) sufficient experience with arthroscopic operations, due to other causes.

Practical Issues from our Study

Rehabilitation is a cheap and useful option for increase the patients' quality of life. Deep Oscillation and Magnetotherapy are effective preformed physical modalities with significant anti-pain and anti-oedema effect. The patient education must be detailed and adapted to the needs of every concrete patient, including other types of patients, excluded from our study (ACL and PCL rupture, meniscal lesions, etc.).

Future Directions

We consider that, in the future, investigators must observe the efficacy of other preformed physical modalities on post-op cases with ACL rupture and subsequent reconstruction. A comparison between different physical factors can be useful for the management protocol in this type of patients.

Conclusion

Physiotherapy and cryotherapy are useful for the knee mobility and stability. Preformed physical modalities can ameliorate the efficacy of rehabilitation in ACL-patients: Magnetic field is useful for analgesia, Deep Oscillation – for the pain and oedema. The complex PRM-programme is the most effective for the knee mobility and stability, respectively – for the autonomy of patients in everyday life. In conclusion, we must emphasize the impact of the complex PRM-programme in patients after ACL-

reconstruction and its efficacy for: pain relief; enhancement of the range of motion of the knee; enrichment of the functional capacity; amelioration of the neuro-muscular coordination; stabilization of the gait; improvement of the quality of life. Different natural and preformed physical modalities must be sinergically combined for amelioration of the efficacy of rehabilitation in patients after ACL reconstruction.

Consent

All authors declare that written informed consent was obtained from every patient before any examination or procedure.

Ethical Approval

All authors hereby declare that the investigations and treatment of patients have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 declaration of Helsinki.

Funding Information

Authors declare that the current article was prepared without sources of funding.

Acknowledgments

Elements of the Physiotherapeutic program are elaborated by the first author under the ERASMUS Plus programme – project “Collaborative learning for enhancing practical skills for patient-focused interventions in gait rehabilitation after orthopaedic surgery (COR-skills)”, No 2015-1-Ro01-KA202-015230.

Competing Interests

Authors have declared that no competing interests exists.

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