Evaluation Study

USE OF PROPRIOCEPTION DURING KNEE REHABILITATION AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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ABSTRACT

Sport practices without basic training, training with large loads, with high and little recovery time, can provoke traumatic injuries. Damage to the anterior cruciate ligament is a very common traumatic injury in many sports disciplines. In recent years we have seen an increasing trend of its injury from the practice of sports by non-professionals caused by non-compliance with pre- and post-workout preparation stages. The purpose of this article is to highlight through clinical cases the effectiveness of treatment through proprioceptive rehabilitation after intervention of ligament reconstruction of the anterior cruciate ligament. To gather theoretical information, bibliographic research based on literature after the 2000s and selected online materials obtained from recent studies has been conducted. The study is based on clinical cases and was conducted during the period September 2023-January 2024, in which five patients were studied. Subjects were treated at the physiotherapy center "Orthomed Sport". Assessment of functional progression in patients has been performed every week, where pain, goniometer articular Range of Motion (ROM), muscle strength, and intra-articular bleeding have been measured. Exercises were performed gradually and under the control of a physiotherapist. From the result of the therapy, it is evident how proprioceptive reeducation is very important in the chronic phase of rehabilitation, as it improves engine control, postural stability, sensitivity after movement, and muscle strength.

KEYWORDS: *genu articulation, ACL, post-operative, rehabilitation, physiotherapy*

INTRODUCTION

Over the past few years, rehabilitative treatment following anterior cruciate ligament (ACL) surgery has accelerated, but the primary objective of the physiotherapist remains the same: to restore the patient to their pre-injury functional level. To achieve this goal, normal recovery of joint mobility, muscle strength, and knee stability must be ensured, allowing the patient to return to activity as quickly as possible.

The reconstructed ligament must be carefully protected to allow for proper healing and prevent damage to the transplanted tissue. However, prolonged immobilization is not advisable due to several side effects, such as muscle hypotrophy, alterations in articular cartilage and ligaments, and reduced joint mobility resulting from intra-articular scar adhesions.

Previously, patients who underwent ACL surgery were immobilized for a long period to protect the new ligament. Brotzman (1) noted that quadriceps femoris muscle atrophy after 5 weeks of immobilization was 40%, while atrophy of this muscle due to immobilization in knee flexion was even greater at 60%. Additionally, he reported that using

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an accelerated rehabilitation protocol results in a reduction of knee stiffness in flexion by 10° and a decrease in joint fibrosis from 12% with classical treatment to 4% with accelerated treatment (1).

Recent studies show that the bundles of the anterior cruciate ligament (ACL) perform different roles during knee movements: the anteromedial bundle is stretched during flexion, while the posterolateral bundle is stretched during extension; the latter also has greater resistance to hyperextension (2).

The most common mechanisms of ACL injury are:

- external rotation in knee valgus;
- knee flexion combined with internal rotation;
- hyperextension combined with internal rotation.

In these cases, the ligament can be damaged in less than 2/100 a second, making it impossible for the athlete to execute a voluntary corrective muscular response that requires more than 200 milliseconds.

The most frequent and traumatic injury to the knee joint is ACL rupture. The consequences of this ligament rupture are:

- joint instability leading to mechanical stress on other structures such as the menisci and cartilage. The patient experiences a sensation that the knee is shifting forward or out of its natural position each time they stand up;
- pain localized in the joint, with the patient reporting a numb feeling in the lateral part of the thigh;
- joint blockage (reduction in range of motion or ROM) resulting from joint pain during movement and the lack of integrity of a crucial component of joint function, such as the ACL;
- swelling (joint effusion): typically, it does not appear immediately but a few hours after the injury. The swelling may decrease on its own after a few days, but the knee will remain unstable, and returning to sports activity without proper physiotherapeutic treatment may lead to further knee problems;
- muscle hypotrophy (quadriceps femoris) because of joint immobility due to pain and walking with slight knee flexion (2).

As a result of the rupture, knee stability is reduced, and the tibia shifts forward by 0.5-1 cm relative to the femoral surface. This forward shift constitutes the so-called anterior drawer syndrome, which is provoked as follows: the knee is flexed to 90°, and with the hands placed on the popliteal fossa, the tibia is pulled forward. If the tibia shifts forward, it indicates an ACL rupture. Often, ACL rupture is accompanied by medial collateral ligament rupture and medial meniscus rupture (3).

Thanks to arthroscopic techniques, ACL reconstruction has become a very common procedure. The most modern surgical treatment for ACL injury is arthroscopic reconstruction using the patient's own tendon.

The most commonly used grafts are those from the semitendinosus-gracilis tendons and the patellar tendon (4).

Recent studies have confirmed the effectiveness of both types of interventions in the functional recovery of the injured knee joint(5).

ACL injury results in joint instability and, over time, in the absence of proper surgical treatment, leads to progressive reduction in joint mobility, degeneration of articular cartilage, meniscal damage, and the development of post-traumatic osteoarthritis (6).

In addition to the quadriceps femoris muscle, strengthening of the hamstring and gastrocnemius muscles is also addressed. The main objective is to ensure that the strength of the flexor muscles matches that of the extensor muscles (7).

Classic rehabilitation protocols are based on the concepts of strength and movement, while accelerated protocols also incorporate proprioceptive exercises, making the rehabilitative treatment more functional. Proprioceptive exercises should be performed progressively.

Given that there is no definitive base protocol for ACL rehabilitation, physiotherapists rely on various protocols aimed at:

- rapid mobilization and loading;
- swift control of edema;
- muscle strengthening;
- proprioceptive re-education;
- cardiovascular training.

This article aims to provide a comprehensive overview of ACL rehabilitation following surgical intervention. In this work, the ACL has been examined by describing its function, methods of injury, incidence, symptoms following injury, types of surgical intervention, and rehabilitation according to accelerated protocols.

Five patients were studied as case examples to highlight the importance of proprioceptive treatment. Thanks to proprioceptive treatment, these patients achieved good results in knee joint functionality following surgical intervention.

MATERIALS AND METHODS

In this study, the selected therapeutic protocol is the Campbell Clinic protocol, as it includes mobilization, extension, loading, and functional rehabilitation in the early stages. This protocol is not considered "aggressive" regarding the rehabilitative phase and returns to sports activity.

The article examines and treats five patients aged 19 to 32, four of whom are professional athletes, and one is an office worker. All patients, in addition to having an ACL injury, also had a medial meniscus tear. The study is a case study conducted from September 2023 to January 2024. The subjects were treated at the physiotherapy center 'Orthomed Sport'. All patients were presented at the clinic following ACL surgical intervention. The subjects were informed about the study's purpose and that their personal data would not be published. They were assessed through questionnaires and various measurements (goniometer, tape measure, etc.). Their treatment at the clinic lasted for 12 weeks, with the first 8 weeks at a frequency of 5 days per week and the remaining 4 weeks at a frequency of 3 days per week, alternating physiotherapy with hydrotherapy.

The physiotherapeutic protocol used is Campbell Clinic because it includes mobilization and knee joint extension in the early stages. It also allows for a return to sports activity without the use of a brace 6 months after surgical intervention.

After taking the patient's history, a static postural assessment and a dynamic postural assessment were conducted. Following the visit and objective examination, the patients began treatment with Continuous Passive Motion (CPM), which helps to increase the joint ROM of the knee. In addition to CPM, an electrical stimulator was used as an adjunct to achieve quadriceps femoris muscle contraction. Functional progress was evaluated weekly, focusing on pain, ROM with a goniometer, muscle strength, and intra-articular bleeding.

Rapid joint mobilization not only promotes tissue nourishment but also maintains good muscle tone. Once a good, pain-free active mobilization of the knee joint is achieved, patients perform muscle strengthening exercises through isometric contractions of the quadriceps to achieve good tonotrophy. In addition to strengthening the quadriceps femoris muscle, emphasis was also placed on other muscles in the femoral region, without neglecting the gastrocnemius and gluteus muscles, which play a role in stabilizing the knee joint. At the end of each session, patients performed stretching exercises and cryotherapy.

Once a full, pain-free ROM and good muscle strength are achieved, patients perform proprioceptive exercises using tools such as the Freeman Table, Bosu, resistance bands, balance boards, etc. The exercises are conducted in a gradual and controlled manner, with 8-10 repetitions for 3 sets.

During the "motor reprogramming" phase through proprioceptive exercises, patients also engage in sport-specific training related to their activity. They perform directional changes, stationary jumps, diagonal jumps, step exercises, etc. These patients perform proprioceptive exercises on the Freeman Table before each workout or match; specifically, they complete bipodal exercises for one and a half minutes and monopodal exercises for one and a half minutes. The aim of these exercises is to enhance the effectiveness of proprioceptive treatment in post-surgical rehabilitation of the ACL.

For each patient, two physiotherapy records were used: one at the initial assessment (in) for evaluating the patient and one at discharge (out) to assess the effectiveness of the treatment. At the conclusion of the rehabilitation program, conclusions for all five patients are presented with corresponding tables (Table I) and Graphs (1-10).

RESULTS

By observing the results of the treated clinical cases, the use of a well-designed rehabilitation protocol combined with a robust proprioceptive program yields satisfactory results in patient recovery following ACL reconstruction.

From the data, it is evident that proprioceptive re-education is crucial in the rehabilitation phase, as it enhances motor control, postural stability, movement sensitivity, and reduces the risk of re-injury.

Proper proprioceptive re-education is essential for achieving good functional outcomes in the knee joint following surgical intervention.

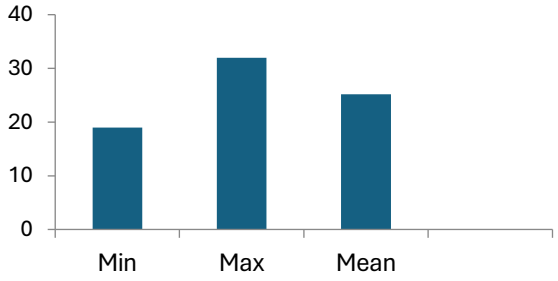
All treated patients utilized the same rehabilitative techniques, and at the conclusion of the rehabilitation cycle, the following results were observed:

- patients who experienced significant pain: 80% achieved complete pain relief, while 20% experienced partial improvement in knee pain;
- patients with joint limitation: 100% achieved full recovery of joint mobility;

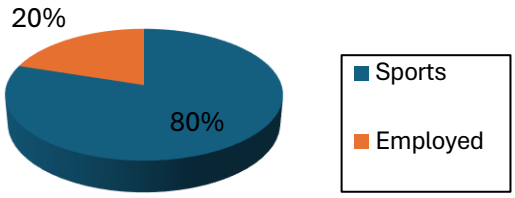
- patients with intra-articular bleeding: 100% achieved complete resolution of the bleeding;
- patients with reduced muscular capacity: 100% achieved full improvement in muscle strength.

Table I. *Descriptive statistics.*

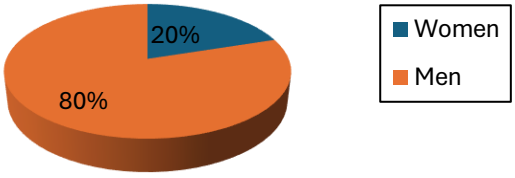
Age	Mean Minimum Maximum	25.2 years 19 years 32 years
Patient Type	Sports Employed Unemployed	4 1 0
Gender	Female Male	1 4
Pain	Total reduction Partial reduction	4 1
Joint Limitation	Full recovery Partial recovery	5 0
Muscular Capacity	Full recovery Partial recovery	4 1
Use of Assistive Devices	Crutches Braces Crutches + Braces None	2 0 1 2
Intra-Articular Bleeding	Full recovery Partial recovery	5 0
Type of Intervention	Patellar tendon graft Semitendinosus/Gracilis tendon graft	1 4
Physiotherapy Description	Kinetek/Patellar mobilization Electrical stimulator/Bike Isometric contractions Isotonic contractions Squat (single/double leg) Freeman table/Motomed/Bozu Bands/skimmy/Hydrotherapy Balance exercises Theraband exercises Final degree leg extensions Cryotherapy post-exercise	5 5 5 5 5 5 5 5 5 5 5



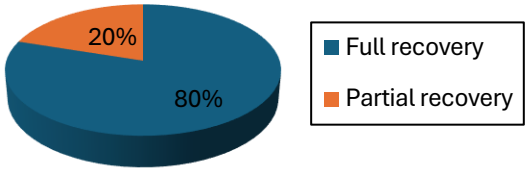
Graph 1: *Age.*



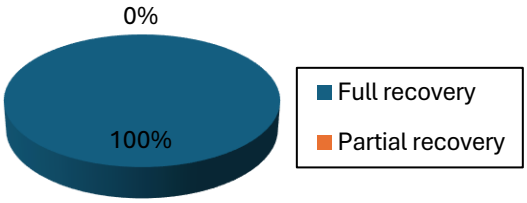
Graph 2: *Patient Type.*



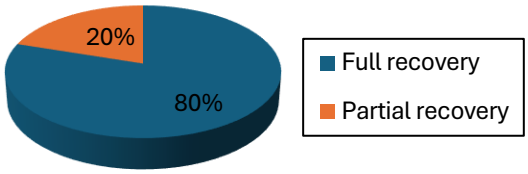
Graph 3: *Gender.*



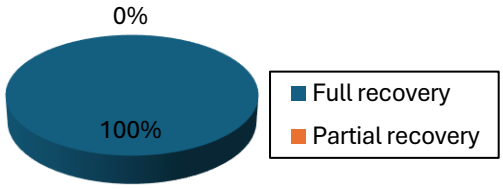
Graph 4: *Pain.*



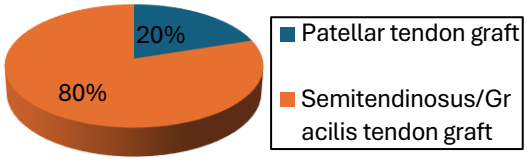
Graph 5: *Joint limitation.*



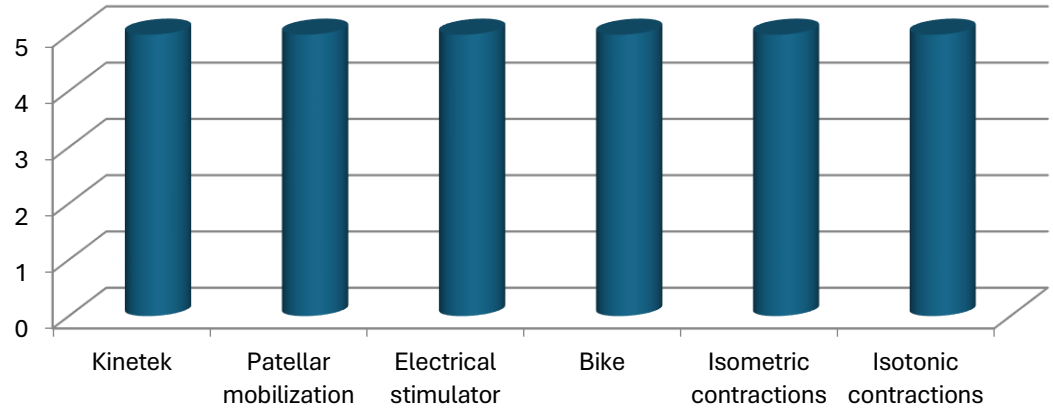
Graph 6: *Muscular capacity.*



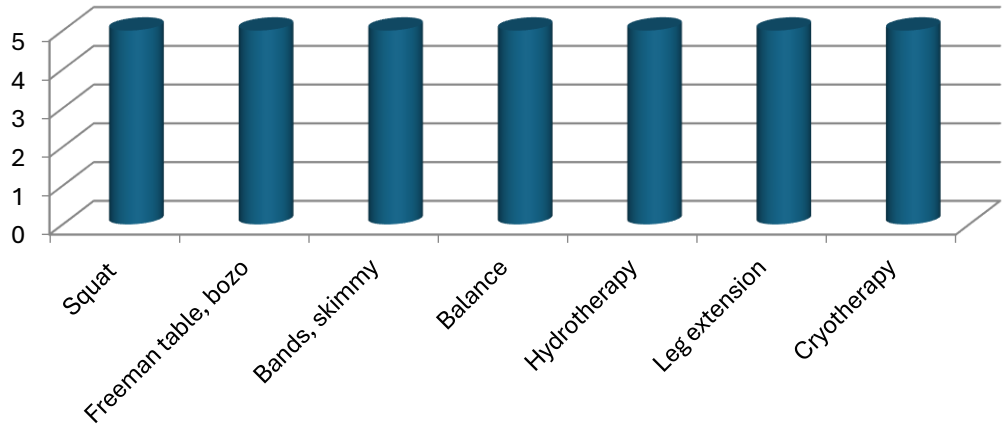
Graph 7: *Intra articular bleeding.*



Graph 8: *Type of Intervention.*



Graph 9. *Physiotherapy description.*



Graph 10. *Physiotherapy description.*

DISCUSSION

Numerous aspects of rehabilitation following ACL reconstruction have been investigated with Level I and II clinical trials. As with most systematic reviews, including published studies often involves a publication bias in favor of positive findings. This is less relevant when studying rehabilitation, as both positive and negative findings are deemed important. Although many of the included studies have a selection bias, it is still possible to draw some valuable conclusions.

Overall, no brace or length of brace wear demonstrated an advantage over another type of brace, another duration of bracing, or no bracing. Bracing does not provide any benefit and is not necessary. Accelerated rehabilitation has shown no deleterious effects, and it is likely safe for patients to begin immediate postoperative weight-bearing, move the knee from 0 to 90 of flexion, and perform closed-chain strengthening exercises.

Eccentric quadriceps muscle strengthening and isokinetic hamstring muscle strengthening were safely incorporated three weeks after surgery; they may be safe sooner, but further research is needed.

Neuromuscular exercises are not likely to harm patients; however, their impact was small, making them unlikely to yield large improvements in outcomes or help patients return to sports faster.

Neuromuscular exercises should not be performed to the exclusion of strengthening and range-of-motion exercises.

The studies presented in this paper focused on improving rehabilitation following ACL reconstruction, with a goal of safely allowing expeditious return of mobility, strength, and ultimately sport participation.

However, few studies measured the ability to return to sports and its timing following the interventions. The availability of such data could strengthen the conclusions of studies and should be considered in future research. Despite the large number of randomized trials, further investigations of the timing of rehabilitation and supplemental rehabilitation exercises are needed to continue to improve the care and function of patients following ACL reconstruction.

CONCLUSIONS

Following ACL reconstruction, patients often exhibit deficits in muscle strength, activation, power, postural stability, and biomechanical alterations. These factors negatively impact the psychological aspect, and decreased mobility increases the risk of re-injury.

This study confirmed that proprioceptive and balance exercises improve postural stability during the initial rehabilitation phase following ACL reconstruction. It was also confirmed that there are no contraindications for neuromuscular exercises, which can be safely used in patients who have undergone ACL surgery. At the final assessment, it was noted that all patients who used proprioceptive exercises fully regained muscle strength and joint mobility, resolving intra-articular bleeding. Regarding pain, 80% of patients experienced complete relief, while 20% had partial improvement.

It was observed that while proprioceptive rehabilitation is crucial, it alone does not complete knee joint rehabilitation. It is important to find a balance between proprioceptive exercises and strength training exercises.

The study results show that muscle strength is a significant factor that enhances knee joint performance during sports activities, reducing the risk of repeated injury. By incorporating proprioceptive exercises that specifically stimulate movement gestures, as well as external and internal stimuli that athletes encounter daily during activity, an optimal biomechanical function of the knee joint can be achieved. For example, Patient 1 was recommended to resume running on soft terrain after 3 months post-surgery and to restart sports activity after 5 months, given the good muscle strength, joint mobility, and knee stability.

Good proprioception and knee joint stability help reduce stride length, especially in backward walking. Although this type of walking is infrequent, it helps understand motor control during walking.

Based on the analysis of clinical cases, the following conclusions were drawn:

- proprioceptive rehabilitation is highly important during the rehabilitation phase as it improves motor control, postural stability, and movement sensitivity and reduces the risk of re-injury;
- proprioceptive rehabilitation does not shorten the return-to-sport time, so it is recommended to combine these exercises with strength and ROM exercises;
- proprioceptive rehabilitation aids in the recovery of stabilizing reflexes, facilitating functional recovery of the knee to its pre-trauma state;
- proprioceptive rehabilitation helps modify muscle strength, proving effective in managing repetitive injuries and preventing subsequent trauma.

All these factors enable patients to regain the necessary stability, strength, and proprioceptive sensitivity, thereby reducing the risk of new injuries to the knee joint.

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