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Physiotherapy Management Before ACL Reconstruction: A Case Report

Anjaswari Resti Arimbi[1*], Irianto[2], Bustaman Wahab[3]

[1,2]Professional Physiotherapy Program, Universitas Hasanuddin, Makassar, South Sulawesi, Indonesia
[3]Department of Medical Rehabilitation, Dr. Wahidin Sudirohusodo General Hospital, Makassar, South Sulawesi, Indonesia

*Corresponding author:
E-mail: anjaswrirstarmb@gmail.com

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Abstract

Introduction: Anterior cruciate ligament (ACL) injuries commonly result in knee instability, decreased functional capacity, and an increased risk of osteoarthritis. Preoperative physiotherapy, including progressive strengthening and neuromuscular training, has been reported to optimize postoperative outcomes. This case report aims to evaluate the effects of preoperative physiotherapy on physical readiness in a young adult patient with a grade 3 ACL injury.
Methods: A single case study design was employed. Data were collected through patient self-report and physical examination. The patient underwent four physiotherapy sessions prior to ACL reconstruction, including pain management, quadriceps and hamstring strengthening, and proprioceptive training. Functional outcomes, pain intensity, and muscle strength were assessed at baseline and after the fourth session.
Results: A 33-year-and-9-month-old male patient with a grade 3 ACL injury presented with knee pain, gait instability, and limitations in physical activity. Following four sessions of preoperative physiotherapy, notable improvements were observed in pain reduction, quadriceps and hamstring strength, and functional mobility, particularly walking stability.
Discussion: Preoperative physiotherapy contributed to enhanced physical and psychological preparedness for surgery, potentially mitigating postoperative complications. These findings suggest that targeted pre-reconstruction rehabilitation is essential for optimizing functional outcomes.
Conclusion: Physiotherapy management prior to ACL reconstruction effectively improves function, reduces pain, and prepares patients for the postoperative period. Preoperative intervention should be considered an integral component of ACL injury management.

Keywords

Anterior cruciate ligament, preoperative rehabilitation, physiotherapy management, knee function, pre-reconstruction

Introduction

Anterior cruciate ligament (ACL) injury is one of the most common knee injuries and significantly affects joint stability and load distribution. This instability can reduce quality of life, limit physical activity, and increase the risk of secondary osteoarthritis.[1] Most patients with ACL injuries are under the age of 30 and face a heightened risk of early-onset osteoarthritis due to repeated trauma or suboptimal management.[1]

Management of ACL injuries may involve either surgical (reconstructive) or non-surgical (rehabilitative) approaches, depending on the severity of the injury. In severe cases, ACL reconstruction is often accompanied by partial meniscectomy to restore joint stability, facilitate return to sports, and prevent secondary injuries. [2,3]

Patients with ACL injuries commonly present with pain, joint sounds during movement, swelling, and instability that interferes with daily activities. If not managed properly, these symptoms may lead to muscle weakness and noticeable asymmetry in lower limb muscle girth.[4] Following ACL injury, patients often experience arthrogenic muscle inhibition (AMI)—a reflexive neuromuscular shutdown of the quadriceps muscle caused by impaired neural signaling due to inflammation and immobilization. This condition contributes to weakened periarticular muscles and impaired joint function.[5]

Physiotherapy plays a crucial role in preparing patients for ACL reconstruction. Preoperative rehabilitation aims to optimize the patient's physical and mental readiness for surgery, which enhances postoperative outcomes and minimizes complications.[6] Patients who undergo ACL reconstruction (ACLR) frequently experience reduced muscle strength, impaired balance, and difficulty walking.[7] Preoperative rehabilitation seeks to mitigate the negative effects of postoperative immobilization and preserve the patient's functional condition.

Failla et al. reported that a combination of progressive strengthening and neuromuscular training before surgery, followed by postoperative rehabilitation, resulted in significantly better functional outcomes than in patients who did not undergo preoperative rehabilitation.[8] This approach not only improved physical preparedness but also reduced fear of reinjury and enhanced the patient's psychological readiness for surgery.[9]

This case is noteworthy as it highlights the tangible benefits of a pre-reconstruction rehabilitation program in a young adult with a grade 3 ACL injury—an area seldom reported in local literature. It is expected to contribute to the growing body of clinical evidence supporting the effectiveness of neuromuscular approaches in preoperative physiotherapy. The aim of this case study is to evaluate the effects of a neuromuscular-based physiotherapy intervention in improving physical readiness in a patient with a grade 3 ACL injury in preparation for surgical reconstruction.

Methods

This study employed a descriptive-exploratory case report design to evaluate the effects of pre-reconstruction physiotherapy intervention in a 33-year and 9-month-old male patient diagnosed with a grade 3 ACL injury. The patient was selected based on inclusion criteria, which included a severe ACL injury with surgical indication and no prior history of physiotherapy. There were no comorbidities that could hinder the rehabilitation process. This case was categorized as an intrinsic case study due to its focus on an in-depth understanding of a single individual as a representation of a clinical phenomenon.

The diagnosis was confirmed by an orthopedic specialist through MRI findings and physical examination, with positive results on the Lachman Test and Anterior Drawer Test. The primary challenges faced by the patient included quadriceps muscle weakness and fear of returning to physical activity. Consequently, the intervention strategy was aimed at strengthening the muscles and restoring confidence in knee function.

The rehabilitation program was carried out over four sessions within a two-week period as part of the patient's preparation for anterior cruciate ligament (ACL) reconstruction surgery scheduled for October 2024. Each session lasted approximately 45 minutes and consisted of three main components: pain management, muscle strengthening, and functional training. Pain management was conducted using Transcutaneous Electrical Nerve Stimulation (TENS) applied for 15 minutes per session. Muscle strengthening exercises included isometric quadriceps contractions (3 sets of 10 repetitions), straight leg raises, and progressive mini squats. Functional training involved weight shifting, gait training, and motor control exercises based on stabilization patterns. The intervention protocol remained consistent across all four sessions, as the patient demonstrated a positive response beginning from the initial session.

Initial assessment indicated right quadriceps muscle weakness, with a Manual Muscle Testing (MMT) score of 3 out of 5, moderate pain with a Visual Analog Scale (VAS) score of 6 out of 10 during activity, and swelling in the affected thigh. Thigh circumference measurements were 45 cm at 7 cm above the patella and 49 cm at 15 cm above the patella. There were no limitations in active or passive range of motion; however, the patient reported a sensation of instability during walking.

The outcome measures used in this study included MMT to assess quadriceps muscle strength, VAS to quantify pain levels during activity, and thigh circumference measurements at 7 cm and 15 cm above the patella to evaluate muscle mass. Assessments were performed during the first and fourth sessions (pre- and post-intervention) to allow for a descriptive and narrative comparison of clinical outcomes. The rehabilitation process was structured over a series of sessions to ensure systematic evaluation and intervention. The timeline of the intervention, including assessment and treatment activities, is detailed in Table 1.

Table 1. Timeline of Rehabilitation Intervention and Clinical Activities

Time	Activity
July 2024	Patient presented with complaints of pain, instability, and a positive MRI.
Session 1	Baseline assessment: MMT, VAS, circumference, and treatment planning.
Sessions 2–3	Active intervention (TENS, muscle strengthening, and functional training).
Session 4	Final evaluation and documentation of clinical changes.

Data were analyzed descriptively by comparing baseline and post-intervention measurements to identify trends in clinical improvement.

Results

Subject Characteristics

The patient, Mr. A, a 33-year-9-month-old male, presented to Dr. Wahidin Sudirohusodo General Hospital with complaints of pain and instability in the right knee. The symptoms had persisted since January 2023 following a jumping incident on an inclined surface. The patient reported hearing a "pop" sound accompanied by severe pain and weakness in the right lower limb. During the first two weeks post-injury, the patient experienced swelling and was unable to walk. In July 2024, he was referred to the same hospital for a preoperative rehabilitation program in preparation for ACL reconstruction surgery scheduled for October 2024. The patient consistently attended physiotherapy sessions every Tuesday and Thursday. Supporting radiological examination via X-ray revealed grade 1 osteoarthritis in the right knee. The orthopedic surgeon clinically diagnosed a complete ACL rupture with a concomitant medial meniscus tear.

Initial Physical and Functional Assessment

Static inspection showed that the right lower limb appeared smaller than the left, with no signs of inflammation. Dynamic inspection revealed unrestricted flexion and extension, but joint instability was observed during standing, indicated by compensatory hamstring activation. Basic movement function showed full range of motion (ROM) during active knee flexion and extension, though extension was accompanied by pain. Passive movements were pain-free. The Task-In-Movement Test (TIMT) indicated that the patient was able to perform tasks without pain.

Pain assessment revealed discomfort during walking and stair climbing. Manual Muscle Testing (MMT) showed mild weakness in the adductor muscles with a score of 4/5. Thigh circumference measured 42 cm on the right

and 43.5 cm on the left at 7 cm above the patella (1.5 cm difference), and 46 cm on the right versus 47 cm on the left at 15 cm above the patella (1 cm difference).

Physiotherapy Intervention

The physiotherapy intervention consisted of four sessions over a two-week period. Each session lasted approximately 45 minutes, with exercise intensities adjusted between 80% and 100% of the patient's tolerance. Each exercise was performed for 5–8 repetitions in 2 sets. To ensure that the rehabilitation approach was targeted and goal-oriented, each physiotherapy intervention was designed in alignment with specific clinical objectives. A detailed overview of the interventions and their corresponding goals is presented in Table 2.

Table 2. Details of Physiotherapy Intervention Based on Clinical Objectives

No	Clinical Objective	Modality	Parameters
1	Preliminary stimulation	Infrared rays	30 minutes, 40–50 cm distance
2	Pain reduction and tissue permeability	Ultrasound diathermy	3 W/cm², circular technique, 10 minutes
3	Muscle relaxation	Manual therapy	Thumb–finger–thenar technique, 7 minutes
4	Patellar mobility	Manual therapy	Caudocranial and mediolateral mobilization, 3 mins
5	Muscle strengthening	Exercise therapy: 1. calf raises 2. SLR with resistance 3. hamstring–quadriceps strengthening 4. adductor–abductor exercises (clamshells, glute bridges)	8 × 8 reps × 2 sets, 4 minutes per exercise
6	Muscle flexibility	Stretching gastrocnemius and hamstrings	16 × 4 repetitions, 4 minutes
7	Post-exercise pain relief	TENS	48 Hz, 4 local analgesic pads, 12 minutes

Evaluation of Intervention Outcomes

Following four sessions of preoperative physiotherapy, clinical outcomes were evaluated using objective measurements. To evaluate the effectiveness of the preoperative rehabilitation program, clinical outcomes were measured before and after the intervention. These outcomes included pain level, muscle strength, and functional ability. A comparison of pre- and post-intervention results is summarized in Table 3.

Table 3. Pre- and Post-Intervention Outcomes Following Pre-ACLR Therapy

No	Parameter	Measurement Tool	Pre (Right)	Post (Right)	Δ (Change)	Interpretation
1	Pain during movement	VAS	3	1	-2	Significant reduction in pain
2	Adductor muscle strength	MMT	4	5	+1	Increased muscle strength
3	Thigh circumference	Tape measure	7 cm: 42 cm 15 cm: 46 cm	7 cm: 43,3 cm 15 cm: 47 cm	+1,3 cm +1 cm	Increased thigh muscle mass

Based on the data above, pain during movement decreased significantly, with a VAS score reduction from 3 to 1. Adductor muscle strength improved from MMT grade 4 to 5. Thigh circumference increased by 1.3 cm at 7 cm above the patella and 1 cm at 15 cm above the patella, indicating improved muscle mass in the affected limb. The patient is scheduled to undergo ACL reconstruction surgery in October 2024, followed by a structured postoperative rehabilitation program. Follow-up assessments will be conducted regularly to monitor long-term outcomes. Throughout the four physiotherapy sessions, the patient demonstrated high adherence to the prescribed regimen and actively followed all instructions. No barriers to participation were encountered, and no adverse effects—such as increased pain, swelling, or excessive fatigue—were reported during or after the exercise sessions.

Discussion

The anterior cruciate ligament (ACL) is one of the four major ligaments that provide stabilization to the knee joint. Located in the center of the joint, the ACL connects the femur to the tibia and functions to prevent the tibia from sliding too far anteriorly relative to the femur while also helping to control rotational movement of the knee. ACL injuries commonly result from sports activities involving sudden changes in direction, jumping, or improper landings. These injuries are typically associated with deep knee pain, swelling, and difficulty bearing weight on the affected limb. Treatment often requires medical interventions such as physical therapy or reconstructive surgery to restore function and stability to the joint.[10]

ACL reconstruction (ACLR) is a surgical procedure to replace a torn ACL using an autograft or allograft. The primary objective is to restore knee stability and function, thereby enabling the patient to return to normal activities. Recovery entails extensive rehabilitation to regain strength and range of motion.[11] The prevalence of ACL injuries in the United States is estimated at approximately 200,000 cases annually, with a higher incidence among athletes—particularly females—due to biomechanical and hormonal differences, presenting a 2- to 8-fold increased risk compared to males in sports like soccer or basketball.[10]

The pathomechanics of ACL injuries involve a complex interaction between mechanical forces and unstable knee positioning. Injury mechanisms typically include excessive loading while the knee is in valgus or flexed positions,

sudden rotational movements, and muscular imbalances, particularly between the quadriceps and hamstrings.[9] ACL injuries are classified into three grades based on severity: Grade 1 (microtears), Grade 2 (partial tear), and Grade 3 (complete rupture with joint instability).[12]

Physiotherapy plays a vital role in pre-operative preparation for ACLR, both physically and psychologically, to facilitate better post-operative recovery.2 The current evaluation demonstrated a significant reduction in pain following intervention, primarily attributed to the use of TENS, which inhibits pain signal transmission via activation of sensory neurons in the substantia gelatinosa, thus reducing pain perception.[13] A reduction in VAS score from 6 to 3 after four sessions supports the effectiveness of this approach. Additionally, neuromuscular electrical stimulation (NMES) is recommended in later phases to enhance quadriceps strength and prevent post-operative muscle atrophy.[14]

Quadriceps and adductor muscle strength improved through a progressive resistive exercise program, which is essential since post-operative immobilization often leads to muscular weakness. Pre-operative strengthening is thus crucial to expedite recovery and preserve optimal knee function.[15] An improvement in MMT score from 3/5 to 4/5 and an increase in thigh circumference from 45 cm to 46.5 cm (measured 7 cm above the patella) indicate a positive response to the intervention. These exercises enhance muscle activation, metabolism, and perfusion, thereby promoting hypertrophy.[16]

The observed increase in thigh circumference also reflects a gain in muscle mass attributable to progressive resistive training. Physiological adaptations include microtrauma to muscle fibers, triggering repair and hypertrophy processes. Combined with a high-protein diet, such exercises stimulate protein synthesis and muscle fiber growth.[16] Findings by Fitzgerald et al. support this, indicating that a four-week prehabilitation program prior to ACLR significantly improves post-operative outcomes.

A comprehensive approach in this case was a key strength, as the intervention strategy was multimodal—incorporating electrotherapy, strengthening exercises, and quantitative monitoring via MMT, VAS, and circumference measurements. Interventions were applied progressively and adapted to the patient's condition. The rationale for each therapeutic modality was grounded in scientific literature.

Nevertheless, this study has limitations, including the short intervention duration (only four sessions over two weeks) and absence of post-operative follow-up. These constraints limit the ability to assess long-term outcomes. Additionally, the lack of a comparison group and the absence of objective functional assessments such as gait analysis or specific functional scoring systems restrict generalizability. Future research using quasi-experimental or randomized controlled trial designs with larger sample sizes is recommended to strengthen these findings.

This study reinforces the importance of incorporating pre-operative rehabilitation into ACLR management protocols. Such an approach can accelerate recovery, maintain muscle strength, and prevent common post-operative deconditioning.

In conclusion, this case demonstrates that pre-operative ACLR rehabilitation provides substantial benefits, including reduced pain, enhanced muscle strength, and increased muscle mass. A personalized and multimodal strategy was proven effective in preparing the patient for improved post-operative outcomes. This may serve as a reference for physiotherapists in designing pre-ACLR rehabilitation protocols.

Conclusion

Neuromuscular-based pre-reconstruction rehabilitation for anterior cruciate ligament (ACL) injuries has proven effective in optimizing both physical and psychological conditions prior to surgery. The application of transcutaneous electrical nerve stimulation (TENS) significantly reduced movement-related pain, accompanied by an improvement in quadriceps and hamstring muscle strength from grade 4 to grade 5 on the Manual Muscle Testing (MMT) scale. Additionally, an increase in thigh muscle circumference was observed, contributing to enhanced joint stability.

The patient's functional abilities, particularly in ambulation, also improved following four rehabilitation sessions. Appropriate intervention strategies that can be adapted into home-based exercises—such as resistance band strength training and proprioceptive exercises focusing on standing balance—are recommended to maintain patient activity during the preoperative period and to support a better postoperative prognosis after ACL reconstruction. Moreover, continuous patient education is essential to promote psychological readiness and facilitate adherence to the subsequent phases of rehabilitation.

Author Contribution

Anjaswari Resti Arimbi contributed to conceptualization, data collection, intervention, analysis, and manuscript drafting. Irianto contributed to study design, clinical assessment, and manuscript review. Bustaman Wahab provided clinical supervision, guidance on intervention protocols, and critical revision of the manuscript. All authors read and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This case report did not require formal ethical approval. The patient's identity was anonymized, and all clinical information was handled confidentially. Written informed consent was obtained from the patient for publication of this case report.

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