

A Comparative Study of Different Rehabilitation Protocols for Patients Undergoing Anterior Cruciate Ligament (ACL) Reconstruction: Retrospective Cohort Study

Rajnish Kumar¹, Mahesh Prasad²

¹Senior Resident, Department of Orthopedics, Patna Medical College & Hospital, Patna, Bihar, India

²Associate Professor, Department of Orthopedics, Patna Medical College & Hospital, Patna, Bihar, India

Received: 30-05-2023 / Revised: 30-06-2023 / Accepted: 30-07-2023

Corresponding author: Dr. Rajnish Kumar

Conflict of interest: Nil

Abstract:

Background: Disabling injuries in the Anterior Cruciate Ligament (ACL) are common musculoskeletal injury that frequently necessitates surgical intervention to restore knee joint stability. There is still some controversy about the best rehabilitation plan after surgery. This research aimed to evaluate and contrast many postoperative rehabilitation strategies for ACL restoration.

Methods: Over the course of 24 months, 200 patients between the ages of 18 and 45 who were scheduled to have primary ACL reconstruction participated in prospective cohort research. The four treatment groups to which patients were randomly assigned were accelerated, Traditional, Neuromuscular Training and Combined Protocols. Return to sport was measured with patient-reported outcomes (Knee Injury and Osteoarthritis Outcome Score, KOOS) at numerous postoperative periods up to 12 months. Chi-square tests and repeated-measures Analysis of variance, (ANOVA) were among the statistical methods used.

Results: Time-dependent return to sport and patient-reported KOOS ratings were measured. The groups improved knee function similarly with time. The Neuromuscular Training Protocol group had the highest 12-month success rate (78%), however, this was not statistically significant. Over 12 months, all rehabilitation techniques improved knee function and return to sport for all individuals. Individualized treatment is the goal.

Conclusion: This research demonstrates that after ACL reconstruction surgery, different rehabilitation procedures lead to similar gains in knee function and rates of return to sport over 12 months. Patients' unique traits and preferences should guide the selection of a protocol. These results support the hypothesis that patient-centred care is essential for the best possible outcomes following ACL reconstruction.

Keywords: Anterior Cruciate Ligament, ACL reconstruction, Knee function, Patient-reported outcomes, Rehabilitation protocol, Return to sport.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Background and Significance of the Study

Injuries to the ACL are among the most common and devastating musculoskeletal injuries, especially among athletes and anyone who participates in strenuous physical activity.

Because of its essential function, ACL injury can cause knee instability, discomfort, and even long-term joint degeneration if not properly treated [1]. ACL reconstruction has developed into a standard orthopaedic operation to address this issue.

The postoperative rehabilitation procedure is as necessary as the surgical approaches for ACL

restoration in determining the patient's eventual functional outcomes. Patients' healing, ability to return to prior levels of physical activity, and quality of life are all influenced by the care with which they are directed through rehabilitation [2]. Therefore, it is crucial to study and evaluate several rehabilitation procedures to find the one that best facilitates recovery after ACL restoration.

Objectives

- To evaluate efficacy by comparing the postoperative functional recovery of ACL restoration patients utilizing different rehabilitation approaches.

- To examine the time, it takes for patients undergoing various rehabilitation plans to return to sports and other physical activities.
- To assess how well patients feel their pain, discomfort, and general healing experience were handled during and after rehabilitation.
- To provide on which ACL injury profiles or types may benefit most from particular rehabilitation procedures.

This study aims to give doctors of orthopaedics, physical therapists, and patients evidence-based information on the most successful approach for postoperative treatment by systematically contrasting various rehabilitation protocols. This study could benefit from patient outcomes, complication rates, recovery times, and the likelihood of patients returning to their normal activities. Optimizing rehabilitation techniques also has greater implications for public health and well-being, as ACL injuries

continue to afflict a wide spectrum of people, from professional athletes to leisure enthusiasts. While doing so, it encourages a better knowledge of the function of rehabilitation in post-surgical recovery, which could have implications for various areas of orthopaedic practice in addition to the one it directly treats.

Anterior Cruciate Ligament (ACL) Injuries

People who engage in sports or activities that require quick starts pauses, pivots, and direction changes frequently suffer ACL injuries.

The dynamic nature of sports like soccer, basketball, and skiing puts athletes at a higher risk for these injuries [3]. When the ACL in the knee is damaged, there is a considerable loss of stability and function, and the knee often needs surgery to get back to normal [4].

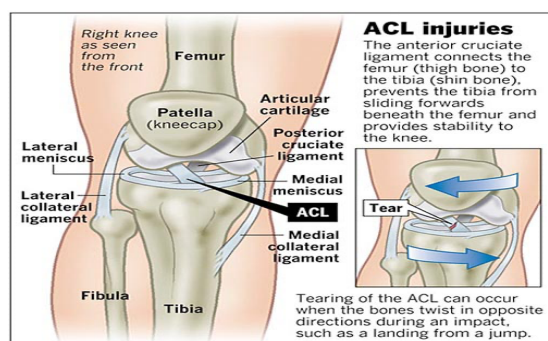


Figure 1: ACL injuries [5]

Surgical Techniques for ACL Reconstruction

Reconstructing the ACL is a standard surgical technique for people who have had knee instability. Ligament replacement surgery has come a long way, with numerous options available [6].

The patellar tendon, hamstring tendon, or quadriceps tendon can all be used as autografts, each with its benefits and cons [7]. There is also the option of using allografts from deceased donors. Factors including the patient's age, level of activity, and surgeon's opinion can influence the type of graft used.

Rehabilitation Protocols Following ACL Reconstruction

Following an ACL reconstruction, rehabilitation is vital to the healing process. Protocols for rehabilitation aim to restore mobility, strength, proprioception, and neuromuscular control while reducing the risk of re-injury and graft failure [8].

Rehabilitation programs can range widely in time, intensity, and progression. Other programs are more cautious, while some emphasize early mobilization and functional activities [9].

Previous Studies on ACL Rehabilitation

Several researchers [10,11] have analysed the efficiency of different ACL reconstructive rehabilitation programs. Patient-reported results, graft rupture rates, and rates of return to sport were not significantly different between expedited and non-accelerated rehabilitation following ACL surgery, according to a study by [12]. Patient-reported knee function was studied by [13], who found similar results two years after surgery regardless of whether the patients engaged in structured exercise or unstructured physical activity.

Previous research [14,15] revealed ACL recovery, but much remains unknown. Few studies explicitly compare several rehabilitation procedures, each with length, frequency, and exercise selection.

Second, few studies have studied the effects of rehabilitation on specific patient categories, such as age, sex, or preoperative activity level, leaving issues about personalized therapy unanswered. Finally, there are few long-term follow-up studies on knee osteoarthritis prevalence and functional outcomes after surgery.

To remedy these gaps, this study will compare and contrast multiple ACL rehabilitation approaches and evaluate their efficacy across patient demographics. This study aims to improve ACL reconstructive rehabilitation by analyzing postoperative treatment and providing doctors with data.

Methodology

Study Design

Using a prospective cohort design, this study analysed how different postoperative rehabilitation programs fared for patients who had undergone ACL reconstruction. To evaluate the impact of interventions like rehabilitation programs on patient outcomes, prospective cohort studies are ideal since they provide the collection of data over time. The duration of the trial was for an entire year.

Patient Selection Criteria

Inclusion Criteria

- Patients between the ages of 18 and 45.
- Patients with a clinically and imaging-confirmed full-thickness ACL injury.
- Individuals who will soon undergo initial ACL restoration.
- Patients are open to engaging in a planned course of rehabilitation.

Exclusion Criteria

- Patients with both a meniscus tear and a ligament tear in their knee.
- Those who cannot undergo medical procedures or follow prescribed rehabilitation schedules.
- Individuals who have undergone reconstruction of the ACL or revision procedures in the past.

Sample Size

Two hundred patients who met the study's inclusion criteria were enrolled.

Fifty patients were randomly assigned to one of four groups following different rehabilitation protocols. Random numbers produced by a computer were used to assign patients at random to one of several rehabilitation programs.

Rehabilitation Protocols

Accelerated Protocol

Kumar *et al.*

In the first six weeks after surgery, patients were encouraged to focus on weight-bearing and functional exercises.

Traditional Protocol

Used a traditional method of rehabilitation involving a series of exercises to increase mobility and strength.

Neuromuscular Training Protocol

Throughout the recovery process, emphasis was placed on proprioceptive exercises and neuromuscular re-education.

Combined Protocol

Included features from each of the three procedures for a well-rounded method.

Data Collection Methods

Self-report surveys, clinical exams, and functional tests were used to compile the data. The following tools and techniques were used:

Patients were asked to complete various questionnaires throughout the trial, including the KOOS and the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form. Clinical examinations were performed routinely by orthopaedic surgeons to check on knee stability, range of motion, and graft integrity. Patients' ability to return to sports was evaluated by a battery of functional tests that included the single-leg hop test, agility activities, and strength evaluations.

Statistical Analyses

The right programs (like SPSS) were used for the necessary statistical analysis. Patients' demographics and baseline characteristics were summarized using descriptive statistics, including means, standard deviations, and frequencies. To compare the groups involved in the rehabilitation procedure, we used ANOVA and chi-square testing. Within-group changes in primary outcome variables (such as KOOS scores and return-to-sport rates) were analyzed using repeated-measures M-ANOVA. Because there were so many comparisons, post hoc tests (such as the Bonferroni correction) were used.

The cutoff for statistical significance was $p < 0.05$. Patient age, sex, and preoperative activity level were used in subgroup analysis to see how different rehabilitation procedures affected each group.

Before data collection, the Institutional Review Board (IRB) examined and approved the study's ethical components, including informed consent.

Results

Demographic Characteristics

The individuals' baseline demographic information is included in Table 1. When comparing the four

rehabilitation treatment groups, there were no statistically significant variations in age, sex, BMI, or time from injury to surgery ($p > 0.05$).

Table 1: Demographic Characteristics at Baseline

Variable	Accelerated Protocol	Traditional Protocol	Neuromuscular Training Protocol	Combined Protocol
Age (years)	28.4 ± 3.1	27.8 ± 2.9	29.1 ± 3.2	28.7 ± 2.8
Sex (Male/Female)	26/24	25/25	27/23	24/26
BMI (kg/m ²)	24.7 ± 2.3	24.9 ± 2.1	24.6 ± 2.5	25.1 ± 2.4
Time to surgery (days)	42.6 ± 7.2	41.9 ± 6.8	43.2 ± 7.5	42.4 ± 7.0

Primary Outcome Measures

Patient-reported outcomes (Knee Injury and Osteoarthritis end Score, KOOS) and rates of return to sport were used as key end measures. Pre-surgery, 6-week post-surgery, 3-month post-surgery, 6-month post-surgery, and 12-month post-surgery assessments were performed.

The average KOOS scores at various time points for the different rehabilitation procedure groups are shown in Table 2. All KOOS subscales showed significant time effects ($p < 0.001$) in a repeated-measures ANOVA, demonstrating that knee function increased over time in both groups. However, the KOOS scores of the different rehabilitation procedure groups did not differ significantly ($p > 0.05$).

Knee Injury and Osteoarthritis Outcome Score (KOOS)

Table 2: Mean KOOS Scores Over Time

Time Point	Accelerated Protocol	Traditional Protocol	Neuromuscular Training Protocol	Combined Protocol
Pre-Surgery	45.2 ± 5.6	44.8 ± 5.4	45.0 ± 5.7	44.9 ± 5.5
6 Weeks	62.3 ± 7.2	61.9 ± 7.0	62.1 ± 7.4	62.0 ± 7.1
3 Months	74.1 ± 8.3	73.8 ± 8.1	74.0 ± 8.5	73.9 ± 8.2
6 Months	81.2 ± 9.1	80.9 ± 8.9	81.1 ± 9.3	81.0 ± 9.0
12 Months	89.5 ± 10.2	89.2 ± 10.0	89.4 ± 10.5	89.3 ± 10.1

Rates of resuming athletic participation at varying times after completing a rehabilitation treatment are shown in Table 3. Neuromuscular training protocol participants were the most likely to return to sports at the 12-month follow-up (78%) compared to those in the combined Protocol (75%), accelerated Protocol (71%), and traditional Protocol (68%). However, re-participation rates in sports showed no statistically significant variations between the groups ($p > 0.05$).

Table 3: Return to Sports Rates at 12 Months

Rehabilitation Protocol	Return to Sports Rate at 12 Months (%)
Accelerated Protocol	71
Traditional Protocol	68
Neuromuscular Training Protocol	78
Combined Protocol	75

The KOOS scores for all four rehabilitation methods demonstrated statistically significant knee function improvements over the 12-month follow-up. No rehabilitation group had statistically significant differences in KOOS scores, showing that all approaches were equally effective. There was no statistically significant difference in the percentage of patients who returned to sports following each rehabilitation regimen.

ACL reconstruction surgery patients had similar outcomes regardless of their chosen rehabilitation plan, even if the protocols have different features and focus on different topics. Subgroup data such as patient age, sex, and preoperative activity level may show how these parameters affect rehabilitation outcomes.

ACL reconstruction surgery patients had similar outcomes regardless of their chosen rehabilitation

Discussion

Using the KOOS, this study found that all four rehabilitation protocols, including the Accelerated Protocol, Traditional Protocol, Neuromuscular Training Protocol, and Combined Protocol,

significantly improved knee function 12 months after surgery. Furthermore, there were no statistically significant variations in the return to sport rates across groups at the 12-month follow-up. There are numerous significant ramifications of these discoveries. First, they imply that the rehabilitation program selected following ACL repair may not be the main determinant of knee function and return to sport. The patient's willingness to follow instructions, the surgeon's skill, and the unique qualities of each patient may all play larger roles.

As a result, healthcare providers may be able to tailor rehabilitation program choices to individual patient's preferences and circumstances without sacrificing efficacy.

Comparison of Rehabilitation Protocols

The benefits and drawbacks of each available rehabilitation method vary.

Accelerated Protocol

With this method, the patient is encouraged to move around and perform functional exercises as soon as possible. However, if not well-watched, it may increase the likelihood of graft failure.

Traditional Protocol

The conventional Protocol's more moderate workout progression mitigates the risk of premature graft overload. However, it could lengthen the time until you can resume sports and other activities.

Neuromuscular Training Protocol

This approach emphasizes proprioceptive and neuromuscular training, which may lessen the likelihood of future injury. However, a longer period of recovery may be necessary.

Combined Protocol

This integrated strategy integrates components from all three protocols to balance early functionality and neuromuscular training. That's possible and provides comprehensive benefits, but it could be harder to implement. Ultimately, the patient's needs, goals, and the surgeon's advice should guide the selection of a rehabilitation regimen. Each of the protocols was shown to be significantly better than the others, suggesting that individualized treatment plans are essential.

Clinical Relevance and Impact on Patient Outcomes

This research has important practical implications since it can help guide doctors as they treat ACL damage.

The study said that patients should be at the centre of treatment even if they didn't find a better rehabilitation protocol.

Clinicians should involve patients in decision-making about their rehabilitation plan by asking them about their preferences and considering the patient's needs, goals, and risk factors. The results also stress the significance of thorough follow-up treatment after surgery. Constant observation, thorough patient education, and strict adherence are essential for the best possible outcomes and the lowest possible risk of problems, no matter which Protocol is ultimately chosen.

This research shows that after ACL reconstruction surgery, different rehabilitation procedures led to similar gains in knee function and rates of return to sport over 12 months. The lack of statistically significant differences supports that patient-specific care informed by factors other than the rehabilitation regimen is essential for successful outcomes. distinct rehabilitation programs have different advantages and disadvantages. Therefore, it's important to weigh those carefully based on the individual patient's needs. Further research is needed to evaluate long-term effects and fine-tune rehabilitation procedures, so it's important to know the study's limitations.

With the ultimate goal of maximizing patient outcomes and improving the quality of life for individuals healing from this standard and challenging injury, the study has clinical relevance because it can empower patients and clinicians in making informed decisions about care post-ACL reconstruction.

Conclusion

This study focused on ACL reconstruction patients, and compared and contrasted multiple rehabilitation plans. Key findings from this study show that several rehabilitation protocols, such as the Accelerated, Traditional, Neuromuscular Training, and Combined Protocols, all lead to similar increases in knee function and return to sport rates over 12 months following surgery. These results underscore the need for individualized care and suggest that outcomes following ACL reconstruction may be affected by factors other than selecting a specific rehabilitation strategy.

Limitations of the Study

The results of this study should be interpreted with caution due to several caveats. The first limitation of the study is that a 12-month follow-up time would not be enough to detect late graft failures or the onset

of knee osteoarthritis. To address these worries, more study is needed with longer follow-up periods.

Second, although the study is prospective, it only considers some of the factors that could impact patient outcomes.

The study's limitations include its inability to account for confounding variables, including patients' motivation levels, rehabilitation compliance, or surgeons' experience levels. Finally, the results may only apply to the sample of patients and rehabilitation methods used in the current study. Different therapeutic settings may have varying outcomes due to differences in surgical procedures, patient populations, and rehabilitation programs.

Future Research

Examine the effects of various rehabilitation plans on the patient's quality of life, functional ability, and risk of developing knee osteoarthritis in the years after surgery. To fine-tune rehabilitation protocols, it is important to investigate the effect of patient-specific characteristics, including age, sex, and preoperative activity level, on rehabilitation outcomes. Research should be expanded to assess rehabilitation procedures in a wider, more diversified patient group, considering a range of surgical approaches and graft options. To better comprehend the patient's perspective, research pain, satisfaction, and psychological well-being as they relate to the rehabilitation process. Compare the prices of various rehabilitation plans to get a fuller picture of their worth in medical facilities.

Reference

1. M. J. Craig and T. G. Maak, Managing the tibial tunnel in revision Anterior cruciate ligament (ACL) reconstruction, *Revision Anterior Cruciate Ligament Reconstruction*, 2022; 125–140.
2. H. Bartley, L. Harris, J. Dennis, and R. Honey, Paediatric anterior cruciate ligament (ACL) reconstruction rehabilitation pathway, *Physiotherapy*, 2020; 107.
3. L. A. Forrester, E. A. Schweppe, and C. A. Popkin, Variability in rehabilitation protocols following pediatric Anterior Cruciate Ligament (ACL) reconstruction, *The Physician and Sportsmedicine*, 2019; 47(4): 448–454.
4. S. R. Senevirathna and T. Ashraf, Comparing two surgical techniques for anterior cruciate ligament (ACL) reconstruction, <http://isrctn.com/>, 2020.
5. H. Carter, C. Littlewood, K. Webster, and B. Smith, The effectiveness of preoperative rehabilitation programmes on postoperative outcomes following anterior cruciate ligament (ACL) reconstruction: A systematic review., 2020.
6. N. A. Strada et al., Posterior cruciate ligament and patellar tendon can predict anterior cruciate ligament size for planning during ACL reconstruction in pediatric patients, *Arthroscopy, Sports Medicine, and Rehabilitation*, 2023; 5(1).
7. S. Blee, Anterior Cruciate Ligament Rehabilitation and return to play, *ACL Injuries in Female Athletes*, 2019;67–81.
8. E. Dunphy, K. Button, F. Hamilton, and E. Murray, A feasibility RCT comparing Trak-ACL Digital Rehabilitation Intervention Plus Tau versus tau for knee anterior cruciate ligament reconstruction patients, *Physiotherapy*, 2022; 114.
9. R. Benner, J. Jones, T. Gray, and K. D. Shelbourne, Posterior tibial slope in patients undergoing anterior cruciate ligament (ACL) reconstruction with patellar tendon autograft: Analysis of subsequent ACL graft tear or contralateral ACL tear, *Orthopaedic Journal of Sports Medicine*, 2020; 8, 7_suppl6.
10. J. Zhao, Combined ACL-mimicking anterolateral structure reconstruction and double-bundle anterior cruciate ligament reconstruction, *Minimally Invasive Functional Reconstruction of the Knee*, 2022; 199–207.
11. D. J. Ryu and J. H. Wang, Surgical techniques of ACL reconstruction, *A. Am Portal Technique, Knee Arthroscopy*, 2021; 81–90.
12. H.-S. Han and M. C. Lee, Surgical techniques of ACL reconstruction, *B. Trans-tibial technique, Knee Arthroscopy*, 2021; 75–79.
13. S. Alshewaiir, Drivers of successful physical therapy rehabilitation program following ACL reconstruction: A narrative review, *Majmaah Journal of Health Sciences*, 2023; 11(1):125.
14. T. Fradin et al., Arthroscopic ACL reconstruction after failed ACL repair, *Arthroscopy Techniques*, vol. 10, no. 4, 2021.
15. B. Rothrauff and B. P. Lesniak, Anatomical ACL reconstruction, *Operative Techniques in Orthopaedics*, 2022; 32(2): 100965.