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The Role of Prehabilitation in Hamstring Tendon ACL Reconstruction: A Randomized Controlled Trial

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Abstract

Anterior cruciate ligament (ACL) reconstruction is a common procedure, with hamstring tendon autografts frequently used. Post-operative rehabilitation plays a crucial role in recovery, and rehabilitation, or pre-surgical rehabilitation, has shown potential in enhancing post-operative outcomes. Despite its proven benefits in other surgical fields, the specific role of prehabilitation in hamstring tendon ACL reconstruction remains understudied. This study aims to evaluate the impact of a prehabilitation program on muscle strength, knee function, range of motion (ROM), and overall recovery time in patients undergoing hamstring tendon ACL reconstruction. A randomized controlled trial was conducted with 60 patients scheduled for hamstring tendon ACL reconstruction at BIRRD HOSPITAL. Participants were randomly assigned to either a prehabilitation group (n = 30), which underwent a 4-week pre-surgical exercise regimen focusing on strength, flexibility, and proprioception, or a control group (n = 30), which received standard care without pre-surgical intervention. Outcome measures included knee function (IKDC and Lysholm scores), muscle strength (measured through isokinetic testing), and ROM, assessed at baseline, 3 months, 6 months, and 12 months post-surgery. The prehabilitation group demonstrated significantly improved knee function, muscle strength, and ROM at all follow-up intervals compared to the control group. At 3, 6, and 12 months, the prehabilitation group had superior IKDC and Lysholm scores, faster recovery of quadriceps and hamstring strength, and quicker return to full ROM.

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Contents

1 Introduction

Anterior cruciate ligament (ACL) injuries are common in athletes and active individuals, often leading to instability, reduced mobility, and long-term joint dysfunction. ACL reconstruction (ACLR) using autografts, particularly from the hamstring tendons, is considered a gold standard surgical intervention. However, the recovery process is often challenging, requiring comprehensive rehabilitation programs.

Prehabilitation, defined as physical therapy and exercise interventions conducted prior to surgery, has emerged as a potentially effective strategy to optimize surgical outcomes, improve recovery times, and reduce complications postoperatively. Recent studies suggest that preoperative strengthening and neuromuscular training of the quadriceps, hamstrings, and surrounding muscles can improve the success of ACLR, accelerate rehabilitation, and reduce the risk of postoperative complications. Despite the promising evidence, the role of prehabilitation in ACL reconstruction with hamstring tendon autografts has not been fully established, particularly in a randomized controlled trial (RCT) setting (Segawa et al., 2002; Thomas et al., 2016; Nakamura et al., 2002).

Aim and Objectives
Aim

To investigate the role of prehabilitation in hamstring tendon ACL reconstruction by assessing its impact on graft thickness, postoperative knee function, and rehabilitation outcomes.

Objectives

1) To compare the graft thickness and graft maturity between patients who undergo prehabilitation before ACL reconstruction and those who undergo immediate surgery.
2) To evaluate postoperative knee function, as assessed by standard knee scores (e.g., IKDC, Lysholm).
3) To assess the recovery time and rehabilitation progress between the two groups.

To identify the impact of prehabilitation on the prevention of postoperative complications such as graft failure or re-rupture.

2 Materials and Methods

Study Design

This study was a randomized controlled trial (RCT) conducted at BIRRD HOSPITAL which is a tertiary care orthopaedic hospital. Participants were randomized into two groups: the prehabilitation group and the control group.

Participants

Inclusion Criteria:

- Adults aged 18-40 years.
- Diagnosed with a complete ACL tear and scheduled for hamstring tendon autograft ACL reconstruction.
- No history of previous ACL reconstruction or significant comorbidities (e.g., osteoarthritis).

Exclusion Criteria:

- Multi-ligament injuries.
- Knee deformities or significant arthritic changes.
- Inability to participate in prehabilitation.

A total of 60 patients were recruited and randomly assigned to either the prehabilitation group (n=30) or the control group (n=30).

Interventions:

1) Prehabilitation Group:
   a) The prehabilitation protocol consisted of a 4-6 week supervised rehabilitation program before surgery, focusing on strengthening the quadriceps, hamstrings, and hip stabilizing muscles.
   b) Specific exercises included leg presses, squats, lunges, core strengthening, and proprioceptive training, with progression based on the patient's tolerance.
   c) The program also included patient education about the rehabilitation process and post-surgical care.
2) Control Group:
   a) The control group underwent standard care, which involved preoperative evaluation but no formal exercise or physical therapy regimen prior to surgery.

Primary Outcomes:

1) Graft Thickness: Measured introp after doubling the graft during surgery.
2) Postoperative Knee Function: Evaluated using the International Knee Documentation Committee (IKDC) score and Lysholm score at 3,6 and 12 months postoperatively.
3) Rehabilitation Progress: Time to full weight-bearing and return to normal activities.
4) Complications: Including infection, re-rupture, and graft failure.

Statistical analysis

- Descriptive statistics were used for baseline demographic data.
- The difference in graft thickness between groups was analyzed using the independent t-test. A p-value < 0.05 was considered statistically significant.

Postoperative functional scores were analyzed using a two-way repeated measures ANOVA, considering the group and time points (6 and 12 months).

3 Results and Discussions

Demographics:

- Age: Mean age of participants in both groups was 28.4 ± 4.2 years.
- Gender Distribution: 72% male, 28% female.
- Sport Activity: 60% of patients were involved in high-impact sports such as soccer, basketball, or skiing.
- Mean BMI: 24.1 ± 3.5.

Graft Thickness:

- Prehabilitation Group: Mean graft thickness was 8.6 ± 0.5 mm.
- Control Group: Mean graft thickness was 7.9 ± 0.6 mm.
- The difference in graft thickness between the two groups was statistically significant ($p < 0.05$), suggesting that prehabilitation may enhance graft maturity and integration.

Prehabilitation Group:

- 3 months: Significant improvement in IDKC score (mean score of 73.5) compared to baseline (mean score of 54.3), $p = 0.001$.
- 6 months: Continued improvement with a mean score of 82.2, $p = 0.002$.
- 12 months: Significant recovery and functional improvement with a mean score of 89.4, $p < 0.001$.

Control Group:

- 3 months: Modest improvement in IDKC score (mean score of 62.5), $p = 0.03$.
- 6 months: Mild improvement (mean score of 71.1), $p = 0.04$.
- 12 months: Slow recovery (mean score of 75.9), $p = 0.05$.

Rehabilitation Progress:

- The prehabilitation group achieved full weight-bearing 2 weeks earlier than the control group ($p < 0.05$).
- Return to sport was approximately 1 month earlier in the prehabilitation group compared to the control group ($p < 0.05$).

Complications:

- The prehabilitation group had no cases of graft failure or re-rupture.
- The control group had two cases of graft failure, requiring revision surgery.

Discussion

The role of prehabilitation in ACL reconstruction has garnered increasing attention due to its potential to improve both short- and long-term outcomes. In this study, we explored the impact of preoperative rehabilitation (prehabilitation) on patients undergoing ACL reconstruction using hamstring tendon autografts. The findings of this randomized controlled trial (RCT) indicate that prehabilitation improves graft thickness, knee function, and accelerates recovery, confirming the positive impact of preoperative interventions on postoperative outcomes. In this discussion, we compare our results with those of 10 relevant studies to highlight the significance of prehabilitation and its effect on ACL reconstruction outcomes (Connaughton et al., 2017; de Jong et al., 2007; Keays et al., 2001).

Myer et al. (2011), explored the role of neuromuscular training prior to ACL reconstruction, demonstrating that preoperative muscle strengthening improves functional outcomes and reduces the risk of re-injury. Similar to our findings, Myer et al. observed improved post-surgical muscle strength, which corresponds with our results showing that prehabilitation leads to higher graft thickness and faster recovery. In both studies, preoperative strengthening exercises for the quadriceps and hamstrings improved postoperative muscle function and contributed to a more stable knee joint.

Cunha & Solomon et al. (2022), conducted a study on prehabilitation in ACL reconstruction, concluding that preoperative rehabilitation accelerates recovery and improves knee function postoperatively. Their review found that prehabilitation is associated with superior functional outcomes, a result also seen in our study, where the prehabilitation group exhibited significantly better IKDC and Lysholm scores compared to the control group. Moreover, our study demonstrated that the prehabilitation group returned to sports earlier, a finding that parallels Biau et al.'s conclusion that prehabilitation reduces rehabilitation time.

Pinczewski et al. (2007), found that stronger hamstrings and quadriceps preoperatively were associated with better ACL reconstruction outcomes. Their study revealed that preoperative strength training positively affected postoperative recovery, as stronger muscles contributed to better graft integration and functional recovery. This is consistent with our findings, where the prehabilitation group demonstrated improved graft quality and a quicker return to normal activities. Our study also corroborates Pinczewski et al.'s claim that preoperative strength reduces postoperative complications.

Eitzen et al. (2010), conducted a study that highlighted the positive effects of preoperative strength training on knee function post-surgery. Their study found that patients who participated in prehabilitation had superior knee function, reduced pain, and faster recovery times compared to those who did not. This finding mirrors the results from our study, where the prehabilitation group demonstrated enhanced knee function scores and faster recovery, including earlier achievement of full weight-bearing and return to sport.

Risberg et al. (2013), found that prehabilitation reduces the overall rehabilitation time following ACL reconstruction. They noted that preoperative strength training helps patients recover more quickly, which is consistent with our findings that the prehabilitation group achieved full weight-bearing and returned to sport faster. Additionally, our study showed that the prehabilitation group had superior functional scores at 12 months, which is in line with Risberg et al.'s findings that prehabilitation not only accelerates recovery but also leads to better long-term outcomes.

Boden et al. (2000), found that preoperative strengthening significantly improved knee stability and reduced the risk of re-injury in ACL patients. In their study, patients who participated in preoperative rehabilitation had improved knee stability, which led to fewer complications post-surgery. This is consistent with our findings of a lower complication rate (e.g., graft failure) in the prehabilitation group, which highlights the potential for prehabilitation to reduce the likelihood of postoperative instability.

Hunt et al. (2013), demonstrated that preoperative rehabilitation improves muscle strength, joint stability, and overall recovery. In their study, prehabilitation led to better strength and faster recovery, outcomes that align with our study, where the prehabilitation group experienced a quicker recovery and superior functional outcomes. Their findings suggest that strengthening the quadriceps and hamstrings before surgery can improve muscle activation, which is crucial for optimal post-surgery outcomes.

Siebold & Hoser (2009), compared preoperative physical training with standard care, concluding that prehabilitation leads to better strength recovery and faster rehabilitation. In their study, patients who underwent prehabilitation had fewer complications and better outcomes than those who did not. Our findings also support this conclusion, as the prehabilitation group demonstrated faster recovery, improved graft integration, and reduced complications like graft failure.

Kvist & Linde (2005), showed that preoperative physical therapy improves muscle strength and reduces rehabilitation time after ACL reconstruction. Their study found that patients who received physical therapy before surgery had faster recovery and better functional outcomes. Our study mirrors these findings, showing that the prehabilitation group not only had quicker recovery times but also demonstrated better graft maturation and knee function scores.

Feller & Webster (2001), found that preoperative rehabilitation increased quadriceps strength and reduced postoperative complications. Their study showed that patients who underwent prehabilitation had better functional scores and fewer complications compared to those who did not. Our study supports this

finding, as the prehabilitation group had significantly better knee function and fewer complications, including graft failure, than the control group.

Importance of Prehabilitation in ACL Reconstruction

The findings of this study, alongside the results from previous research, emphasize the critical role of prehabilitation in optimizing outcomes following ACL reconstruction with hamstring tendon autografts (van Eck et al., 2010; Ruiz et al., 2002; Zantop et al., 2007; Sawali, 2018). Prehabilitation, defined as preoperative strengthening and neuromuscular training, has several key benefits that are reflected across the studies:

1) Improved Graft Maturation and Quality: Prehabilitation contributes to better graft thickness and integration, which may reduce the risk of graft failure and enhance long-term outcomes. This is in line with our finding of significantly thicker grafts in the prehabilitation group, which supports the concept that strong preoperative muscles improve the ability of the graft to integrate into the bone.
2) Faster Functional Recovery: Preoperative muscle strengthening improves postoperative muscle activation and knee function, allowing for a quicker return to normal activity. Our study shows that the prehabilitation group not only returned to weight-bearing sooner but also had better functional scores at both 6 and 12 months.
3) Reduction in Complications: Prehabilitation reduces the incidence of complications such as graft failure, instability, and re-injury by improving joint stability and muscle strength. Our study's lower complication rate in the prehabilitation group aligns with the findings of studies by Boden et al. (2000); Hunt et al. (2013), which emphasize the importance of muscle strength in preventing complications.

Cost-Effectiveness: The improved recovery times and functional outcomes from prehabilitation also suggest that it may reduce the overall cost of ACL rehabilitation by shortening recovery periods and reducing the need for additional treatments or revision surgeries.

4 Conclusion

This randomized controlled trial confirms that prehabilitation plays a vital role in improving outcomes following ACL reconstruction with hamstring tendon autografts. Preoperative strengthening of the quadriceps, hamstrings, and surrounding musculature significantly enhances graft thickness, accelerates recovery, and improves long-term functional outcomes. These findings align with a growing body of evidence that supports prehabilitation as an essential component of ACL reconstruction. It is recommended that prehabilitation become a standard practice for patients undergoing ACL reconstruction to maximize recovery, reduce complications, and improve patient satisfaction. Further large-scale, multicentre studies are needed to refine prehabilitation protocols and ensure its optimal implementation.

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