Comparative Effectiveness of Different Rehabilitation Protocols for ACL Reconstruction

Mohammed S. Aldakhil[1], Ahmed A. Alzahrani[2], Alhassan A. Alsharif[3], Thamer M. Alshammary[4]

Physical Therapists
Health affairs at the Ministry of National Guard

Abstract:
This study compares the effectiveness of two rehabilitation protocols, Traditional Rehabilitation Protocol (TRP) and Accelerated Rehabilitation Protocol (ARP), following anterior cruciate ligament (ACL) reconstruction in a sample of 100 patients. Patients were randomly assigned to either the TRP or ARP group post-surgery. Clinical outcomes, including knee stability, muscle strength, pain levels, and functional performance, were assessed at 12 weeks. Both protocols significantly improved knee stability and functional outcomes, with the ARP group showing trends towards superior gains in muscle strength and pain management. This study highlights the potential benefits of early mobilization and progressive loading in post-operative rehabilitation.

Keywords: ACL reconstruction, rehabilitation protocols, accelerated rehabilitation, knee stability, muscle strength, functional outcomes.

Introduction

Anterior cruciate ligament (ACL) injuries are among the most common knee injuries, often requiring surgical intervention, particularly in active individuals and athletes. ACL reconstruction aims to restore knee stability and function, yet the success of surgery heavily depends on post-operative rehabilitation protocols (Frobell et al., 2010). Rehabilitation plays a crucial role in facilitating recovery, improving functional outcomes, and reducing the risk of reinjury (Irrgang et al, 1998).

The optimal rehabilitation protocol following ACL reconstruction remains a topic of ongoing debate. Traditional protocols typically emphasize a gradual progression from early mobilization to functional exercises, focusing on restoring knee range of motion, muscle strength, and proprioception (Irrgang et al, 1998). However, variations in rehabilitation approaches exist, including accelerated protocols that advocate for more aggressive early interventions to expedite return to sports (Shelbourne & Gray, 2009).

Rationale for the Study

Variability in rehabilitation protocols may impact outcomes such as functional recovery, return to pre-injury activity levels, and long-term joint health. While some studies suggest benefits of accelerated rehabilitation in promoting early recovery and minimizing muscle atrophy (Wright et al., 2008). others argue for the cautious approach of gradual progression to mitigate the risk of graft failure and complications (Shelbourne & Gray, 2009).

Research Gap

Despite extensive research on ACL reconstruction and rehabilitation, there is a need for comparative studies evaluating the effectiveness of different rehabilitation protocols directly. Such studies are essential to guide evidence-based practice and optimize patient outcomes following ACL reconstruction surgery.

Objectives

This study aims to compare the effectiveness of different rehabilitation protocols following ACL reconstruction, focusing on functional outcomes, patient-reported outcomes, and the incidence of complications. By systematically evaluating these protocols, we seek to provide insights that inform clinical decision-making and enhance rehabilitation strategies for ACL reconstruction patients.

Literature Review

1. ACL Reconstruction and Rehabilitation Protocols

Anterior cruciate ligament (ACL) injuries are prevalent in sports and can significantly impact knee stability and function. ACL reconstruction surgery aims to restore knee biomechanics and function, but successful outcomes heavily depend on post-operative rehabilitation protocols (Frobell et al., 2010;Beynnon et al., 2005).

2. Traditional Rehabilitation Protocols

Traditional rehabilitation protocols typically emphasize a phased approach, starting with early mobilization, range of motion exercises, and progressive strengthening to restore knee stability and function (Levy et al., 2009). These protocols aim to minimize complications and optimize long-term outcomes, although the duration and intensity of each phase may vary.

3. Accelerated Rehabilitation Protocols

In contrast, accelerated rehabilitation protocols advocate for more aggressive early interventions to expedite recovery and promote earlier return to sports activities (Beynnon et al., 2005). These protocols often involve quicker progression to weight-bearing activities, functional exercises, and sports-specific training, aiming to restore pre-injury levels of activity sooner.

4. Comparative Studies and Outcomes

Several comparative studies have evaluated the effectiveness of different rehabilitation protocols following ACL reconstruction. For example, studies comparing traditional versus accelerated protocols have shown varying results in terms of functional recovery, graft stability, and patient-reported outcomes (Wright et al., 2008; Shelbourne & Gray, 2009).

5. Factors Influencing Rehabilitation Outcomes

Factors such as patient age, graft type, concomitant injuries, and surgeon preference can influence the choice and effectiveness of rehabilitation protocols (Shelbourne & Gray, 2009). Understanding these factors is crucial for tailoring rehabilitation strategies to individual patient needs and optimizing post-operative outcomes.

6. Evidence Gaps and Research Needs

Despite extensive research, gaps remain in our understanding of which rehabilitation protocols yield superior outcomes for ACL reconstruction patients. Further research is needed to elucidate optimal timing, intensity, and progression of exercises to enhance functional recovery and reduce the risk of complications (Beynnon et al., 2005).

Methodology

Study Design

This study employed a randomized controlled trial (RCT) design to compare the effectiveness of two rehabilitation protocols following anterior cruciate ligament (ACL) reconstruction: a traditional rehabilitation protocol (TRP) and an accelerated rehabilitation protocol (ARP). The RCT was conducted at rehabilitation department at military hospital.

Participants

100 Participants were recruited from patients undergoing ACL reconstruction surgery at military hospital. Inclusion criteria included:

- Diagnosis of complete ACL tear confirmed by clinical examination and MRI.
- Age between 18-40 years.
- No significant concomitant knee injuries requiring surgical intervention.
- Participants were randomly assigned to either the TRP or ARP group using computer-generated randomization.

Interventions

1. Traditional Rehabilitation Protocol (TRP):
   - Phase 1 (Weeks 0-2): Early mobilization, range of motion exercises, and patellar mobilizations.
   - Phase 2 (Weeks 3-6): Progressive strengthening exercises, proprioceptive training, and gait training.
   - Phase 3 (Weeks 7-12): Functional exercises, agility drills, and sport-specific activities gradually reintroduced.

2. Accelerated Rehabilitation Protocol (ARP):
   - Phase 1 (Weeks 0-1): Immediate weight-bearing as tolerated, early range of motion exercises, and patellar mobilizations.
   - Phase 2 (Weeks 2-4): Aggressive quadriceps strengthening, closed kinetic chain exercises, and neuromuscular training.
   - Phase 3 (Weeks 5-12): Advanced plyometric exercises, sport-specific drills, and return to full training regimen.

Outcome Measures

Outcome assessments were conducted at baseline (pre-surgery), 6 weeks post-surgery, and 12 weeks post-surgery. Primary outcome measures included:

- Knee stability assessed via Lachman test and KT-1000 arthrometer.
- Quadriceps and hamstring muscle strength measured using isokinetic dynamometry.
- Functional performance evaluated through hop tests (single-leg hop, triple hop, and crossover hop).

Secondary outcome measures included patient-reported outcomes such as:

- Knee pain intensity using Visual Analog Scale (VAS).
- Knee function and quality of life using Knee injury and Osteoarthritis Outcome Score (KOOS).

Statistical Analysis

Statistical analyses were performed using SPSS version XX (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation) were calculated for continuous variables. Between-group comparisons were analyzed using independent t-tests or Mann-Whitney U tests for continuous variables and chi-square tests for categorical variables. Repeated measures ANOVA was used to analyze changes over time within each group, with post-hoc analyses performed as appropriate.

Ethical Considerations

Ethical approval was obtained from ethics committee. Informed consent was obtained from all participants prior to enrollment, and participants were informed of their right to withdraw from the study at any time without consequence.

Findings

Table 1: Participant Characteristics at Baseline

Group	Age (years, mean ±SD	Gender (M/F)	Body Mass Index (kg/m², mean ± SD)	Injury Mechanism (Sports/Non-sports)
TRP (n=50)	28.5 ±5.2	40/10	25.6 ±2.9	35/15
ARP (n=50)	27.8 ±4.7	38/12	26.0 ±3.1	37/13

Interpretation:
Both groups (TRP and ARP) were well-matched in terms of age, gender distribution, BMI, and injury mechanism at baseline, ensuring comparable participant demographics.

Table 2: Clinical Outcomes at Baseline, 6 Weeks, and 12 Weeks Post-Surgery

Outcome Measure	Baseline (Pre-surgery)	6 Weeks Post-surgery (Mean ±SD)	12 Weeks Post-surgery (Mean ±SD)
Knee Stability			
Lachman Test (mm)	TRP: 12.5 (±3.2)	TRP: 5.5 (±1.8)	TRP: 3.2 (±1.2)
	ARP: 13.0 (±2.8)	ARP: 5.0 (±1.5)	ARP: 3.0 (±1.0)
	p=0.08	p=0.12	p=0.06
Knee Function			
KOOS Score	TRP: 60 (±10)	TRP: 75 (±12)	TRP: 80 (±12)
	ARP: 62 (±9)	ARP: 80 (±10)	ARP: 85 (±11)
	p=0.10	p=0.03	p=0.02
Muscle Strength (N)			
Quadriceps	TRP: 75 (±15)	TRP: 95 (±18)	TRP: 105 (±18)
	ARP: 78 (±14)	ARP: 110 (±20)	ARP: 115 (±20)
	p=0.12	p=0.04	p=0.02
Hamstrings	TRP: 65 (±12)	TRP: 85 (±15)	TRP: 90 (±15)
	ARP: 68 (±11)	ARP: 95 (±16)	ARP: 100 (±16)
	p=0.15	p=0.06	p=0.03
Functional Performance (cm)			
Single-leg Hop Test	TRP: 85 (±10)	TRP: 105 (±12)	TRP: 110 (±12)
	ARP: 88 (±9)	ARP: 115 (±11)	ARP: 120 (±10)
	p=0.08	p=0.02	p=0.01
Triple Hop Test	TRP: 210 (±20)	TRP: 250 (±22)	TRP: 260 (±22)
	ARP: 215 (±18)	ARP: 270 (±20)	ARP: 280 (±18)
	p=0.10	p=0.01	p=0.005
Crossover Hop Test	TRP: 190 (±15)	TRP: 220 (±16)	TRP: 225 (±16)
	ARP: 195 (±14)	ARP: 235 (±15)	ARP: 240 (±14)
	p=0.12	p=0.01	p=0.008
Knee Pain (VAS, 0-10)			
Pain Level	TRP: 6.8 (±1.2)	TRP: 4.0 (±0.8)	TRP: 3.2 (±0.7)
	ARP: 6.5 (±1.1)	ARP: 3.0 (±0.6)	ARP: 2.8 (±0.5)
	p=0.15	p=0.02	p=0.01

- Knee Stability and Graft Function: Both TRP and ARP groups showed improvements in knee stability and graft function as indicated by reduced Lachman test scores and KT-1000 measurements at 12 weeks post-surgery. Although not statistically significant ($p > 0.05$), trends favor the ARP group with slightly greater improvements.

- Muscle Strength: The ARP group demonstrated statistically significant improvements in quadriceps and hamstring strength compared to the TRP group at 12 weeks post-surgery ($p < 0.05$). This suggests that the ARP facilitates superior muscle recovery following ACL reconstruction.

- Functional Performance: Significant improvements were observed in functional performance tests (single-leg hop, triple hop, and crossover hop tests) for both groups. The ARP group consistently outperformed the TRP group in these tests, with statistically significant differences noted in the triple and crossover hop tests ($p < 0.05$).

- Knee Pain and Function: Both groups reported significant reductions in knee pain and improvements in knee function (KOOS scores) over the study period. The ARP group exhibited significantly lower pain levels and higher functional scores compared to the TRP group at 12 weeks post-surgery ($p < 0.05$), indicating better pain management and functional outcomes with accelerated rehabilitation.

Discussion

The aim of this study was to compare the effectiveness of two rehabilitation protocols, Traditional Rehabilitation Protocol (TRP) and Accelerated Rehabilitation Protocol (ARP), on clinical outcomes following ACL reconstruction. The findings provide valuable insights into optimizing post-operative rehabilitation for ACL injuries.

Comparison of Clinical Outcomes

Both TRP and ARP groups showed significant improvements in knee stability and graft function from baseline to 12 weeks post-surgery. While the ARP group demonstrated trends towards superior outcomes in terms of reduced Lachman test scores and KT-1000 measurements compared to the TRP group, these differences were not statistically significant. This consistency with previous studies supports the notion that both protocols effectively restore knee stability (Ingle et al., 2009; Shelbourne & Nitz, 1990).

Muscle Strength and Functional Performance

Significant improvements in muscle strength were observed in the ARP group compared to the TRP group at 12 weeks post-surgery, particularly in quadriceps and hamstring strength. This aligns with the accelerated rehabilitation principles of early mobilization and progressive loading, which are known to enhance muscle recovery and functional outcomes (Risberg et al., 1999).

Pain Management and Functional Outcomes

In terms of pain management and functional recovery, both groups demonstrated substantial improvements. However, the ARP group reported significantly lower pain levels and higher functional scores as measured by KOOS scores compared to the TRP group at 12 weeks post-surgery. This suggests that the ARP may offer advantages in pain relief and functional recovery, facilitating earlier return to daily activities and sports participation (Wright et al., 2008; Levy et al., 2009).

Clinical Implications

The findings of this study have several clinical implications. The ARP protocol appears beneficial for patients seeking faster recovery and improved functional outcomes following ACL reconstruction. Clinicians may

consider integrating ARP principles, such as early range of motion exercises and neuromuscular training, into rehabilitation programs to optimize patient outcomes (Ahn et al., 2010; Fithian et al., 2005).

Conclusion

In conclusion, both TRP and ARP rehabilitation protocols effectively improve clinical outcomes following ACL reconstruction. The ARP protocol shows promise in enhancing muscle strength, pain management, and functional recovery compared to traditional rehabilitation approaches. Tailoring rehabilitation strategies based on individual patient characteristics and recovery goals remains crucial in optimizing post-operative care for ACL injuries.

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