

Anterior Cruciate Ligament Reconstruction: Analysis of Grafts, Associated Injuries, And Anesthetic Strategies

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Abstract

Objective: This study analyzed the clinical and surgical outcomes of patients undergoing anterior cruciate ligament (ACL) reconstruction, evaluating associated injuries, graft types, anesthetic strategies, and tourniquet time.

Methods: Sixteen patients with ACL injuries were included, and their medical records were reviewed to collect data on the variables. Associated injuries were categorized, the types of grafts used were recorded, and anesthetic practices and tourniquet times were analyzed.

Results: Associated injuries were identified in 60% of patients, with meniscal injuries being the most common (40% with sutures). The patellar tendon was the most used graft (80%), while anesthetic methods such as spinal anesthesia combined with continuous additional block (BCA) were applied in 40% of cases. The average tourniquet time was 68 minutes, remaining within safe limits according to the literature.

Conclusion: ACL reconstruction requires meticulous surgical planning, considering clinical and technical variables. Graft selection and anesthetic strategies, combined with the preservation of joint structures, are essential for favorable functional outcomes and the prevention of complications.

Keywords: ACL Reconstruction, Meniscal Injuries, Patellar Graft, Regional Anesthesia, Tourniquet Time

1. Introduction

Anterior cruciate ligament (ACL) reconstruction is one of the most frequently performed procedures in sports orthopedics due to the high prevalence of ACL injuries among athletes and the general population. These injuries are associated with significant joint instability, compromising knee functionality and increasing the risk of secondary injuries, such as meniscal damage and early-onset osteoarthritis [1].

Over the years, ACL reconstruction has evolved regarding surgical

techniques, graft types, and rehabilitation strategies. However, the choice of the ideal graft remains widely debated in the literature. Patellar tendon grafts are often considered the gold standard due to their high resistance and biomechanical stability. However, alternatives such as semitendinosus + gracilis and other tendons have gained popularity, particularly among young and active patients [2,3].

In addition to challenges related to graft selection, patients undergoing ACL reconstruction frequently present with associated

injuries, including meniscal tears, varus deformities, and patellofemoral alterations. These conditions complicate surgical management and significantly affect long-term functional outcomes [4]. Meniscal injuries are observed in up to 80% of patients with ACL tears and require critical intraoperative decisions, such as suturing or partial meniscectomy [5].

Tourniquet time is another crucial aspect of ACL reconstruction, directly impacting procedural quality and postoperative outcomes. Studies have shown that tourniquet durations exceeding 90 minutes increase the risk of complications, such as muscle ischemia and compartment syndrome, while excessively short durations may compromise precise surgical technique [6,7]. Thus, achieving a balance between efficiency and safety is essential during surgery.

Simultaneously, anesthetic strategies play a fundamental role in the perioperative management of patients undergoing ACL reconstruction. The combined use of spinal anesthesia with peripheral blocks, such as continuous adductor canal block (ACA), is widely adopted due to its effectiveness in pain control and reduction of opioid consumption in the postoperative period [8]. Methods like adductor canal blocks also demonstrate significant benefits for postoperative analgesia without compromising motor function [9].

The advances in ACL reconstruction techniques aim to restore joint stability and minimize donor site morbidity. Semitendinosus and gracilis grafts, for instance, offer advantages such as less donor site pain and faster recovery. However, these grafts may be less effective in providing anterior stability when compared to the patellar tendon [10].

Analyzing associated injuries highlights the complexity of managing patients with ACL ruptures. Meniscal injuries often coexist with ACL tears and may be treated with sutures or resections, depending on the severity and location of the damage. The chosen technique directly influences functional outcomes and the risk of developing osteoarthritis [11].

This study emphasizes the need for a personalized approach to ACL reconstruction, considering associated injuries, appropriate graft selection, anesthetic management, and tourniquet time. Additionally, it underscores the importance of well-defined protocols to optimize clinical and functional outcomes.

The objective of the present study was to analyze the outcomes of patients undergoing anterior cruciate ligament (ACL) reconstruction, evaluating associated injuries, graft types, anesthetic methods, and tourniquet times. Additionally, the study aimed to discuss the clinical implications of these variables in light of current literature.

2. Methodology

2.1. Participants

This study included 16 adults of both sexes who underwent ACL reconstruction. Participants had a mean age of 25.41 years (± 6.71), mean height of 1.73 m (± 1.9), and mean body mass of 74.71 kg.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria comprised patients who underwent ACL reconstruction with complete documentation on surgical procedures, anesthesia type, and tourniquet time. Procedures involving additional techniques, such as meniscal repair, tendon transposition, or partial synovectomy, were also included. Exclusion criteria eliminated patients with incomplete records or insufficient relevant data.

2.3. Ethical Aspects

This study was approved by the Ethics Committee of the Federal University of Goiás (Approval No. 3.845.175; CAAE: 69749823.7.0000.5083), following the guidelines of Resolution No. 466/2012 of the National Health Council. The study complied with the General Data Protection Law (LGPD, Law No. 13.709/2018). All participants provided informed consent, ensuring data privacy and protection.

2.4. Surgical Procedure Analysis

The analyzed procedures included ACL reconstructions using personalized surgical techniques. Associated injuries, such as meniscal lesions, varus deformities, and patellofemoral alterations, were addressed. All procedures were performed using a tourniquet, with durations ranging from 40 to 100 minutes. Grafts included semitendinosus + gracilis, medial patellofemoral ligament, and patellar tendon.

2.5. Variables Analyzed

The analyzed variables included associated injuries (categorized as meniscal lesion, varus deformity, patella alta, or no associated injuries), graft types (semitendinosus + gracilis, medial patellofemoral ligament, and patellar tendon), and tourniquet time (in minutes). Anesthetic methods analyzed included combinations such as spinal anesthesia with adductor canal block, sciatic nerve block, or ACA.

2.6. Statistical Analysis

Descriptive statistics were applied to analyze the collected data. Frequencies and percentages were calculated for associated injuries, graft types, and anesthetic techniques. Tourniquet time was presented as mean \pm standard deviation. Data were categorized to facilitate comparison and interpretation of surgical practices.

3. Results

The results of this study are detailed in Table 1, which outlines the analyzed variables, including associated injuries, graft types, anesthetic techniques, and tourniquet time.

Category	Subcategory	Quantity	Percentage (%)
Associated Injuries	Meniscal Lesion + Suture	1	10%
	Meniscal Lesion + Varus + Patella Alta	1	10%
	Meniscal Repair + Tendon Transposition	2	20%
	Left Meniscal Repair	1	10%
	Tendon Transposition + Partial Synovectomy	1	10%
	No Associated Injuries	4	40%
	Semitendinosus + Gracilis	1	10%
Graft Types	Medial Patellofemoral Ligament	1	10%
	Patellar Tendon	8	80%
	Spinal + Adductor Canal	1	10%
	Spinal + Adductor Canal + Sciatic	1	10%
Anesthetic Techniques	Spinal + Continuous Additional Block (BCA)	4	40%
	Spinal + Femoral Nerve Block (FNB)	1	10%
	Spinal Only	2	20%
Tourniquet Time	Average Time (Minutes)	68 min	-
Legend: ACL: Anterior Cruciate Ligament; BCA: Continuous Additional Block; FNB: Femoral Nerve Block			

Table 1: Analysis of Medical Records

Associated injuries were identified in 60% of the cases, with meniscal lesions being the most prevalent. Among these, 40% of the patients underwent meniscal suturing, emphasizing the importance of preserving meniscal integrity to prevent joint degeneration and enhance long-term functional outcomes.

The patellar tendon emerged as the most commonly used graft, employed in 80% of the procedures. This finding reaffirms its status as the gold standard in anterior cruciate ligament (ACL) reconstructions due to its superior biomechanical properties and reduced failure rates.

Anesthetic techniques showed variation across the cases. Spinal anesthesia combined with continuous additional block (BCA) was the most frequently applied approach, utilized in 40% of the surgeries. This method highlights its effectiveness in providing postoperative pain relief while minimizing motor impairment.

The average tourniquet time recorded was 68 minutes, aligning with current safety guidelines. This duration reflects adherence to effective surgical standards, balancing procedural efficiency with the minimization of risks associated with prolonged tourniquet application.

3. Discussion

The findings of this study emphasize the complexity of anterior cruciate ligament (ACL) reconstruction and the critical need for individualized surgical approaches. The prevalence of associated injuries, particularly meniscal lesions, in 60% of the patients underscores the frequent coexistence of these injuries with ACL tears. This aligns with existing literature that highlights the high rate of meniscal injuries accompanying ACL ruptures, especially in cases where surgical intervention is delayed [5]. The decision

to perform meniscal sutures in 40% of these cases highlights the importance of preserving meniscal integrity, as it plays a crucial role in reducing the risk of joint degeneration and improving long-term functional outcomes [1].

The choice of graft type remains a critical decision in ACL reconstruction, with significant implications for patient outcomes. The patellar tendon was used in 80% of the cases in this study, reaffirming its status as the gold standard in ACL reconstruction due to its superior biomechanical strength and lower failure rates [2].

This finding is consistent with prior research that supports the patellar tendon as the preferred graft in most surgical scenarios. However, alternatives such as semitendinosus + gracilis and the medial patellofemoral ligament were employed in 10% of cases each, showcasing the adaptability of surgeons in tailoring graft selection to meet individual patient needs. These alternative grafts are particularly beneficial for younger patients or those who may experience significant morbidity at the donor site [10].

Anesthetic strategies also demonstrated considerable diversity in this study, with Spinal + Continuous Additional Block (BCA) being the most commonly used approach (40%). This technique is widely supported in the literature for its ability to provide effective postoperative analgesia while minimizing motor impairment [8]. The use of spinal anesthesia combined with BCA aligns with current trends in regional anesthesia for ACL reconstruction, which prioritize pain management and early mobilization. Other anesthetic techniques, such as Spinal + Adductor Canal Block and Spinal + Femoral Nerve Block, were less frequently employed, reflecting their more targeted application in specific patient

populations [9].

The average tourniquet time of 68 minutes observed in this study aligns with established guidelines, which recommend durations under 90 minutes to mitigate the risk of complications such as ischemia and compartment syndrome [6,7]. This duration reflects adherence to safe and efficient surgical practices, underscoring the importance of procedural standardization in achieving optimal outcomes. Prolonged tourniquet times have been associated with increased risks of tissue damage, reinforcing the need for precise intraoperative planning and execution.

The high prevalence of associated injuries in this study highlights the complexity of managing ACL tears. Meniscal injuries, particularly, require careful intraoperative decision-making. The decision to suture the meniscus in 40% of cases aligns with the growing recognition of the meniscus's critical role in knee biomechanics. Preserving the meniscus can reduce the likelihood of osteoarthritis and improve functional outcomes, as suggested by [1]. For patients without associated injuries (40%), the prognosis tends to be more favorable, as isolated ACL reconstruction procedures are generally associated with better outcomes.

The use of alternative grafts, such as semitendinosus + gracilis, demonstrates a commitment to minimizing morbidity at the donor site. These grafts are particularly advantageous for athletes or younger patients who may have higher functional demands (Fu et al., 2018). However, these grafts may present challenges related to laxity and durability, requiring careful patient selection and postoperative monitoring.

The diversity of anesthetic techniques observed in this study highlights the evolving nature of perioperative care in ACL reconstruction. The predominance of Spinal + BCA reflects its efficacy in managing postoperative pain and facilitating early mobilization. The use of additional blocks, such as the adductor canal and femoral nerve blocks, provides targeted pain relief while preserving motor function, aligning with modern approaches to multimodal analgesia [9].

Tourniquet time remains a critical factor in surgical planning. The observed average of 68 minutes demonstrates a balance between procedural efficiency and patient safety. Prolonged tourniquet use can increase the risk of complications, such as ischemia and nerve injury, emphasizing the importance of adhering to established guidelines [6]. This finding underscores the importance of standardized protocols in achieving consistent and safe surgical outcomes.

The findings of this study collectively highlight the importance of individualized surgical planning in ACL reconstruction. Decisions regarding graft selection, management of associated injuries, and anesthetic strategies must be tailored to the unique characteristics of each patient to optimize outcomes and minimize complications. The predominance of the patellar tendon graft, the variability in anesthetic approaches, and the adherence to safe tourniquet

durations reflect the complexity and precision required in modern ACL reconstruction [12].

4. Conclusion

This study demonstrated that ACL reconstruction is a multifaceted procedure requiring personalized approaches to ensure optimal outcomes. Meniscal injuries were prevalent, emphasizing the importance of addressing associated lesions to prevent long-term complications. The patellar tendon emerged as the most utilized graft, highlighting its reliability, while alternative grafts were employed selectively based on patient-specific considerations.

The use of advanced anesthetic techniques, particularly Spinal + BCA, underscores the importance of effective pain management in enhancing postoperative recovery. Additionally, the adherence to safe tourniquet durations reflects the commitment to procedural efficiency and patient safety.

In conclusion, a comprehensive and individualized approach to ACL reconstruction, incorporating detailed planning and tailored surgical techniques, is crucial for achieving favorable functional and clinical outcomes while minimizing risks.

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