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Current trends in ACL reconstructions. A Perspective Review of Recent Literature

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ABSTRACT

INTRODUCTION

The anterior cruciate ligament (ACL) is a critical structure in the knee, playing an essential role in maintaining joint stability and facilitating physical activity. ACL injuries, whether from acute trauma or chronic overuse, are prevalent among athletes and the general population, leading to significant functional impairment and an increased risk of osteoarthritis. Over recent years, there has been a notable evolution in the surgical techniques employed for ACL reconstruction, driven by advancements in medical technology, enhanced understanding of knee biomechanics, and an increasing emphasis on patient-centered outcomes. By integrating the growing body of evidence on surgical innovations, graft selection, and rehabilitation outcomes, this review aims to offer clinicians and researchers an up-to-date

framework for improving ACL reconstruction protocols and enhancing patient quality of life [1,2,3].

METHODS

This review aims to synthesize recent literature on current trends in ACL reconstructions by examining a wide range of studies that report on surgical techniques, graft choices, and adjunctive procedures related to ACL injuries. The methodology involved a comprehensive literature search from 2020 to 2025 across various electronic databases, including PubMed, Scopus, and Google Scholar. The search strategy utilized keywords such as "anterior cruciate ligament reconstruction," "ACL injury trends," "graft choices," “ACL surgical techniques,”and "rehabilitation protocols." Studies that specifically focused on evolving surgical techniques, graft materials, surgical outcomes, and the use of adjunctive procedures were included. No studies are excluded from the review.

AIM OF THE STUDY

The aim of the present perspective review is to synthesize and critically appraise the current trends in anterior cruciate ligament (ACL) reconstructions, as documented in recent literature.

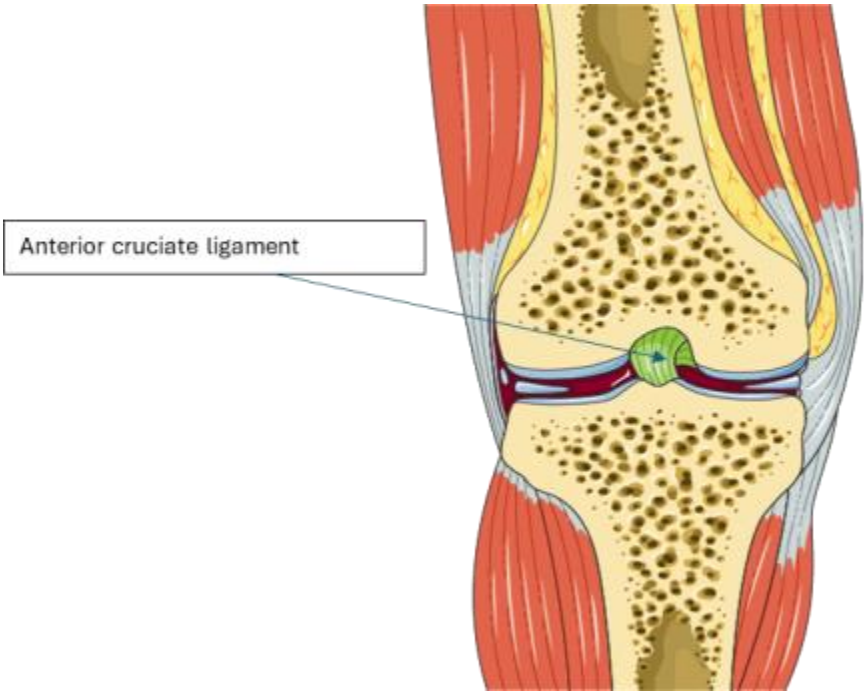
CONCLUSION

ACL reconstruction represents a multifaceted clinical challenge that requires meticulous attention to surgical techniques, graft selection, rehabilitation protocols, and psychological upport. Recent findings underscore the superiority of autografts in achieving optimal functional outcomes, alongside the critical importance of structured rehabilitation strategies tailored to individual patient needs. Furthermore, addressing the psychological dimensions of recovery can significantly enhance a patient's journey toward regaining pre-injury levels of activity. Moving forward, concerted efforts toward standardizing rehabilitation processes, integrating psychological interventions, and exploring innovations in regenerative medicine will be pivotal in optimizing ACL reconstruction outcomes. A collaborative, multidisciplinary approach will not only refine surgical care but also foster holistic recovery, ultimately improving the quality of life for individuals affected by ACL injuries.

KEYWORDS: anterior cruciate ligament reconstruction, ACL injury trends, ACL surgical techniques, graft choices, rehabilitation protocols

INTRODUCTION AND BACKGROUND

The anterior cruciate ligament (ACL) plays a critical role in knee stability and function, making ACL injuries particularly impactful for athletes and active individuals. As the incidence of ACL ruptures rises, particularly among younger, active populations, the demand for ACL reconstruction (ACLR) procedures has seen significant growth over the past few decades [4].



This diagram was prepared using Servier MedicalArt software (smart.servier.com, accessed on 6.04.2025).

Notably, this surge is accompanied by an increase in concomitant procedures, such as meniscal repair, underscoring a more comprehensive approach to managing knee injuries [4]. A systematic understanding of contemporary ACL reconstruction trends is essential for enhancing patient outcomes and refining surgical techniques. Recent literature has identified several emerging patterns in the approach to ACL reconstruction, underscoring advancements in surgical techniques, graft choice, and the incorporation of adjunctive procedures.

In the context of surgical advancements, the integration of combined techniques for ACL reconstruction has gained prominence. One significant trend is the incorporation of lateral extra-articular tenodesis alongside standard ACL reconstruction. Research has shown that this method improves rotational stability in high-risk athletes and addresses persistent concerns regarding knee instability post-surgery [5,6]. Additionally, the combination of ACL and anterolateral ligament reconstruction has been shown to reduce graft failures effectively, emphasizing the value of addressing multiple ligamentous structures in a single procedure

[7,8]. Anatomical approaches to ACL reconstruction are currently being emphasized, with evidence suggesting that these approaches are associated with reduced rates of post-traumatic osteoarthritis compared to non-anatomical techniques [1,9]. These findings advocate for more meticulous drilling techniques aimed at achieving precise anatomical positioning of grafts, thereby enhancing functional outcomes for patients [1]. There is also a growing recognition of the significance of biological enhancements, such as stem cell therapies, to promote better healing and integration of grafts; however, the majority of research in this area remains primarily animal-based [10].

Concurrently, the concept of addressing injuries of the anterolateral complex, a group of structures that support knee stability has gained traction, with research endorsing lateral augmentation procedures in conjunction with traditional ACLR, although definitive clinical guidelines have yet to be established [11,12]. This shift reflects a holistic view of knee instability, acknowledging that isolated ACL injuries often occur alongside injuries to the surrounding stabilizing structures, necessitating a more comprehensive surgical strategy [11,13].

Additionally, advancements in graft material and fixation techniques are continually evolving. The use of novel graft types, such as quadriceps tendon grafts and bioenhanced

methods, such as the Bridge-Enhanced ACL Repair (BEAR) technique, is being examined for their long-term efficacy and safety compared to traditional autografts and allografts [14,15]. Moreover, the literature consistently suggests that while ACLR is generally successful, success rates can be influenced by various surgical approaches and graft sources, with autografts remaining a common choice [16,17].

Overall, the field of ACL reconstruction is evolving, driven by both technological and methodological innovations that inform clinical practices and improve patient outcomes. Current trends reflect a move towards multi-faceted approaches that prioritize not only the

mechanical stability of the knee but also biological healing and functional recovery. This systematic review aims to synthesize recent literature to elucidate these trends and their implications for future practices in ACL reconstruction.

MATERIALS AND METHODS

Inclusion criteria focused on peer-reviewed 2020-2025 articles that explored the efficacy of various ACL reconstruction techniques, advancements in surgical practices, and innovations in graft materials. Randomized controlled trials, systematic reviews, and meta-analyses were prioritized to ensure rigorous evidence was incorporated into the findings. Studies analyzing factors influencing patient outcomes and complications associated with different surgical approaches, such as autograft versus allograft options, were specifically included to provide a balanced perspective on graft choice influences on recovery and long-term outcomes [18].

Data extraction involved organizing findings into categories that reflect technological innovations, clinical outcomes, and rehabilitation strategies. Special focus was placed on recent advancements like Bridge-Enhanced ACL Repair (BEAR), dynamic intraligamentary stabilization, and other augmentation techniques [19,20]. Moreover, studies on anatomical versus non-anatomical reconstruction methods were reviewed, with particular attention given to the implications of precise femoral tunnel placement on post-traumatic osteoarthritis risk [9,21].

Synthesized data were analyzed qualitatively to identify recurring themes and divergences in practice, as well as to highlight emerging consensus regarding ideal surgical approaches and postoperative care protocols. This process included examining complications specific to novel techniques, rehabilitation patterns, and patient-reported outcomes [22, 23]. Notably, studies that focused on biological enhancements in ACL repair, such as the use of platelet-rich plasma and stem cell therapies, were integrated into the narrative to outline current trends in biological augmentation of surgical outcomes [23]. In summary, the methods employed in this systematic review included a thorough and methodical approach to literature review and data synthesis to elucidate trends in ACL reconstruction practices. The aim was to ensure that the findings reflected both innovations and the current clinical realities impacting the management of ACL injuries.

RESULTS

The results of recent studies in the field of ACL reconstruction emphasize the critical role of rehabilitation protocols, graft choices, and their influence on clinical outcomes. Among the findings, the efficacy of various surgical techniques and rehabilitation methods is highlighted, showcasing their effects on post-operative recovery and long-term knee function.

1. Graft Selection and Clinical Outcomes:

A cohort study [24] demonstrated that quadriceps tendon (QT) autografts provided comparable, if not superior, functional outcomes to hamstring tendon (HT) autografts in both primary and revision ACL reconstructions. This suggests that the choice of graft may significantly influence recovery trajectories following ACLR. Furthermore, a study [25] confirmed in their matched-pair analysis that QT autografts facilitated better patient-reported outcomes compared to traditional methods, establishing a critical link between graft selection and clinical success post-surgery.

2. Rehabilitation Protocols:

Rehabilitation remains a cornerstone of post-ACL reconstruction success. A systematic review [26] indicated that structured postoperative rehabilitation significantly reduces adverse events, including graft ruptures, and can enhance functional recovery. The study outlined various rehabilitation modalities, emphasizing the necessity for individualized approaches tailored to patient needs, which aligns with findings in the literature that highlight the effectiveness of criterion-based rehabilitation protocols in achieving optimal recovery [27].

3. Return to Sport and Functionality:

Recent research indicates a direct correlation between rehabilitation adherence and successful return-to-sport rates. The study [28] reported that athletes following comprehensive rehabilitation regimens exhibited notable improvements in knee stability and performance metrics, including hop tests and return-to-sport timings, compared to those managed conservatively. Moreover, a focus on early rehabilitation, including hip and knee strength, has been emphasized in various protocols to enhance outcomes [29].

4. Comparative Efficacy of Exercises:

A systematic review [30] examined the contrasting effects of open versus closed kinetic chain exercises during ACL rehabilitation and found that while both modalities significantly improved knee strength and function, there appeared to be no singularly superior approach. This suggests that a blend of techniques may be optimal for various patient profiles.

Moreover, the adoption of aquatic therapy has been noted for providing unique benefits without the impact stress associated with land-based exercises, although further validation in terms of clinical efficacy is warranted [31].

5. Psychological Factors and Rehabilitation Outcomes:

The mental aspect of rehabilitation cannot be overlooked, the review [32] highlighted that psychological barriers, such as fear of reinjury and lack of confidence, adversely affect rehabilitation outcomes. Higher self-efficacy has been linked to improved knee function and successful return to pre-injury levels of activity. This underscores the need for integrative strategies that incorporate psychological support alongside physical rehabilitation.

6. Long-Term Outcomes and Post-Traumatic Osteoarthritis (PTOA):

Research has begun to reveal associations between early-stage rehabilitation efficacy and long-term changes in knee biomechanics that may contribute to PTOA. The study [33] performed a systematic review outlining how aggressive postoperative rehabilitation positively impacts PTOA incidence, while also advocating for lifestyle interventions conducive to joint health. Adherence to these protocols might mitigate adverse long-term outcomes, fostering better patient quality of life.

DISCUSSION

The complex landscape of anterior cruciate ligament (ACL) reconstruction and rehabilitation is characterized by the multifaceted influences of graft selection, rehabilitation strategies, psychological factors, and long-term outcomes on clinical success. The synthesis of these elements reveals critical insights that can optimize postoperative recovery.

Firstly, as highlighted in studies focusing on graft selection, the choice of graft significantly affects clinical outcomes. The review [28] provided evidence that adherence to detailed rehabilitation protocols is linked to improved knee stability and performance metrics, which can enhance return-to-sport rates.

Psychological factors significantly influence the rehabilitation process. Supporting this, Murray et al. [34] indicated a clear correlation between psychological readiness and the successful return to sports, highlighting the necessity for an interdisciplinary approach that integrates psychological support into physical rehabilitation. Athletes often navigate complex emotional landscapes during recovery, underscoring the need to address both psychological and biological aspects of rehabilitation.

Long-term outcomes warrant attention, especially concerning post-traumatic osteoarthritis (PTOA). McIntosh et al. [33] highlighted that early-stage rehabilitation efficacy is associated with positive changes in knee biomechanics, which may help mitigate the risk of PTOA.

Adherence to robust rehabilitation protocols is proposed as a strategy to enhance patient quality of life and potentially reduce the incidence of joint issues in the long term.

In conclusion, the interplay of graft selection, rehabilitation protocols, psychological factors, and long-term outcomes reveals a comprehensive framework critical for improving ACL reconstruction results. This systematic insight underscores the necessity for personalized treatment modalities that address both physical and psychological dimensions, paving the way for more effective recovery approaches. Future studies should continue to explore these relationships, particularly in the context of developing integrative treatment pathways tailored to individual patient profiles.

CONCLUSIONS

Anterior cruciate ligament (ACL) reconstruction is an area of ongoing development characterized by continuous advancements in surgical techniques, rehabilitation protocols, and injury prevention strategies. As evidenced by recent studies, the superiority of autografts, particularly in terms of their biomechanical properties and success rates, remains a critical consideration in optimizing patient outcomes following ACL injuries. Research has

consistently demonstrated that autografts yield improved functional outcomes compared to allografts, emphasizing their relevance in surgical planning and execution.

Equally important is the role of structured rehabilitation in the recovery process. A systematic approach to rehabilitation that is tailored to individual patient needs can significantly enhance postoperative recovery, minimize complications, and ultimately facilitate a successful return to normal activities. The critical assessment of current rehabilitation protocols highlights a need for standards that ensure consistency and efficacy across patient populations. Evidence suggests that more structured rehabilitation regimens reduce adverse events such as graft ruptures and facilitate better functional recovery, thus underscoring their importance in the holistic management of ACL injuries.

Furthermore, the psychological readiness of patients plays an equally vital role in their recovery trajectories. Understanding and addressing the emotional and psychological barriers associated with ACL reconstruction—such as fear of re-injury and lack of confidence—can significantly influence health outcomes. Studies have shown that patients with higher levels of self-efficacy tend to demonstrate better functional recovery and are more likely to return to pre-injury levels of activity. Therefore, integrating psychological interventions into rehabilitation protocols can foster a more comprehensive recovery experience, ensuring that patients not only physically heal but also regain their psychological resilience.

Looking forward, there is a profound need for future research to focus on standardizing rehabilitation protocols, with an emphasis on integrating psychological support and exploring advances in regenerative medicine. By addressing these domains, we can optimize ACL reconstruction outcomes and enhance quality of life for affected individuals. A multidisciplinary approach that synthesizes surgical advancements, evidence-based rehabilitation, and psychological support will be essential in promoting long-term functional recovery following ACL reconstruction.

In conclusion, the pathway to successful ACL reconstruction requires a balanced and coordinated strategy that encompasses both the technical aspects of surgery and the equally critical components of rehabilitation and psychological readiness. By fostering collaboration among orthopedic surgeons, rehabilitation specialists, and mental health professionals, we can significantly elevate the standards of care for ACL injuries, ultimately leading to improved patient outcomes and enhanced recovery experiences.

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