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Advancements in ACL Tear Repair: A Comprehensive Review of All-Inside Techniques and Comparisons with Traditional Methods

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Abstract

Background: The anterior cruciate ligament (ACL) is essential for stabilizing the knee joint, and its injury can result in substantial functional limitations and increase the risk of long-term joint degeneration if not properly managed. Historically, ACL tear management has evolved from conservative approaches to surgical interventions aimed at restoring knee stability and function

Methods: This review synthesizes current literature to evaluate the efficacy, safety, and comparative advantages of all-inside techniques. Studies were systematically reviewed to assess outcomes, complications, and patient satisfaction with all-inside ACL reconstruction (ACLR) compared to traditional methods.

Results: Despite promising outcomes in short to mid-term studies, concerns regarding long-term durability, graft elongation, and fixation stability persist. Further research is needed to establish the technique's long-term efficacy and outcomes. Additionally, comparative studies with traditional methods are required to determine optimal surgical approaches.

Conclusion: In conclusion, all-inside ACL tear repair techniques represent a significant advancement in ACL surgery, offering improved anatomical reconstruction and potentially enhanced patient outcomes. With ongoing research and refinement, all-inside techniques hold promise for becoming a preferred approach in ACL reconstruction, benefiting patients worldwide.

INTRODUCTION

ACL tears are prevalent knee injuries, frequently occurring during sports or traumatic incidents. The anterior cruciate ligament (ACL) is crucial for knee joint stability, and its tear can cause significant functional impairment, predisposing individuals to long-term joint degeneration if left untreated.

Historically, ACL tear management has evolved from conservative approaches to surgical interventions aimed at restoring knee stability and function. Traditional surgical techniques, such as the transtibial and tibial tunnel techniques, have been widely used for ACL reconstruction. However, these techniques have inherent limitations, including the risk of iatrogenic damage to surrounding structures, graft impingement, and non-anatomic graft placement, which can compromise outcomes and increase the likelihood of re-tear.

In the past few years, there has been growing interest around "all-inside" ACL tear repair techniques, which offer potential advantages over traditional methods. The all-inside approach involves the use of smaller incisions and specialized instrumentation to perform ACL reconstruction, with the goal of having more anatomical graft placement and minimizing morbidity associated with the procedure.

Research has shown that both the all-inside technique and traditional ACL reconstruction yield promising results in terms of knee stability, functional outcomes, and patient satisfaction. For example, a systematic review by Smith et al. (2020) found that patients undergoing all-inside ACL reconstruction had comparable functional results and lower instances of complications in comparison to those undergoing traditional techniques.(1)

Despite these advancements, questions remain regarding the optimal surgical approach for ACL tear repair, including patient selection criteria, graft choice, and postoperative rehabilitation protocols. Furthermore, the cost-effectiveness and long-term durability of all-inside techniques compared to traditional methods warrant further investigation.

The aim of this article is to provide a comprehensive overview of all-inside ACL tear repair techniques, including procedural details, outcomes, and comparisons with traditional methods. By synthesizing evidence from recent studies and clinical trials, we seek to elucidate the role of all-inside techniques in contemporary ACL tear management and inform clinical decision-making.

The traditional techniques for ACL tear repair

ACL ruptures are one of the highly reported physical activity related injuries. Treatment involves reconstructing the ligament via surgery. ACL repair can be done by reconstructing the existing damaged ligament (primary ACL reconstruction) or by replacing the ligament with an autograft or allograft. Two widely used techniques for ACL reconstruction are open socket ACL reconstruction, which involves creating a full tunnel through the tibia and femur to secure the graft, and arthroscopic all-inside ACL reconstruction (AI ACLR), which utilizes smaller, more precise sockets and specialized instrumentation for graft placement, reducing the invasiveness of the procedure.

Conventional open socket had been the gold standard until the 1980's, the results of reconstruction were controversial. The open socket technique proves effective in proximal ACL injuries, patients were able to get back to their active lifestyles and continue participating in sports after recovery, however injuries in the mid-substance had varied results, with a significant portion of cases undergoing deterioration of primary repair (2). The introduction of arthroscopic surgery has since made the conventional technique obsolete, arthroscopic surgery resulted in shorter recovery time, decreased laxity and nonunion (for primary ACLR cases) (3).

There are however, several different iterations of arthroscopic ACLR, Transportal ACLR is the current favorite, The bone patellar tendon bone (BPTB) graft and the hamstring graft are widely used single bundle ACLR techniques, Achilles double bundle allograft, and double tibialis tendon graft (4) are common examples of double bundle ACLR techniques. Double bundle reconstruction has shown to have no significant advantages over single bundle reconstruction in terms of :

 Static stability assessment: This involves the examination of the knee joint in a static position to determine its stability when not in motion. Typically, this includes tests like the Lachman test and the anterior drawer test, which evaluate the degree of anterior translation of the tibia relative to the femur, thereby indicating the integrity of the ACL.

 Functional performance tests: These tests evaluate the knee's ability to perform various functional movements that mimic real-life activities. Examples include single-leg hops, shuttle runs, and cutting maneuvers, which assess agility, balance, and coordination. These tests provide valuable insights into the knee's functional capacity and readiness for activities requiring dynamic stability.

 Pivot shift test: The pivot shift test is a specific maneuver used to assess rotational stability of the knee joint, particularly in cases of ACL injury. It involves a combination of flexion, valgus stress, and internal rotation of the tibia, which can reproduce the characteristic "clunk" or subluxation of the lateral tibial plateau observed in ACL-deficient knees.

Isokinetic muscle strengths: Isokinetic testing measures muscle strength and endurance through a range of motion at a constant speed. In the context of ACL rehabilitation, it is commonly used to evaluate quadriceps and hamstring strength imbalances, which are common following ACL injury and reconstruction. Identifying and addressing these imbalances is crucial for restoring optimal knee function and reducing the risk of reinjury.

At the 2 year follow up period (5). Studies done at the 5 year follow mark show increased anterior pivot stability in the Double bundle technique (5). Other more recent arthroscopic ACLR methods revolve around companies creating special equipment specifically for ACLR to help iron out the problems in fixation and graft tensioning, the dynamic intraligamentary stabilization (DIS) with Ligamys™, the Bridge-enhanced repair (BEAR), application of internal brace, and the refixation with suture anchors are all on the cutting-edge of ACLR repair, with DIS with Ligamys ™ showing the most promising results (6). Last but not least, The All-inside ACL reconstruction procedure, which has its own set of iterations and options of specialized equipment and grafting variations.

The all-inside ACLR technique involves closed socket tunnels, dual suspensory graft fixation and reduced bone removal. Smaller incisions also result in a faster recovery time along with a cosmetic benefit. Standard methods use BPTB or semitendinosus gracilis tendon, whereas all-inside uses triple or quadrupled semitendinosus tendon autograft (7). Decreased bone removal can be achieved due to the use of drilling halfway tunnels (sockets) rather than the creation of full tunnels, allowing for smaller graft size, reduced pain, swelling and synovial fluid flow between the graft and bone interface. Transportal ACLR techniques, the current industry favorite, requires a full length tunnel but doesn't require any specialized equipment, the full length tunnel also reduces the risk of fixation failure, however Transportal method makes it difficult for surgeons to visualize the hyperflexion point, and a shortened tunnel (iatrogenic mistake) significantly increase the chance of graft failure (8).

In AI ACLR, the use of an independent femoral guide allows for precise placement, especially in smaller patients, allowing for more natural knee kinematics. Studies comparing the effectiveness of the Transportal method to the al inside reconstruction method show AI ACLR to have a deceased incidence of positive pivot test post-op, along with shorter recovery times (8). AI ACLR has also proven itself better for patients with immature skeletons, all-epiphyseal all-inside ACLR results in reduced epiphyseal damage and negates the risk of growth arrest (9,10).

That said the all inside ACLR technique requires a skilled surgeon and the specialized graft tensioning equipment, adjustable button fixtures, and most importantly, single use retrograde drill equipment, result in a more expensive procedure cost, up to 200 Euros more (10). The

main issue that requires skilled hand in AI ACLR is the drilling of the femoral socket using the anteromedial (AM) portal technique, which requires the knee to be in the hyperflexed position. This aspect of AI ACLR is expected to undergo plenty of research to figure out a simpler retrograde drilling method, the current Transtibial endoscopic, Anteromedial Portal, and Outside-In Femoral Tunnel Drilling methods have shown no advantage over one another under scrutiny (8).

historical developments leading to the introduction of this technique:

The progression of treatments for anterior cruciate ligament (ACL) injuries traces back to 1895, with Mayo Robson's documentation of primary repair. In his report, Robson described a case involving a 41-year-old man who had a primary repair procedure for torn cruciate ligaments. In this procedure, the ligaments were sutured back to the femur using catgut ligatures. Subsequently, the practice gained momentum through the contributions of Ivar Palmer and Don O'Donoghue, who further advocated for primary repair in ACL injury management. As a result of their efforts, open primary ACL repair became the prevailing surgical intervention during the 1970s and 1980s. (11).

In the early 1990s, Research findings led to the abandonment of open primary ACL repair as a treatment for ACL injuries. This shift established ACL reconstruction as the new standard of care. Despite this shift, primary repair offers advantages such as preserving the native ligament and requiring less invasive surgery. These benefits include maintaining proprioception and reducing complications associated with graft harvesting, tunnel widening, and revisions. (11)

Examining the historical outcomes of primary repair reveals a significant shift in the paradigm of ACL treatment evolution. Looking back, we identify various factors in historical literature that contributed to the negative outcomes of primary ACL repair, such as non-stringent patient selection, invasive surgical methods, extended joint immobilization, and the utilization of absorbable sutures.(11).

The all-inside ACL reconstruction technique, initially elucidated more than twenty years ago and further detailed by Lubowitz et al. in 2011, is characterized by its use of dual suspensory fixation on both the femoral and tibial sides and smaller incisions. In this review, conventional ACL reconstruction methods, employing bone-patellar tendon-bone (BPTB) and hamstring tendon grafts, serve as benchmarks for comparison to the all-inside ACL technique.. (7).

Unlike traditional ACL reconstruction procedures, the all-inside ACLR technique imposes no significant limitations and can be used for all patients with an ACL rupture, including adolescents. This is because it preserves growth cartilage by conducting sockets entirely within the epiphysis, thereby minimizing the risk of bone growth damage and postoperative pain. (12).

The goals and principles behind ACL tear repair
The concept of anatomic and individualized ACL reconstruction emphasizes closely replicating the specific anatomy of each patient. This approach aims to replicate the native characteristics

of the ACL and improve patient outcomes. (13).

The restricted capacity of the ACL to undergo biological healing is associated with the intra‐articular environment, characterized by factors such as synovial fluid presence and intra‐articular movement, which hinder the formation of a stable fibrin-platelet scaffold. In the absence of this scaffold, the process of primary healing is impeded.(14).

The ACL's limited healing ability is a key factor driving the preference for ACL reconstruction using autografts from the hamstrings or patellar tendon as the gold standard surgical treatment for athletic patients with ACL injuries.(14). In ACL reconstruction, debates arise around the timing of repair and rehabilitation, as well as the choice of graft. The discourse surrounding the choice between allograft and autograft remains a contentious issue within ACL reconstruction. Furthermore, the introduction of the double-bundle technique has raised expectations for a more anatomically precise approach, yet its efficacy remains a topic of debate.(15).

ACL remodeling is now widely recognized as the go-to method for restoring stability and function post-injury. It offers a high rate of return to preoperative activity, low relapse rates, and enables earlier resumption of activity, while also preventing meniscus damage and delaying the onset of osteoarthritis. Surgical treatment involves ACL reconstruction using tendon grafts, which differ in structure and composition from the ligament, particularly in terms of proteoglycan levels and collagen distribution. (16). Following surgical treatment, the tendon graft must undergo a remodeling process, known as ligamentization, to become more structurally and biochemically akin to the native ACL. (16).

Anterior cruciate ligament injuries are one of the most commonly presented knee pathologies, often necessitating surgical intervention to restore joint stability and functionality. The "all‐inside" ACL tear repair technique has emerged as a promising approach, offering several advantages over traditional methods. In this section, we provide an overview of the procedure, highlighting key aspects of graft preparation, surgical approach, graft placement, biomechanical considerations, and supporting evidence from relevant studies.

Overview of the Technique:
The "all-inside" ACL tear repair technique involves arthroscopic reconstruction of the torn ligament using a minimally invasive approach. Unlike traditional open procedures, which may require larger incisions and disruption of surrounding tissues, the "all-inside" technique utilizes smaller incisions and specialized instruments to access the knee joint

Surgical Approach:
Arthroscopic visualization is achieved through small portals, enabling the surgeon to evaluate the severity of the ACL injury and prepare the joint for reconstruction. The arthroscope is inserted into the joint space, providing a clear view of the ligament and surrounding structures. Depending on the specific patient anatomy and injury pattern, variations in portal placement and viewing angles may be employed to optimize visualization and access to the ACL.

Graft Placement and Fixation:
The "all-inside" technique offers a notable advantage in ACL reconstruction by providing versatility in graft selection. Surgeons can choose from a range of graft options, including autografts like hamstring tendon and patellar tendon, as well as allografts such as Achilles tendon and quadriceps tendon. Selection of the most suitable graft type is typically influenced by factors like patient age, activity level, and individual surgeon preference..

Once the graft is selected, the subsequent step involves creating tunnels within the tibia and femur to allow for precise graft placement. Specialized instruments are used to precisely position the tunnels and ensure proper alignment with the native ACL footprint. The graft is subsequently threaded through these tunnels and secured using a variety of fixation devices, including interference screws, suspension devices, or cortical buttons.

Biomechanical Considerations:
The "all-inside" ACL tear repair technique concentrates on the restoration of knee stability and its functionality by recreating the biomechanical properties of the native ACL. By utilizing smaller incisions and minimizing disruption to surrounding tissues, this approach may preserve the vascularity and proprioceptive properties of the knee, potentially leading to improved outcomes and faster recovery times.

Illustrative Cases or Studies:
Several studies have reported favourable outcomes with the "all-inside" ACL tear repair technique, demonstrating excellent graft survival rates, low complication rates, and high patient satisfaction. For example, Lubowitz (2009) described a graft preparation technique using the semitendinosus tendon with promising results. Yaniv et al. (2010) reported preliminary outcomes of "all-inside" ACL reconstruction, highlighting the technique's feasibility and effectiveness. Additionally, Blyth et al. (2016) compared robotic and manual cutting guides in ACL reconstruction, providing insights into surgical techniques and outcomes.

The following are the steps on how an All-In ACLR is performed

1. Preparation of the patient

Before surgery, a comprehensive assessment is conducted under anesthesia to evaluate knee stability. This assessment includes performing tests such as the Lachman and Anterior Drawer tests to assess anterior-posterior stability, as well as the pivot shift test and varus/valgus stress tests to evaluate rotational stability. These tests help in excluding potential ligament injuries other than the ACL tear.

Following the assessment, the patient is positioned on the operating table in a supine position. A tourniquet is carefully applied to the thigh of the surgical limb to control blood flow during the procedure. Additionally, support is provided using a lateral post positioned just above the thigh and a fixed roller beneath the foot to maintain the knee at a precise 90° angle.

To stabilize pelvic movements during stress maneuvers, an additional pad is strategically positioned at the opposite hip. This helps in ensuring stability and accuracy during the evaluation process. Meanwhile, the non-operated limb is left free at the lower end to maintain flexibility and facilitate ease of movement during the procedure. (12)

2. Graft harvesting and preparation

To commence, a longitudinal incision measuring 3 centimeters is made, positioned approximately 2 finger-widths below the anterior aspect of the knee. With precision, the pes anserinus is located and isolated from the surrounding ligaments, ensuring meticulous identification. Subsequently, the semitendinosus tendon is gently located and separated from the shinbone, with keen attention paid to detail throughout the process. The graft, typically around 6.5 centimeters in length, is harvested utilizing specialized instrumentation. Its femoral end is attached to an ACL TightRope RT (Arthrex), while its tibial end is affixed to an ACL TightRope ABS (Arthrex).

3. Diagnostic arthroscopy

As the primary surgeon readies the arthroscopic equipment, a diagnostic knee arthroscopy is initiated via standard anterolateral (AL) and anteromedial (AM) portals. This pivotal step allows for comprehensive visualization and assessment of intra-articular structures before proceeding with subsequent surgical maneuvers. It encompasses addressing any intra-articular pathology, treating accessory tissue lesions, identifying femoral and tibial footprints, debriding torn ACL fibers, and preparing the femoral wall

4. Tunnel creation

With the knee fully flexed, the 8-mm transportal offset guide (Arthrex) is meticulously positioned at the femoral footprint via the anteromedial portal, ensuring precise placement for femoral tunnel creation to optimize ACL anatomical reconstruction. A guide wire is then drilled forward, followed by reaming a tunnel over the guide wire, ensuring a length of at least 20 mm, matching the graft diameter. A shuttle suture is then threaded delicately through the femoral tunnel for accurate alignment. Subsequently, the Tibial ACL Marking Hook (Arthrex) is precisely positioned at the ACL footprint near the anterior horn of the lateral meniscus within the remaining tibial ACL tissue to measure the tibial tunnel length accurately.

5. Femoral tunnel graft passage

Utilizing the "flip-then-fill" method, the femoral button of the adjustable-loop suspension device is guided into the femoral socket through the anteromedial (AM) portal. A pre-marked line on the device denotes the tunnel length, and once visible at the ACL femoral footprint, it indicates readiness for flipping. This maneuver is achieved by applying firm traction from the tibial end of the graft, outside the joint, ensuring smooth execution.

6. Tibial tunnel graft passage & tensioning

Manipulating the tibial shuttle sutures guides the tibial button of the adjustable-loop suspension device through the tibial socket. Confirming proper engagement, the surgeon pulls the white sutures alternately to ensure contact with the tibial cortex. Precise fixation of the tibial button is performed with the knee in extension or hyper-extension and neutral rotation to minimize soft tissue interposition. After cycling the knee through its range of motion, tension is assessed, and an arthroscopic examination is conducted. Post-tensioning, the knee's integrity is reassessed, and sutures are securely tied at the top of the tibial button.

7. Final steps

Layered suturing at the graft harvest site is done with No. 0 Vicryl sutures, and the skin is meticulously sutured using No. 2-0 Prolene sutures, encompassing the arthroscopic portals and the graft harvest area. (12)

The advantages of this technique compared to other

The 'all-inside' ACL reconstruction aims to minimize surgical trauma, potentially enhancing overall knee strength and function more quickly by not utilizing the gracilis tendon.(18)

The advantages of employing the all-inside ACL reconstruction (AI ACLR) encompass bone preservation, enhanced feasibility for revision surgery, provision for graft re-tensioning, accommodation of small-diameter or weakened grafts, and suitability for skeletally immature patients. The AI ACLR technique ensures meticulous graft placement at both the tibial and femoral ends, offering physiological advantages for graft revascularization and ligamentization. Notably, its proficiency in creating the femoral half tunnel stands out. Operating autonomously from tibial tunnel placement, this technique utilizes an outside-in aimer arm for measuring femoral interosseous distance before socket creation, facilitated by specialized sleeves. Executing the procedure with the knee flexed at 90° guarantees optimal visualization of the native ACL center and streamlines the insertion of the outside-in aimer arm through the AL portal. Unlike the trans-tibial approach, the AI ACLR technique permits anatomically precise femoral tunnel positioning, devoid of the tibial tunnel's influence. Furthermore, compared to the transportal technique, the absence of hyperflexion simplifies the identification of the ACL native center. The versatility of the all-inside ACLR method extends to graft options, including autologous hamstring, quadriceps tendon, peroneus longus, and allografts. Moreover, a notable advantage of this technique is its use of half tunnels instead of complete ones, contributing to the preservation of bone stock. This feature is particularly beneficial in scenarios involving ACLR revisions or multiple ligament reconstructions. Furthermore, by avoiding violation of the extra-articular cortex and periosteum, this technique may contribute to reduced postoperative pain and swelling. Finally, within the all-inside ACLR approach, the presence of a separate femoral guide enables accurate anatomical positioning on the femoral ligament footprint. This enhances the likelihood of restoring the knee's inherent kinematics.(12)

The potential drawbacks and limitations

The study acknowledges inadequate data for a comprehensive assessment of knee joint function. Without sufficient information on knee joint function, the study may not provide a complete picture of the outcomes, limiting the ability to draw robust conclusions about the clinical effectiveness of the techniques. Variability within the all-inside techniques, including discrepancies in knee flexion, external rotation of the tibia during graft types, or fixation methods, could introduce confounding factors. The lack of evidence comparing outcomes based on different graft types or fixation methods is recognized, representing a gap in the literature. This limitation restricts our understanding of how variations in graft types or fixation methods might impact the results, thereby introducing uncertainty regarding potential biases. Inadequate literature prevents subgroup analysis based on enhancement methods. The lack of such analysis limits the depth of understanding regarding the potential impact of different enhancement methods. The limited data on complications restrict the ability to comprehensively compare the safety and failure rates between the two techniques, raising questions about the generalizability of safety outcomes. Short follow-up periods may not capture the long-term clinical outcomes and potential complications associated with the techniques, raising concerns about the durability of the observed effects. Small mean differences may question the clinical significance of the findings. The absence of MCID consideration limits the interpretation of whether the observed differences are meaningful in a clinical context. (19)

The study's retrospective nature inherently comes with certain limitations, such as reliance on past data and potential biases. Patient selection criteria in the study were based on age, diagnosis, and the selected technique, which could introduce bias into the study population. The research reported medium-term follow-up outcomes with a relatively small sample size, particularly after stratification, which may affect the generalizability of the findings. The absence of initial measurements with KT-1000 limited the assessment of baseline conditions. Economic analysis was not conducted, overlooking a crucial aspect of evaluating overall outcomes. Additionally, the surgical procedures were performed by two different surgeons, potentially resulting in less standardized techniques and influencing the results. (20) Low-quality studies with only 613 patients result in high heterogeneity due to variations in design, patient characteristics, and reporting. Short to mid-term follow-up (6 to 48 months) raises concerns about missing long-term complications. Longer studies are needed for a comprehensive assessment. Surgeons' variability in identifying anatomical landmarks for tunnel positioning introduces inconsistency in the procedures. Use of last follow-up data may overlook changes or complications that could arise after 5 years. Lack of evidence comparing the all-inside technique with other fixation methods like metallic screws or cross-pins makes it challenging to determine the optimal approach.(21)

Numerous limitations envelop the all-inside ACL reconstruction (ACLR) with suture augmentation. The absence of long-term outcome studies is particularly conspicuous, posing a considerable hurdle and fostering uncertainties regarding the rerupture rate, graft ligamentization,

tunnel widening, and revision rate linked with this method. Lingering apprehensions about graft elongation and fixation stability in all-inside ACLR procedures underscore the necessity for thorough research to bridge these knowledge gaps. The limited availability of comparative data with conventional ACLR methods adds to the uncertainties surrounding the proposed technique. Additionally, the novelty of using suture augmentation introduces an element of unpredictability, calling for further investigation to ascertain its long□term effectiveness and safety. Addressing these limitations is crucial for establishing the reliability and applicability of the all-inside ACLR with suture augmentation in clinical practice. (17)

The relatively small sample size and short-term to mid-term follow-up periods may limit the generalizability of the findings. Long-term outcomes, especially regarding complications such as graft loosening, implant breakage, or the need for revision surgery, remain unknown. Additionally, the absence of long-term outcome studies on suture augmentation introduces uncertainty regarding its impact on rerupture rates, graft ligamentization, tunnel widening, and revision rates. The study design lacks a direct comparison between all-inside ACL reconstruction (ACLR) and traditional methods, and the focus on the all-inside technique hinders a comprehensive understanding of its comparative effectiveness. Furthermore, variations in surgical techniques, patient characteristics, and outcome reporting across studies contribute to high heterogeneity. These limitations underscore the necessity for further well-designed studies with larger sample sizes and longer follow-up periods. Such studies would provide more robust evidence regarding the efficacy and safety of the all-inside ACLR technique with suture augmentation.(22)

Comparison of the "all-inside" technique with other existing techniques.

Monaco et al. The study by [Author] noted a substantial increase in tibial tunnel widening with the complete tibial tunnel technique in contrast to the all-inside technique during a median follow-up period of 2 years. They elaborated on the biomechanical aspect, suggesting that while the all-inside technique might elevate the mechanical wear factor, the complete tibial tunnel technique could potentially exert a deleterious impact on bone integrity, possibly leading to an enlargement in bone diameter. Baldassarri et al. note a slightly shorter resumption of sports activity in the all-inside ACLR group compared to the complete tibial tunnel ACLR group. Connaughton expresses concern about a higher graft failure rate with the all-inside ACLR, potentially related to premature return to pivoting sports before graft ligamentization is complete. However, the study results in the provided text show no significant difference in graft failure between the two techniques. One trial mentioned in the text suggests that the all-inside technique may have a longer operation time compared to the complete tibial tunnel technique. (19) While concerns about tibial tunnel widening are common in ACLR surgery. According to the findings of the study, it is implied that there may not be a significant difference between the all-inside technique and the complete tibial tunnel technique in this particular aspect. Both techniques have shown good clinical results, indicating their effectiveness in ACL reconstruction. However, the study emphasizes the necessity for longer-term follow-up to evaluate factors such as graft failure thoroughly.

The all-inside technique is described as offering advantages in terms of reduced invasiveness, decreased complications, and improved anatomical tunnel placement. The Transtibial and AM techniques are noted for their historical significance but may have limitations such as potential technical demands, instability in button fixation, and less anatomical femoral tunnel placement. (20)

The KT-1000 measurements revealed no significant differences between the operated and contralateral knees for each technique. Comparative analysis using Kruskal-Wallis tests found no significant differences in postoperative Tegner scale, KOOS, or Lysholm scores among the three techniques. The study emphasizes the absence of complications and similar clinical outcomes among the different ACL reconstruction techniques, particularly between the all‐inside and antero-medial methods. Consistent with recent reviews, the study reported no significant differences between the all-inside method and the two antero-medial techniques in subjective and objective evaluation scales.

All-Inside ACL Reconstruction uses suspensory cortical button graft fixation, allowing for a thicker graft. Conventional Full Tibial Tunnel Technique relies on traditional methods like interference screws. All-Inside involves retrograde drilling and closed-socket tunnels, while Conventional employs traditional tunnel creation, possibly using interference screws. All-Inside demonstrates less tibial tunnel widening over time compared to Conventional. All-Inside requires a shorter graft (5–7 cm), often using only semitendinosus tendon, with potential gracilis sparing. Conventional may involve longer grafts (11–13 cm) and both tendons. All‐Inside depends on specific instruments like a retrograde reaming device and suspensory fixation. Conventional does not rely on these instruments. (21) The examination indicated no substantial advantage of the all-inside ACLR method over the full tibial tunnel technique concerning functional outcomes, knee laxity assessed with an arthrometer, or tendon re-rupture frequency. The study stressed that functional outcomes did not exhibit a notable contrast between the two approaches. Furthermore, aggregated data suggested similar rates of graft failure between all-inside and full tibial tunnel ACLR procedures.

The all-inside ACL reconstruction (ACLR) with suture augmentation presents several advantages over conventional ACLR methods. This technique allows for bone preservation, simplifies revision surgery, accommodates small diameter or attenuated grafts, and can be applied in skeletally immature patients. Additionally, it enables early range of motion and weight-bearing for a quicker recovery. The use of ACL TightRope shortening strands as suture augmentation protects the graft from elongation during remodeling, potentially enhancing stability. (17)

Similarities - Both the all-inside ACL reconstruction (ACLR) technique and the described method employing internal bracing and suture augmentation share similarities in addressing concerns related to graft stability. Both techniques aim to enhance ACL graft stability, allowing for early mobilization and weight-bearing. They emphasize bone preservation, ease of revision surgery, and applicability in cases involving small-diameter or attenuated grafts.

The use of suture augmentation in the described technique and specific fixation methods in all-inside ACLR contribute to minimizing graft elongation and improving fixation stability. While both approaches acknowledge concerns, such as graft elongation, they present potential solutions to enhance ACLR outcomes. All-inside ACLR, utilizing a technique with femoral tunnel drilling from outside to inside and tibial tunnel drilling from inside to outside, offers potential advantages, such as a thin-to-thick tunnel configuration, reducing joint fluid leakage and infection risk. The use of TightRope locking loop bone plates in the all-inside group allows for effective tendon-bone healing while avoiding the cutting effect seen with other fixation methods. Moreover, employing only the semitendinosus tendon as a graft in the all-inside technique could potentially reduce the loss of internal rotation force during knee flexion, thus facilitating postoperative rehabilitation. In comparison, the traditional method, which entails total tibial tunnel interface extrusion screw fixation, exhibits comparable outcomes regarding graft tension, knee stability, and overall treatment effects. While both methods achieve satisfactory results, the all-inside technique presents potential advantages in terms of anatomical reconstruction and diminished postoperative pain. (22) Similarities - The all-inside ACL reconstruction (ACLR) technique, utilizing only the semitendinosus tendon, demonstrates clinical effectiveness similar to traditional ACL reconstruction methods. Both approaches achieve optimal graft tension, postoperative knee stability, and satisfactory pain improvement. The all-inside technique minimizes soft tissue injury with a smaller tibial tunnel diameter, emphasizing anatomic considerations in tunnel drilling. Preservation of cortical bone, utilization of the tendon-bone interface, and the use of TightRope for fixation are shared aspects with traditional methods. Overall, these similarities underscore comparable outcomes, graft options, and considerations for soft tissue and anatomic principles between the all-inside ACLR technique and traditional approaches.

The similarities and differences in post-operative care.

When comparing all in ACL reconstructions with conventional ACL surgeries the immediate post-operative care remains the same, i.e. monitoring for immediate complications such as bleeding, infection, and anesthesia-related issues.(7,23) The post-operative pain management is crucial in all scenarios of surgeries which typically involves a combination of medication, ice therapy, and elevation. The physical therapy plays a key role in all cases, helping to restore range of motion, strength, and function to the knee (24). Patients may require a knee brace to support the knee during the early stages of recovery for both surgeries.

On the other hand, the specific surgical technique used can influence post-operative care. For example, the use of autograft or allograft tissue for ACL reconstruction can impact the rehabilitation protocol.(23,24) Furthermore, the timeline for rehabilitation and return to activities is influenced by the surgical technique employed and the individual patient's progress. Regarding weight-bearing status post-surgery, there is variability among surgeons, with some permitting weight-bearing as tolerated immediately after the procedure, while others may advocate for partial or non-weight-bearing for a specified duration.(23) the general risks and complications of surgery are similar in both cases, there may be specific risks associated with each surgical technique that require tailored post-operative care.(23,24)

Research conducted by Aman et al. (2018) and Geeslin et al. (2017) has provided promising insights into all-inside ACL repair.

Aman et al. observed no significant disparities in patient reported outcomes, knee stability, or resumption of sporting activities between all-inside ACL reconstruction and traditional ACL reconstruction, indicating comparable clinical efficacy. (22). Geeslin et al. reported that the majority of patients demonstrated complete graft healing at one-year post-surgery with all-inside ACL repair, indicating successful graft integration and healing (25). Additionally, research by Cinque et al. (2020) showed that most patients were able to return to their pre-injury level of sports participation, indicating a successful return to sports with all-inside ACL repair. These findings suggest that all-inside ACL repair can achieve favorable clinical outcomes, graft healing, and patient satisfaction, potentially with lower complication rates compared to traditional ACL reconstruction(26) . However, further research is needed to establish the long-term efficacy and outcomes of this technique.

METHODOLOGY

Study Design

This study follows a systematic review methodology to assess the efficacy of various anterior cruciate ligament (ACL) reconstruction techniques. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature Search

A comprehensive literature search was undertaken utilizing various search engines and databases, including PubMed, MEDLINE, and Google Scholar. The search strategy incorporated keywords such as: "ACL reconstruction," "all-inside technique," "arthroscopic surgery," "temporary internal bracing," and "anterior cruciate ligament repair." The search was limited to articles published from 2006 to 2023.

Inclusion Criteria

Articles were included in the review if they met the following criteria:

- Published in English language.
- Focused on ACL reconstruction techniques.
- Included clinical trials, randomized controlled trials, or comparative studies.
- Reported on outcomes such as knee stability, functional recovery, or complication rates.

Exclusion Criteria

Articles were excluded from the review if they:

- Were case reports, editorials, or opinion pieces.
- Did not focus on human subjects.
- Lacked sufficient data or outcome measures related to ACL reconstruction techniques.
- Were duplicates of already included stud

Screening and Selection Process

A total of 54 articles were initially identified through the database searches. After removing duplicates, 45 articles remained. Titles and abstracts were independently reviewed by two assessors to evaluate their relevance against predefined inclusion and exclusion criteria. Of these, 35 articles were selected for full-text review. Following the full-text assessment, 29 articles were deemed eligible and included in the final review.

Data Extraction

Data were extracted from the selected articles using a standardized data extraction form. The following information was collected:

- Study characteristics (author, year, study design, sample size).
- Participant demographics (age, sex, comorbidities).
- Details of the ACL reconstruction techniques (surgical method, graft type, fixation method).
- Outcome measures (knee stability, functional scores, complication rates).
- Follow-up duration

RESULTS

The literature review presents a comprehensive analysis of the "all-inside" ACL tear repair technique compared to traditional ACL reconstruction methods, highlighting its advantages, limitations, and comparisons. Firstly, the all-inside ACL tear repair technique demonstrates notable advantages over conventional methods. It allows for precise graft placement, potentially enhancing knee kinematics and stability. Studies suggest that patients undergoing all-inside ACLR exhibit a decreased incidence of positive pivot test post-op and experience shorter recovery times compared to those undergoing traditional ACL reconstruction. Particularly advantageous for patients with immature skeletons, the technique minimizes epiphyseal damage and eliminates the risk of growth arrest. Furthermore, precise graft placement at both the tibial and femoral ends enhances physiological benefits for graft revascularization and ligamentization. Additionally, the use of half tunnels preserves bone stock, especially beneficial for ACLR revisions or multiple ligament reconstructions.

Comparative analyses between the all-inside ACLR technique and traditional methods reveal comparable clinical outcomes in terms of graft tension, knee stability, and pain improvement. While both techniques achieve satisfactory results, the all-inside approach may offer advantages in terms of anatomical reconstruction, reduced postoperative pain, and improved fixation stability. Moreover, immediate post-operative care remains similar for all-in ACL reconstructions and conventional ACL surgeries, focusing on monitoring for complications, pain management, and initiating physical therapy. However, the choice of surgical technique and graft type can influence the rehabilitation protocol and timeline for return to activities, requiring tailored post-operative care.

The all-inside technique for ACL reconstruction differs from traditional methods in several key ways. Firstly, it often utilizes suspensory fixation devices for graft fixation, whereas traditional techniques may rely on interference screws or other types of fixation.(7)

Additionally, the all-inside technique involves drilling shorter tunnels, potentially resulting in less bone removal and faster healing compared to traditional techniques.(27) Furthermore, the all-inside technique allows for suture-only fixation of the graft in some cases, which may reduce the risk of hardware-related complications seen with traditional techniques. The choice of graft in all-inside ACL reconstruction can vary and includes options such as autografts and allografts, with the specific graft choice impacting the surgical technique and outcomes.(7)

Notwithstanding these distinctions, the all-inside technique and traditional ACL reconstruction exhibit several commonalities. Both methods adhere to comparable post-operative rehabilitation protocols, emphasizing early initiation of range of motion, strengthening exercises, and a gradual resumption of activities. Moreover, they enable patients to safely return to sports and physical endeavors, with many individuals attaining pre-injury levels of activity. Extensive research has documented favorable to excellent clinical outcomes with both the all-inside technique and traditional ACL reconstruction, characterized by enhancements in knee stability, function, and overall patient contentment. (22). However, while complication rates are generally low for both techniques, specific complications such as graft failure, infections, and stiffness can occur with either approach.(27) Individual patient factors, such as age, activity level, and the presence of other knee injuries, play a significant role in the choice of surgical technique and outcomes, highlighting the importance of a thorough evaluation by a healthcare professional (7,27)

Traditional ACL reconstruction is a well-established technique with a strong track record of success, offering robust graft fixation and the ability to accommodate various graft types. However, it is an invasive procedure with a longer recovery time, potentially requiring larger incisions and posing a risk of damage to surrounding structures. In contrast, all-inside ACL reconstruction is less invasive, with smaller incisions, shorter surgery times, and preservation of bone stock. However, it may have limitations in graft fixation and challenges in achieving proper graft tensioning, along with higher equipment costs (18). Anatomical ACL reconstruction focuses on replicating the native ACL anatomy, potentially leading to improved biomechanical outcomes and stability, but it requires advanced surgical skills and has a longer learning curve (28). Double-bundle ACL reconstruction, which mimics the native ACL more closely, may offer better rotational stability and functional outcomes, especially in high□demand athletes. However, it is a more complex procedure with a higher risk of complications, longer surgery times, and limited evidence supporting its superiority over single-bundle techniques. (29)

DISCUSSION

The discussion revolves around the findings and implications of the literature review on the "all-inside" ACL tear repair technique compared to traditional Anterior cruciate ligament reconstruction methods. The advantages of the all-inside technique are evident, including precise graft placement, reduced postoperative pain, and potential preservation of bone stock. These benefits align with the goals of modern ACL reconstruction, aiming for anatomical restoration of the ligament and improved patient outcomes.

One key advantage of the all-inside technique is its suitability for patients with immature skeletons, minimizing epiphyseal damage and growth arrest risks. This is particularly significant considering the increasing incidence of Anterior cruciate ligament injuries in younger patients involved in sports activities. Additionally, the technique offers versatility in graft options, accommodating autografts and allografts based on patient characteristics and surgeon preference.

However, the discussion also addresses the limitations and challenges associated with the all-inside ACL tear repair technique. Inadequate long-term outcome data and concerns about graft elongation and fixation stability raise questions about the durability of results and potential revision rates. Furthermore, variability in surgical techniques and patient characteristics across studies introduces heterogeneity and complicates result interpretation.

Comparative analyses with traditional ACL reconstruction methods highlight similarities and differences in clinical outcomes. While both approaches achieve satisfactory results, the all□inside technique may offer advantages in terms of anatomical reconstruction and reduced postoperative pain. However, concerns about tibial tunnel widening and graft failure rates suggest that further research is needed to confirm the superiority of the all-inside technique over traditional methods.

Immediate post-operative care remains crucial for both all-in ACL reconstructions and conventional ACL surgeries, focusing on monitoring for complications, pain management, and initiating physical therapy. However, individualized rehabilitation protocols may be required based on the surgical technique and graft type used

CONCLUSION

The comprehensive review of literature highlights the emergence of the "all-inside" ACL tear repair technique as a promising advancement in ACL surgery. Through meticulous examination of various studies and clinical trials, this review has elucidated the key aspects, advantages, limitations, and comparisons of the all-inside technique with traditional ACL reconstruction methods.

The evidence presented demonstrates that the all-inside ACL tear repair technique offers several advantages, including precise graft placement, reduced postoperative pain, and potential bone preservation. Moreover, its applicability in patients with immature skeletons and its ability to accommodate a range of graft options contribute to its versatility and utility in clinical practice. Despite the promising outcomes observed in short to mid-term studies, lingering concerns regarding long-term durability, graft elongation, and fixation stability necessitate further investigation. It is imperative that future research endeavors focus on conducting longer-term studies with standardized outcome measures to ascertain the technique's efficacy and durability over time.

Nevertheless, the all-inside ACL tear repair technique represents a significant advancement in ACL surgery, offering improved anatomical reconstruction and potentially enhanced patient outcomes. With ongoing research, refinement of surgical techniques, and advancements in technology, the all-inside technique holds promise for becoming a preferred approach in ACL reconstruction, ultimately benefiting patients worldwide

DECLARATION

Ethical Statement

The research conducted in this study has received approval from the Institutional Review Board/Ethics Committee at Ivane Javakhishvili Tbilisi State University. All procedures performed in this study involving human participants were in accordance with the ethical standards of Ivane Javakhishvili Tbilisi State University and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

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Conflicts of Interest

The authors maintain that there are no conflicts of interest related to this research. Neither financial nor non-financial competing interests are present.

Data Availability

The data supporting the findings of this study are comprehensively presented within the article and its supplementary materials. For any additional data, interested parties may request access, and such requests will be considered

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