Is There a Role for Internal Bracing and Repair of the Anterior Cruciate Ligament?

A Systematic Literature Review

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Background: Renewed interest has arisen in arthroscopic anterior cruciate ligament (ACL) repair techniques.

Hypothesis: ACL repair with or without some form of internal bracing could lead to good outcomes in a carefully selected subset of patients.

Study Design: Systematic review.

Methods: An electronic database search was performed to identify 89 papers describing preclinical and clinical studies on the outcome of ACL repair.

Results: Proximal ACL tear patterns showed a better healing potential with primary repair than distal or midsubstance tears. Some form of internal bracing increased the success rate of ACL repair. Improvement in the biological characteristics of the repair was obtained by bone marrow access by drilling tunnels or microfracture. Augmentation with platelet-rich plasma was beneficial only in combination with a structural scaffold. Skeletally immature patients had the best outcomes. Acute repair offered improved outcomes with regard to load, stiffness, laxity, and rerupture.

Conclusion: ACL repair may be a viable option in young patients with acute, proximal ACL tears. The use of internal bracing, biological augmentation, and scaffold tissue may increase the success rate of repair.

Keywords: anterior cruciate ligament; ACL; repair; internal bracing; systematic review

Decades ago, open primary repair of the anterior cruciate ligament (ACL) was the standard of care for ACL injuries.69,72,74 However, mixed outcomes of this surgery as well as the rise of ACL reconstruction techniques led to abandonment of this method in the early 1990s.24

Recently, renewed interest in ACL repair techniques has arisen. This is likely due to a combination of the improved results seen in preclinical studies as well the availability of biologic augmentation and internal bracing techniques.91,100

This systematic literature review aimed to determine the scientific basis for ACL repair and evaluate its outcomes. This report discusses the findings of the available preclinical and clinical studies on this topic and identifies factors that could influence the success of ACL repair such as tear type and location, suture material, fixation technique, biological enhancement, patient age, skeletal maturity, and the timing of surgery. It was hypothesized that ACL repair with or without some form of internal bracing could lead to good outcomes with regard to knee laxity and patient-reported outcomes in a carefully selected subset of patients.

METHODS

This systematic review was conducted following the guidelines provided by the Cochrane Handbook41 and according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.57

Eligibility Criteria

All studies reporting on the outcome of ACL repair were included in this systematic review. Studies were also included if they compared ACL repair (with or without internal bracing) to other types of treatment for ACL injury (including nonoperative treatment, ACL reconstruction, or augmentation). Both open and arthroscopic
techniques were included. All levels of evidence were included. Clinical (adult and pediatric patients) and preclinical studies were included. The primary outcomes of interest for the clinical studies were the success of the performed ACL repair procedure as indicated by the clinical failure rate (ie, revision rate), anterior laxity (measured by use of Lachman, anterior drawer, and arthrometer testing), and pivot-shift test results. Secondary outcomes included validated patient-reported outcome measures (International Knee Documentation Committee Subjective Knee Form [IKDC], Lysholm score, Knee injury Osteoarthritis Outcome Score [KOOS], Single Assessment Numeric Evaluation [SANE], and Tegner activity score) and patient satisfaction. In addition, several other variables that may affect the outcome of ACL repair were assessed, such as ACL tear type and location, suture type and fixation technique, biological enhancement of healing, age and skeletal maturity of the patient, and timing of surgery.

Information Sources and Search
An electronic database search was performed using MEDLINE (1950 to December 2016), EMBASE (1980 to December 2016), CINAHL (1982 to December 2016), and the Cochrane database. In addition, the reference lists of all included papers were reviewed for potentially missed studies. The following key words were used: (“anterior cruciate ligament” OR “ACL”) AND “repair” OR “internal brace.” No restrictions were placed on the date of publication or the language.

Study Selection
From the title and abstract, relevant studies were selected for full text review. For inclusion in the systematic review, the authors analyzed the full texts using the above-mentioned predefined criteria. The authors of this review were not blinded to the authors of the studies, affiliated institutions, or the journals that published the results.

RESULTS
Study Selection
The electronic search resulted in 2529 hits. After exclusion of all duplicates and review of the titles and abstracts, 110 eligible studies remained. Of these, 32 were excluded based on the full text article. Checking the reference lists of the included studies resulted in 9 additional papers. This resulted in 87 studies for inclusion in this systematic review (Figure 1).

Preclinical Studies
Of the included studies, 23 were preclinical studies. Many of these studies were performed by the group led by Martha Murray. These researchers have created a well-described Yorkshire pig ACL transection model and have used this model to test several different repair techniques as well as different mechanical and biological methods to improve healing of the ACL. Some of these studies are discussed further in other sections of this review.

In a study on 24 skeletally immature pigs with an ACL transection, the animals were randomized to receive bioenhanced ACL repair, allograft ACL reconstruction, or nonoperative treatment. After 15 weeks, both the ACL repair and ACL reconstruction had superior results compared with transection alone. However, no differences were found between repair and reconstruction for displacement, stiffness, or laxity. Using a similar model with 12-month follow-up, the same authors showed that the structural properties of the ACL after ACL repair were not significantly different from the properties after ACL reconstruction but were significantly more favorable than the properties of untreated ACL transection. Macroscopic cartilage damage after the ACL repair was significantly less than the damage associated with untreated ACL transection and ACL reconstruction at 12 months. The authors therefore concluded that ACL repair provides chondroprotection to the knee joint.

Clinical Studies
The remaining 64 included papers were clinical studies. Of these, none were evidence level 1 studies, 8 were level 2, 39 were level 3, 17 were level 4, and 1 was level 5. Some of these studies are discussed in more detail in other sections of this review.

References 29, 38, 43, 50, 51, 54, 56-61, 71, 94-96.
References 1, 3-10, 13-21, 23-25, 30, 31, 33, 34, 36, 37, 39, 40, 42, 44, 46, 48, 49, 52, 53, 55, 63-70, 72-76, 81-90, 93, 97-99.
In a recent case series of 11 patients treated with arthroscopic ACL repair, DiFelice et al\textsuperscript{15} reported a Lysholm score of 93.2, Tegner score of 6.9, and IKDC score of 86.4. The reported failure rate (>3 mm side-to-side difference in knee laxity) was 9%, and the remaining patients had less than 3 mm side-to-side difference with KT-1000 arthrometer testing.\textsuperscript{15} In a nonrandomized comparative study of 20 patients undergoing ACL repair and 20 patients undergoing ACL reconstruction, at 2-year follow-up no significant difference was found in the Lachman test, pivot-shift test, and patient-reported outcomes between the groups. The KT-1000 arthrometer result was less than 3 mm side-to-side difference in all patients. Three patients had a 1+ Lachman test (15%) and 4 patients had a 1+ pivot-shift test (20%) in the ACL repair group. Revision rates were higher with repair (15%) than with reconstruction (0%).\textsuperscript{1}

The remainder of the published studies are mostly those presenting the mid- and long-term follow-up results of open ACL repair techniques. Taylor et al\textsuperscript{24} presented the 30-year follow-up results of the original cohort by Feagin and Curl.\textsuperscript{24} Taylor et al presented data on 34 of the original 57 patients (60%) and found an average Lysholm score of 70.1, SANE of 68.9, KOOS of 3.7, and Tegner of 3.7. Eighteen patients (53%) rated their knee as normal or nearly normal on IKDC subjective score.\textsuperscript{90} Drosg et al\textsuperscript{16} compared acute primary repair, acute repair augmented with a synthetic ligament-augmentation device, and acute repair augmented with autologous bone–patellar tendon–bone graft. They presented results at 2-, 5-, and 16-year follow-up with 50 patients in each group. Of those, 129 patients (88%) were available for follow-up. Revision rate was 24% in the primary repair group, 10% in the augmentation device group, and 2% in the patellar tendon augmentation group. Repair with patellar tendon augmentation resulted in the most stable knee as measured by Lachman test. No differences were found in Lysholm score or the incidence of osteoarthritis among the groups at final follow-up.\textsuperscript{16} Long-term follow-up (15-23 years) results of the original cohort by Strand et al\textsuperscript{97} were published in 2005.\textsuperscript{88}

In the 2005 publication, the authors report on 140 patients including sports. On magnetic resonance imaging at 6-month follow-up, the continuity of ACL was well maintained.\textsuperscript{3} Two case reports described arthroscopic primary repair of tibial-side soft tissue avulsions of the ACL.\textsuperscript{93} One case entailed an ACL and anterior horn of the lateral meniscus avulsion, which was successfully repaired arthroscopically.\textsuperscript{93} The second study described a “tibial peel off tear” of the ACL without bony avulsion, which was treated with transosseous suture repair. For this patient, the IKDC subjective score was 90, IKDC objective score was A, and Lysholm score was 95 at 24 months after surgery. KT-2000 arthrometer testing showed 2 mm side-to-side difference. Pivot-shift test and Lachman test were negative, and the patient had no limitation in range of motion. The patient returned to full activities including sports. On magnetic resonance imaging at 6-month follow-up, the continuity of ACL was well maintained.\textsuperscript{3}

A recently published systematic review on ACL repair identified 8 of the aforementioned clinical studies with a total of 166 patients, most of whom were from the original cohorts from the 1970s and 1980s. The investigators found generally high rates of failure, need for additional surgery, and revision for instability in most of these patients. However, the investigators also found an unspecified subset of patients who achieved good to excellent subjective and objective long-term outcomes. The study concluded that long-term human studies suggest collectively unacceptable outcomes for open primary repair of the ACL.\textsuperscript{91}

**ACL Tear Type and Location**

Sixteen studies focused on the influence of ACL tear type and location on the success of ACL repair.\textsuperscript{1} This discussion starts with the classic papers. Sherman et al\textsuperscript{81,82} performed a subgroup analysis of their ACL repair cohort after seeing the same poor mid- to long-term outcomes as Feagin and Curl.\textsuperscript{23-25} Sherman and colleagues\textsuperscript{82} subgroup analysis indicated better clinical results in those patients with a proximal tear type. This was not the only study to show that proximal tear patterns fared better with ACL repair.\textsuperscript{91}

Weaver et al\textsuperscript{99} reported the outcomes of primary ACL repair in skiers. The investigators found that 79% of subjects with a proximal tear had good patient-reported outcomes, whereas only 23% of subjects with a midsubstance tear reported good outcomes. Kuhne et al\textsuperscript{96} reported on 75 patients with proximal tears and found a 0% failure rate at 4-year follow-up. Eighty-eight percent of their patients had a negative pivot-shift result, 87% had a Lachman result of 1+ or lower, and return to sports was 89%.\textsuperscript{96} Similar outcomes were reported in a study of 42 proximal ACL repairs: 81% negative pivot-shift results, Lachman result of 1+ or lower, and 86% patient satisfaction at 5- to 7-year follow-up.\textsuperscript{34} Raunest et al\textsuperscript{73} reported their outcomes of ACL repair in proximal ruptures at 3.5-year follow-up and found a 0% revision rate and a negative pivot-shift and anterior drawer test in 84% of their patients. Seventy-one percent returned to sports, and 75% of subjects were satisfied with the results.\textsuperscript{73}

Conversely, in studies that focused on midsubstance tears, the outcomes were much less predictable. In a cohort of 42 patients who underwent repair of midsubstance ACL tears, at 4-year follow-up 22% of patients had a positive pivot-shift test and 44% had a positive anterior drawer test.\textsuperscript{31} Similarly, Odensten et al\textsuperscript{67} reported a 20% revision rate at 1.5 years after repair of midsubstance ACL tears. In a subgroup analysis of the study by Kaplan et al,\textsuperscript{44} 56 patients with a midsubstance tear had a 17% failure rate and 42% had laxity on arthrometer testing.

**Suture Type, Fixation Technique, and Internal Bracing**

Twenty-five of the included studies addressed suture type and fixation method.\textsuperscript{8} The high failure rate in the studies by Feagin and Curl\textsuperscript{23-25} could have been attributable, in part, to the use of absorbable sutures. In their technique,
figure-of-8 absorbable sutures were placed in the ACL stump and secured over the iliotibial (IT) band.22-25 Indeed, Marshall et al35,53 showed better results when using multiple strands of looped nonabsorbable sutures tied directly over the cortex of the femoral condyle.

More recent preclinical studies on ACL repair have shown that the strength of the repair is improved when non-absorbable sutures are used.95 Using a sheep model, Seitz et al77,78 performed transsection of the ACL from the femoral condyle and performed primary repair as well as a repair augmented by an internal brace with a polyethylene terephthalate band. At 1-year follow-up, histological and biomechanical analysis of the ACL was performed and results were compared with the contralateral limb. In both groups the ACL healed, but healing occurred faster in the 20 sheep randomized to ACL repair with internal bracing (16 vs 26 weeks). Biomechanical properties were better with internal bracing but in both groups were inferior to the properties of the contralateral limb.77,78 Murray et al58 performed a similar study in their ovine model and found that when compared with suture anchor repair alone, proximal ACL transection repaired with a transtibial suture augmentation resulted in higher yield load, maximum load, and stiffness. Fisher et al26,27 tested the biomechanical properties of internal bracing of the ACL repair in a goat model. They tested 4 states: ACL intact, transected, repaired, and repaired with augmentation using suture passed from the tibia to the femur. Anterior tibial translation was closer to the intact state when internal bracing was added to the ACL repair. The investigators also found a reduced load on the medial meniscus when using this construct.

Wilson et al100 published a recent case report with 2-year follow-up on internal bracing of the ACL. They described the bracing technique as a bridging concept using braided suture tape and knotless suture anchors to reinforce the ligament. The investigators reported radiographic and arthroscopic evidence of ACL healing in their patient with good functional outcomes.100 Smith et al84 reported on 2 pediatric patients with ACL tear and associated tibial spine avulsion who underwent direct surgical repair, supplemented with an internal brace. At 3 months, both patients had achieved knee stability on physical examination and complete ACL healing on second-look arthroscopy. Eggi et al17,18 and Henle et al40 suggested a slightly different technique which they applied to 10 patients who had a proximal (n = 3) or midsubstance (n = 7) ACL rupture that was less than 14 days old. A suture repair of the ACL was performed with transosseous absorbable sutures. Then, microfracture of the femoral footprint was performed and the knee was stabilized with a large polyethylene suture that was tensioned by use of a spring implant (Ligamys; Mathys Ltd Bettlach) on the anteromedial aspect of the tibia, with the intent of pulling the knee into a constant posterior drawer while allowing a dynamic excursion of 8 mm. The 5-year follow-up rate was 80%. The investigators reported a median Lysholm score of 100, IKDC of 98.9, Tegner of 5.5, and Lachman side-to-side difference of 2 mm. They reported that 2 (20%) patients had rerupture during follow-up and underwent ACL reconstruction.15,18,40 Despite the acceptable outcomes reported in this small cohort, the method entails a theoretical risk of overconstraint of the knee—a potential risk factor for early osteoarthritis—as well as concerns regarding the technical difficulty of performing a revision surgery with this large implant in place.11,92

Augmentation methods other than suture have been suggested as well, including collagen scaffolds,29,40,51,58,57,71 patellar tendon,4 or IT band.13 A study on 47 patients undergoing ACL repair with extra-articular augmentation with IT band showed that 64% of patients rated their knee as good or excellent. Ninety-one percent had a stable knee as tested by Lachman, pivot-shift, and jerk tests. Rate of return to sports was 90%, with 72% returning at their preinjury level.13 An extra-articular augmentation with IT band was used by Higgins and Steadman42 for elite skiers with an ACL injury. In 78% of the knees, there was pain-free function; mild pain was reported in 19%. On clinical examination, 85% had normal pivot-shift examination with no evidence of abnormal motion. Arthrometer measurements revealed an average of 7.76 mm of anterior displacement with 20 pounds of force on the knee with an ACL repair compared with 5.56 mm on the uninjured knee. Five patients (11%) had reinjury to the ACL at an average time of 28 months postoperatively, with 2 (4%) of the 5 patients undergoing rererepair.42

Biological Enhancement of Healing

Eleven studies focused on the role of biologics in primary ACL repair.** Fisher et al28 used extracellular matrix to aid healing in an ACL transection model in goats. At 12 weeks, the investigators found improved healing compared with the suture repair alone with significantly larger cross-sectional area. A study on the safety of this extracellular matrix showed that it did not result in an increase in the local or systemic inflammatory reaction.51 The investigators then evaluated the effect of injection temperature on the effectiveness of this matrix. Warming the composite resulted in faster viscoelastic transition but decreased the elastic modulus by 50%.71

Several studies using platelet-rich plasma (PRP) to aid ACL healing followed. Murray et al39 showed improved biomechanical properties when PRP was added to the scaffold compared with repair using a scaffold alone. However, when the investigators used a similar model without the scaffold and used only PRP, no improvement was found in histological or biomechanical properties compared with suture repair alone.60 As well, uncertainty remains with regard to the necessary concentration of PRP that is required.34

Nguyen et al62 used small intestinal submucosa (SIS) as a bioscaffold in a goat model and then compared suture repair alone to suture repair with SIS augmentation. The cross-sectional areas of the suture-only and the suture-SIS groups were 35% and 50%, respectively, of the intact control. The investigators did not find a difference for in situ force, stiffness, or histological appearance between the groups.

References 28, 29, 43, 51, 54, 56, 57, 60-62, 71.
Age and Skeletal Maturity

Eight studies looked at age as it relates to ACL repair.8,33,38,59,72,84,86 Historically, ACL repair has been associated with a higher success rate when performed in the pediatric and adolescent population.8,33 Therefore, it has been hypothesized that age and skeletal maturity affect the healing potential of the ligament. Indeed, Murray et al.38 showed in a porcine study that immature animals generated a better healing response. The investigators looked at 8 juvenile, 8 adolescent, and 5 adult pigs that underwent bilateral ACL transection. On one side, the ligament injury was left untreated to determine the intrinsic healing response as a function of age. On the contralateral side, an enhanced suture repair incorporating a collagen platelet composite was performed. The ACLs from skeletally immature animals had significantly improved structural properties after transection in both the untreated and repair groups. In another study from the same group, a multivariate model of vascular endothelial growth factor (VEGF) receptor expression and biomechanics showed that age was associated with maximum load and yield load. A high VEGF receptor expression, even more so at higher age, resulted in a more compliant scar, which in turn was associated with increased knee laxity and a compromised clinical result.96 This was again shown in another porcine study on young, adolescent, and mature animals. In young and adolescent animals treated with bioenhanced suture repair, the authors found fibroblastic proliferation with loss and return of collagen alignment in the fibrous zone, osteoclastic resorption within fibrocartilage, and partial reappearance of fibrocartilage zones at 15 weeks. However, in adult animals, degenerative changes were noted including loss of parallel arrangement of collagen fibers and increasing disorganization and loss of columnation of chondrocytes.38

A study by Arbes et al.8 focused on ACL repair in the skeletally immature patient. Twenty patients with a mean age of 14 years were included. However, the study was a very mixed cohort of nonoperative treatment, delayed repair, primary repair, and reconstruction. Of the 3 patients who underwent primary repair, 2 patients (67%) needed reconstruction during follow-up and the remaining 1 patient (33%) was reported to have poor outcomes.9 Another clinical study focusing on the skeletally immature population looked at the outcome at 6.5 years postoperatively for 44 patients with an average age of 14 years at surgery.83 Of those 44 patients, 5 underwent reinsertion, 10 internal fixation, and 15 augmentation with semitendinosus tendon autograft. The remaining 14 patients underwent reconstruction with bone–patellar tendon–bone autograft. The investigators reported good outcomes for stability and no growth disturbance in all patients.83 Steadman et al.86 performed a prospective clinical study of 13 skeletally immature athletes with proximal ACL tears who were treated with “a nonreconstructive technique to promote healing.” The investigators reported a 23% failure rate, as defined by reinjury during follow-up and the need for ACL reconstruction. However, this failure occurred at 30 to 55 months after the healing response procedure. All other patients subjectively reported their knee function as normal. The Lysholm score was 96, Tegner score was 8.5, and KT-1000 arthrometer side-to-side difference was 2 mm. The investigators concluded that the healing response procedure resulted in a stable knee when proper patient selection was performed; that is, skeletally immature patients with proximal ACL ruptures.86

Smith et al.84 reported on a small case series of 2 patients (age 5 and 6 years) with complete proximal ACL ruptures and a third patient (age 7) with an associated tibial spine avulsion who underwent direct surgical repair supplemented with an internal brace that was removed after 3 months. Second-look arthroscopy, examination, and imaging at 3 months confirmed knee stability and complete ACL healing in all cases. None of these patients suffered any growth disturbance.

Timing of Surgery

Four studies commented on timing of surgery as it related to ACL repair.8,49,50,83 Delaying primary repair of the ACL has been suggested as a reason for inferior results.8,83 This hypothesis was tested by Murray’s group. Yorkshire pigs underwent ACL transection and repair at 0, 2, or 6 weeks. Delay of the repair resulted in a decrease in the yield load, maximal load, stiffness, and laxity. All of these were worse with a delay of 6 weeks compared with 2 weeks. The authors concluded that a delay between ACL injury and repair has a significant negative effect on the performance of the repair.50

In a clinical study, Lysholm et al.49 reported on 175 patients who underwent ACL or posterior cruciate ligament repair within 4 weeks of their injury. Two-thirds were treated operatively because of total ligament tears, and the remainder, with minor injuries, were treated nonoperatively. In two-thirds of the patients with complete ACL tear, early repair was successful. Functional loss was correlated with the presence of a positive pivot-shift test. The most common reason for a poor result was either medial meniscectomy or some component of the injury being missed in the primary diagnosis.

DISCUSSION

Historically, the evaluation of ACL repair started in 1895 with Mayo Robson,24 who performed a primary ACL repair on a 41-year-old male patient who had a proximal avulsion of both cruciate ligaments. This was followed by the classic works of Ivar Palmé69,70 and Don O’Donoghue63-66 in the early 1930s through 1960s. These publications led to open primary ACL repair becoming the preferred technique for the treatment of ACL injuries in the 1970s and 1980s, with good short-term results.††

However, Feagin and Curl23-25 were the first to report that at mid-term follow-up, results were less favorable, with a 53% reinjury rate at 5 years, as well as a high incidence of pain, stiffness, and instability. One criticism of these studies was that the authors provided follow-up data for only half of the subjects included in the original

trial. However, other authors started to report similar findings in their mid- to long-term follow-up studies.\textsuperscript{4,44,50,52,53,78,88,89} This may have been confounded, in part, by the surgical technique used, which included both a large arthrotomy and extensive postoperative cast immobilization, practices that are in extreme contrast to the current approach to ACL injuries, which focuses on early range of motion and accelerated rehabilitation.\textsuperscript{79}

Around the same time these studies were being published, ACL reconstruction techniques were becoming more popular, as they yielded improved and more predictable results.\textsuperscript{4} Several prospective randomized trials comparing ACL reconstruction to ACL repair also showed results in favor of ACL reconstruction.\textsuperscript{6,7,19,36,75} In addition, the high comorbidity of an arthrotomy was being reduced by the use of less invasive arthroscopic techniques that allowed early mobilization and range of motion.\textsuperscript{79,80} This culmination of events likely led to the effective abandonment of ACL repair in the 1990s.

Although ACL reconstruction has now become the standard of care, ACL repair is starting to make a resurgence. This is not surprising in light of the new paradigm shift toward restoring native anatomic features\textsuperscript{82} and the renewed interest in the use of orthobiologics to aid in tissue healing.\textsuperscript{45} Another potential benefit of ACL repair is the preservation of proprioceptive ability.\textsuperscript{9,14} Furthermore, native tissue is preserved, which is a major advantage if revision surgery is needed in the future; that is, for graft harvesting as well as with regard to available bone stock.\textsuperscript{2,12,35}

This systematic review of existing literature on ACL repair has limitations. First, all levels of evidence were included, so the review includes several case reports, small case series, and clinical studies without 2-year follow-up. The decision was made to include all levels of evidence because of the lack of high-quality clinical trials on this subject. Therefore, to illustrate this fact and to provide guidelines for future research, the decision was made to include preclinical studies and lower levels of evidence. Second, the review includes studies on both open and arthroscopic techniques, which can confound the results of the repair method itself. Third, none of the included studies focused on the double-bundle anatomic structure of the ACL and whether repair of one bundle and augmentation of the other bundle could be considered. Fourth, many of the included clinical studies either did not comment on the rehabilitation or provided very little detail. The potential differences in rehabilitation technique and postsurgical care could contribute to variability of the results of the included studies. Because of the variability in the reported outcomes and heterogeneity of the included studies, pooling of the data in a meta-analysis format was not possible. Fifth, when extracting data from the included studies, the authors were not blinded to the authors of the studies, affiliated institutions, or the journals that published the results.

In conclusion, this systematic review of literature indicates that there may be a role for ACL repair in a specific, well-defined subset of patients. The findings suggest that proximal tear patterns have better healing potential than distal or midsubstance tears. Some form of internal bracing, with either nonabsorbable suture, scaffolds, or a graft, can increase the success rate of the procedure. Improving the biological characteristics of the repair can be achieved through bone marrow access at the femoral insertion site or intercondylar notch, but PRP augmentation has been shown to be of benefit only when used in combination with a scaffold. ACL repair has a better outcome in younger patients, specifically in the skeletally immature. Last, acute repair offers better outcome than delayed repair.

REFERENCES


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