A Comparison of Operative and Nonoperative Treatment of Anterior Cruciate Ligament Injuries

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Abstract

» Intention to resume high-risk sports activity is a major motivating factor for patients who elect anterior cruciate ligament (ACL) reconstruction rather than nonoperative treatment.

» Some patients are able to cope with an ACL-deficient knee and resume preinjury activity levels, including level-1 sports (football, basketball, soccer, etc.), following nonoperative treatment; however, activity levels correlate with injury risk in ACL-deficient knees.

» Patients who have an ACL injury along with concomitant meniscal injury are at increased risk for osteoarthritis. It is unclear what effect reconstruction of an isolated ACL injury has on future osteoarthritis risk in ACL-deficient patients who are identified as “copers.”

» There are distinct biomechanical differences between copers and noncopers, but no reliable screening tools are currently able to predict which patients will become copers following nonoperative treatment of an ACL injury.

» A trial of nonoperative treatment, including perturbation exercises, to determine whether reconstruction is needed does not increase the risk of additional knee injury.

The anterior cruciate ligament (ACL) plays a critical role in knee stability by restraining anterior tibial translation1,2 and internal-external rotation3-6. Over 100,000 ACL reconstructions were performed in the United States in 2006, and the annual rate is increasing7. The incidence of ACL tears is also increasing, particularly among young female athletes8. Although some patients have achieved good results after nonoperative treatment9-15, a survey of members of the American Orthopaedic Society for Sports Medicine revealed that the majority of respondents used nonoperative treatment for \( \leq 25\% \) of their patients with an ACL injury7,16. Noyes et al. described the “rule of thirds”:

one-third of patients with an ACL injury compensate well with nonoperative treatment (copers), one-third avoid symptoms of instability by modifying activities (adapters), and one-third require reconstruction (noncopers)17. Cohort studies have since substantiated this general “rule of thirds.”12 However, it remains difficult to predict into which third an individual patient will fall. Therefore, there is still substantial ambiguity in determining which patients are most likely to benefit most from early ACL reconstruction following injury.

Direct comparison of operative and nonoperative treatment following ACL injury remains inadequately studied. To our knowledge, only 3 randomized

Disclosure: No external funds were received in support of this study. The Disclosure of Potential Conflicts of Interest forms are provided with the online version of the article.
TABLE I  Clinical Recommendations and SORT Criteria*22 Strength of Recommendations

<table>
<thead>
<tr>
<th>Clinical Recommendation</th>
<th>SORT Evidence Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with ACL injuries and concomitant meniscal injuries should undergo early</td>
<td>B</td>
</tr>
<tr>
<td>reconstruction18-40.</td>
<td></td>
</tr>
<tr>
<td>Patients with isolated ACL injuries intending to return to ≥4 hours per week of level-1</td>
<td>B</td>
</tr>
<tr>
<td>sports participation should undergo early reconstruction12,15,31,44.</td>
<td></td>
</tr>
<tr>
<td>Patients considering nonoperative rehabilitation of an ACL injury may delay</td>
<td>B</td>
</tr>
<tr>
<td>reconstruction and use the immediate post-injury period to determine whether or not</td>
<td></td>
</tr>
<tr>
<td>they will be able to cope with an ACL-deficient knee3,34,39,49,75-78.</td>
<td></td>
</tr>
<tr>
<td>Perturbation training exercises should be included in nonoperative treatment of ACL</td>
<td>B</td>
</tr>
<tr>
<td>injuries86-90.</td>
<td></td>
</tr>
</tbody>
</table>

*A = recommendation based on consistent and good-quality patient-oriented evidence; B = recommendation based on inconsistent or limited-quality patient-oriented evidence; C = recommendation based on consensus, usual practice, opinion, disease-oriented evidence, or case series.

controlled trials (RCTs) have compared operative and nonoperative treatment of ACL injuries. Two studies involved the use of ACL suturing as opposed to modern reconstruction techniques in the operative treatment groups18,19, and both had substantial methodological limitations20. The third study was conducted on a cohort of 32 patients21. Therefore, there have been no Level-I studies directly comparing ACL reconstruction with nonoperative treatment. On the basis of an evaluation of the existing evidence, the authors of a Cochrane review concluded that “there is insufficient evidence from randomized trials to determine whether surgery or conservative management was best for ACL injury in the 1980s, and no evidence to inform current practice.”20

Despite this paucity of high-quality evidence, determinations still have to be made regarding which patients are candidates for nonoperative treatment of ACL injuries, and the goal of the present review was to evaluate the existing data. We aimed to define and evaluate the available data on the natural history of nonoperatively treated ACL injuries and to compare how the functional outcomes and injury risks associated with nonoperative treatment compare with those associated with reconstruction. Furthermore, we sought to define prognostic factors and rehabilitation programs associated with successful nonoperative outcomes and to compare the outcomes following early versus delayed ACL reconstruction.

Methods

Studies were identified through a PubMed search with use of the MeSH term “anterior cruciate ligament” with either “conservative,” “nonsurgical,” “non-operative,” “deficient,” or “non-operative” appearing in the title and/or abstract. The abstracts of all articles meeting these criteria were reviewed. A second search was performed with use of the MeSH term “anterior cruciate ligament.” The titles of all articles meeting these criteria were reviewed. The reference sections of selected articles also were reviewed to identify additional relevant articles. The articles were organized into subsections focusing on rates of return to activities and risks of further injuries following ACL reconstruction and nonoperative treatment, screening criteria for successful nonoperative outcomes, comparisons of early versus delayed ACL reconstruction outcomes, and rehabilitation protocols for patients with a torn ACL. On the basis of the evidence, clinical recommendations were made. The quality of evidence underlying these recommendations was assessed on the basis of SORT (Strength of Recommendation Taxonomy) criteria, where “an A-level recommendation is based on consistent and good quality patient-oriented evidence; a B-level recommendation is based on inconsistent or limited quality patient-oriented evidence; and a C-level recommendation is based on consensus, usual practice, opinion, disease-oriented evidence, or case series”22 (Table I).

Return to Sports Following Nonoperative ACL Rehabilitation Versus Operative Reconstruction

Numerous studies have demonstrated that nonoperative treatment of ACL injury can provide sufficient knee stability for patients willing to avoid high-risk activities, particularly level-1 sports23-27 (Table II). Some patients with a torn ACL, however, attempt to return to higher activity levels. Cohort studies comparing nonoperative treatment with operative reconstruction have demonstrated similar return-to-play rates at 1 year14, 2 to 5 years9,14, 7 years28, and 11 years29 after the injury. Tsoukas et al., in a small RCT comparing nonoperative treatment with reconstruction, reported that the average activity level as measured with the Tegner scale was significantly decreased compared with the preinjury level in the nonoperatively treated group (in which the average activity level decreased from 7 to 5) but not in the reconstructed group.
group (in which the average activity level remained at 7) at the time of the 10-year follow-up21. Wittenberg et al., in a cohort study, reported that sports activity was graded as unlimited by 4 (13%) of 30 patients in the nonoperative treatment group, compared with 11 (37%) of 30 patients in the reconstruction group, at approximately 3 years of follow-up30. In another cohort study, Fink et al. reported a 70% decrease in participation in level-1 sports in the nonoperative treatment group (n = 25), compared with a 44% decrease in the reconstruction group (n = 46), at 10 to 13 years of follow-up31. Two case series of nonoperatively managed patients demonstrated poor outcomes, including decreases in sports participation, as compared with preinjury levels32,33.

These conflicting studies are difficult to interpret9,14,28-31, and the possible influence of confounding factors must be noted. Because preinjury activity level is the only reliable predictor of a patient’s decision to undergo ACL reconstruction12,24,55, patients electing nonoperative rehabilitation typically have lower preinjury levels of activity than patients electing reconstruction. In addition, 1 of the main reasons that patients elect reconstruction is a desire to return to sports activity. Results from the Knee Anterior Cruciate Ligament, Nonsurgical versus Surgical Treatment (KANON) study demonstrated that motivation to resume sports participation is predictive of outcomes following ACL injury36, and this motivation may bias results toward more positive outcomes for patients undergoing reconstruction simply because they work harder to resume sports activity. Fear of reinjury also may be higher in nonoperatively managed patients, and this fear may dissuade them from returning to sports even though they have achieved sufficient knee stability. These factors may bias results toward worse return-to-play outcomes, and it is difficult to determine how to account for them in interpreting these data. One possible explanation may be offered by the Delaware-Oslo ACL Cohort Study37, a prospective study in which patients were counseled on the risks and benefits of reconstruction for 5 weeks while they underwent initial rehabilitation and then elected their treatment strategy. Patients undergoing reconstruction were more likely than nonoperatively managed patients to participate in level-1 sports 2 years following injury; however, there was no difference in level-1 sports participation when adjusted for preinjury sports participation37. This finding suggests that many of the differences in functional outcomes following nonoperative treatment as compared with reconstruction may be due to patient self-selection.

### Risk of Additional Knee Damage Following Operative Reconstruction Versus Nonoperative Treatment

The overall risk of developing osteoarthritis (OA) is increased in patients with concomitant meniscal injury38-40. This increased risk of OA is due to the loss of chondroprotective function41, restriction of anterior knee movement42, and loss of stabilization during rotational loading43 provided by the meniscus in knees with a torn ACL. In 1 case series of patients with an ACL injury who did not undergo ACL reconstruction, 13 (16%) of 79 patients eventually developed OA39. All of the patients who developed OA had undergone a meniscectomy, whereas no patient with an intact meniscus developed OA. Another case series demonstrated that a concomitant meniscal injury increased the severity of OA in a time-dependent manner40. A systematic review demonstrated that the risk of OA progression was as high as 13% for patients with an isolated ACL injury as compared with 48% for those with concomitant meniscal injury38. Roughly 50% of acute ACL injuries involve meniscal tears12, and ACL reconstruction is warranted for those patients in order to reduce the risk of future OA.

In cases of isolated ACL injury, it has been proposed that ACL reconstruction will prevent additional knee damage42 by protecting against meniscal injuries in patients experiencing symptomatic instability. The rate of giving-way episodes among patients with a torn ACL has been reported to be 58% (32 of 55)34, 64% (46 of 72)32, 73% (32 of 44)45, and 86% (24 of 28)45, and meniscal injuries can occur when a knee with a torn ACL gives way46. Three cohort studies demonstrated fewer subsequent meniscal injuries in patients who were managed with reconstruction as compared with those who were managed nonoperatively, suggesting that ACL reconstruction may protect against meniscal injury by limiting giving-way episodes12,47,48. However, in an RCT comparing early reconstruction with optional delayed reconstruction,
patients with a torn ACL who did not experience giving-way episodes did not have an increased incidence of meniscal injury as compared with those who were managed with reconstruction. Although ACL reconstruction may reduce the risk of future meniscal injury as compared with nonoperative treatment, the evidence for this association is weak.

There is considerable conflicting evidence regarding the role of reconstruction of an isolated ACL injury on the future OA risk. In a small RCT in which nonoperative treatment was directly compared with reconstruction, there was no difference in the prevalence of OA at the time of the 10-year follow-up. In cohort studies comparing reconstruction and nonoperative therapy for the treatment of ACL injuries, reconstruction has led to an increased incidence of OA in 3 studies, a decrease in 2 studies, and no difference in 1 study. It is therefore unclear what effect, if any, reconstruction of an isolated ACL injury has on the future OA risk.

Patient self-selection also must be considered when assessing the future injury risk following nonoperative treatment or reconstruction. In the Delaware-Oslo ACL Cohort Study, patients who had elected to undergo reconstruction actually had a higher rate of knee reinjury. However, this association was not seen when the data were adjusted for preinjury activity levels. As activity levels are linked to future risk following nonoperative treatment, several studies have attempted to define the differences between patients who have successful outcomes following nonoperative treatment (copers) and those who have unsuccessful outcomes (noncopers). Copers have been defined as "individuals with complete ACL rupture and no symptoms of knee instability who participated in high-level sports without difficulty," and noncopers have been defined as individuals with ACL tears who had instability with low-level daily activities and were not able to participate in sports. In copers, the femur of the injured limb becomes more anteriorly translated and externally rotated than the femur of the contralateral limb. In addition, copers develop biomechanical patterns similar to those in uninjured subjects, allowing them to function with less anterior knee laxity and less quadriceps-hamstring co-contraction. In comparison, noncopers have worse balance and use movement patterns that lead to excessive internal tibial rotation, causing excessive joint compression and shear forces. However, both copers and noncopers exhibit higher VO2 and heart rates than healthy controls during walking, indicating that these biomechanical compensations demand higher energy and effort than is expended with an intact ACL.

Prediction of which patients will develop into copers could allow these patients to forego surgery and return to previous activity levels following rehabilitation. One attempt to predict which patients would become copers involved the use of a global knee rating (the Knee Outcome Survey Activities of Daily Living Scale [KOS-ADLS] score) and a series of single-leg hop tests to identify potential copers. The patients who were identified as copers achieved a high rate of successful outcomes; however, those who were identified as noncopers achieved similar outcomes, indicating that the screening tool cannot be used to predict a patient's prognosis.

Biopsies performed at the time of ACL reconstruction in knees with documented bone contusions on magnetic resonance imaging (MRI) have shown histological evidence of articular cartilage damage. A severe bone contusion can remain detectable on MRI for as long as 2 years following acute ACL injury; however, bone contusions suffered at the time of ACL injury have not been shown to correlate with degenerative cartilage changes on follow-up radiographs in nonoperatively managed patients. Joint laxity also has been shown to be an unreliable predictor of the need for eventual reconstruction.

There is evidence that the amount of sports activity correlates with the risk of additional knee injury in patients with a torn ACL. In a case series of Olympic athletes who returned to play following the nonoperative treatment of an ACL injury, 95% (18 of 19) had severe OA at the 20-year follow-up and 53% (10 of 19) had undergone total knee arthroplasty by the 35 to 37-year follow-up. One follow-up study demonstrated that increased activity levels led to an increase in knee giving-way episodes in nonoperatively managed patients, and another study demonstrated that the number of hours of sports participation correlated with osteoarthritic progression in the nonoperative treatment group but not in the reconstruction group. In a prospective cohort study, 27 (40%) of 67 patients with a torn ACL who were characterized as high risk (on the basis of instability and number of hours participating in level-1 and 2 sports) required meniscal or ligament surgery, compared with 15 (26%) of 58 moderate-risk patients and 3 (9%) of 33 low-risk patients. Participation in level-1 or 2 sports for >200 hours per year was an important risk factor in that cohort. This finding provides the best available evidence regarding the activity level that will lead to an increased injury risk (roughly 4 hours per week). Younger age may be used as a surrogate marker of activity level. Because cessation of sports participation following ACL injury has a detrimental effect on quality-of-life assessments, reconstruction may be warranted in order to allow patients meeting this criterion to continue unrestricted sports participation. Unfortunately, this means that the
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Outcomes of Early Versus Delayed ACL Reconstruction

One option following ACL injury is to delay reconstruction with a trial of nonoperative treatment in order to determine whether a patient will develop biomechanical coping strategies or will require reconstruction. In the KANON study, an RCT comparing patients undergoing early ACL reconstruction with patients with optional delayed reconstruction, 29 (49%) of 59 patients in the optional-delayed-surgery group had not undergone reconstruction at the time of the 5-year follow-up. There were no differences between the groups in terms of sports participation, OA progression, or subsequent meniscal injury rates. In both an RCT and a meta-analysis, no difference was shown between patients undergoing reconstruction at 2 to 3 weeks after the injury and those undergoing reconstruction at 6 to 12 weeks after the injury. In an uncontrolled prospective series of patients with a torn ACL who were referred for reconstruction only in the presence of giving-way episodes, 76% (71 of 93) had not undergone reconstruction at the time of the 15-year follow-up, and none of the 44 patients who did not undergo meniscectomy developed OA.

However, in retrospective analyses, delayed ACL reconstruction has led to a decreased activity level, an increase in meniscal lesions, and an increase in articular cartilage damage as compared with early reconstruction. Sampling bias could have been a major confounding variable in those studies as patients experiencing a successful recovery after nonoperative treatment would have been unlikely to elect delayed reconstruction, skewing the results toward negative outcomes for the delayed-reconstruction group. However, in multiple prospective trials, when patients experiencing instability episodes have been referred for reconstruction, optional delayed reconstruction has not negatively impacted outcomes such as activity level or the rates of meniscal injury and OA as compared with those for patients managed with early reconstruction. A period of rehabilitation also can help to refine a patient’s prognosis. As screening tools have thus far proved unreliable, this strategy may provide the necessary time to determine whether a patient will develop into a coper without risking additional injury.

A prospective cohort trial demonstrated that patients undergoing ACL reconstruction within 6 months after an injury were more likely to receive meniscal repair than patients undergoing ACL reconstruction >6 months after an injury. The patients undergoing ACL reconstruction >6 months following the injury, meanwhile, were more likely to undergo meniscal resection. Because meniscal repair is associated with better outcomes than meniscal resection, patients electing a trial of nonoperative treatment who eventually undergo reconstruction should therefore have the surgery performed within 6 months after the injury. This timing will increase the likelihood that any meniscal injuries will not have progressed beyond the point that repair is no longer feasible.

Rehabilitation Regimens for Patients with Nonoperatively Treated ACL Injuries

Patients with a torn ACL who elect a delayed-reconstruction strategy and attempt to develop coping mechanisms to stabilize the knee should undergo a rehabilitation program, and there is ample evidence to support the use of perturbation exercises for the nonoperative treatment of ACL injuries. These exercises involve the use of unstable support surfaces such as rollerboards, tiltboards, or foamboards to induce compensatory muscle activity and to help patients develop dynamic stabilization mechanisms. Perturbation training in patients with a torn ACL normalizes knee-joint loading during weight-bearing and non-weight-bearing and reduces quadriceps-hamstring co-contractions, normalizes knee kinematics, and leads to more symmetrical movements. In 1 RCT, the addition of perturbation training to a standard rehabilitation program decreased giving-way episodes as compared with the standard program alone. When patients who were identified as potential copers utilized perturbation training, 79% (22 of 28) returned to preinjury levels of activity without a giving-way episode. These exercises can help the patient to develop biomechanical coping strategies and refine the prognosis without negatively impacting the outcome. On the basis of this evidence, 1 group recommended that perturbation exercises be combined with muscle strength, cardiovascular endurance, agility, and sport-specific skill training for patients utilizing nonoperative treatment of ACL injuries.

Functional knee braces have been shown to reduce anteroposterior laxity. However, these braces do not protect the knee from anterior tibial translation during transitions between weight-bearing and non-weight-bearing or during jumping and they also have been shown to cause hamstring fatigue, increasing the latency of the hamstring reflex. One prospective cohort analysis demonstrated that the braces were beneficial as the rate of subsequent knee injury (MCL [medial collateral ligament], meniscal, or osteochondral knee injury) over 6 ski seasons was 2% (2 of 101) among professional skiers with a torn ACL who chose to use a functional brace as compared with 13% (10 of 79) among those who did not use a brace. In an RCT in which patients were randomized to nonoperative treatment of an acute ACL injury...
with or without a brace, the bracing group reported less instability than the nonbracing group, but there were no benefits in objective measures such as the KOOS (Knee injury and Osteoarthritis Outcome Score), Cincinnati knee score, or peak quadriceps and hamstring torque. The combination of a subjective sense of stability and ineffectiveness during athletic activities means that the biggest effect that these braces offer may be a false sense of security. Therefore, their usefulness may be limited in this setting.

Summary

Some patients can cope with a torn ACL and return to preinjury activity levels, including participation in pivoting sports. Increased activity levels increase the risk of additional knee injury; however, patients with isolated ACL injuries may elect an optional-delayed-reconstruction strategy and utilize perturbation exercises to develop dynamic coping mechanisms for up to 6 months while determining whether or not to undergo reconstruction. The existence of concomitant meniscal injury and symptomatic instability are indications

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Fig. 1
Algorithm for recommended approach to nonoperative treatment of ACL tears.
for reconstruction in order to reduce the risk of additional knee injury. A treatment algorithm describing how this evidence can be applied to patients electing a trial of nonoperative rehabilitation is presented in Figure 1.

**Appendix**

The key conclusions of the studies described in the current article are shown in Tables E-1 through E-5.

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**References**


