A 10-Year Prospective Trial of a Patient Management Algorithm and Screening Examination for Highly Active Individuals With Anterior Cruciate Ligament Injury: Part 1, Outcomes

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A 10-Year Prospective Trial of a Patient Management Algorithm and Screening Examination for Highly Active Individuals With Anterior Cruciate Ligament Injury

Part 1, Outcomes

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Background: A treatment algorithm and screening examination have been developed to guide patient management and prospectively determine potential for highly active individuals to succeed with nonoperative care after anterior cruciate ligament rupture.

Objective: To prospectively characterize and classify the entire population of highly active individuals over a 10-year period and provide final outcomes for individuals who elected nonoperative care.

Methods: Inclusion criteria included presentation within 7 months of the index injury and an International Knee Documentation Committee level I or II activity level before injury. Concomitant injury, unresolved impairments, and a screening examination were used as criteria to guide management and classify individuals as noncopers (poor potential) or potential copers (good potential) for nonoperative care.

Results: A total of 832 highly active patients with subacute anterior cruciate ligament tears were seen over the 10-year period; 315 had concomitant injuries, 87 had unresolved impairments, and 85 did not participate in the classification algorithm. The remaining 345 patients (216 men, 129 women) participated in the screening examination a mean of 6 weeks after the index injury. There were 199 subjects classified as noncopers and 146 as potential copers. Sixty-three of 88 potential copers successfully returned to preinjury activities without surgery, with 25 of these patients not undergoing anterior cruciate ligament reconstruction at the time of follow-up.

Conclusion: The classification algorithm is an effective tool for prospectively identifying individuals early after anterior cruciate ligament injury who want to pursue nonoperative care or must delay surgical intervention and have good potential to do so.

Keywords: knee; rehabilitation; decision making

The majority of orthopaedic surgeons in the United States advocate early surgical intervention when managing patients with ACL rupture who wish to resume high-level sports activities.[29] This practice pattern is influenced by ready access to surgical facilities, widespread private health insurance coverage of ACL reconstruction (ACLR) procedures, high return-to-sport rates after surgery, and the assumption that knee instability is an inevitable consequence of resumption of jumping, cutting, and pivoting sports after ACL injury.[25] Studies have reported poor patient outcomes after nonoperative management of ACL injury, further reinforcing a bias toward surgical management of this injury.[4,6,16,21,26] In addition, there are no randomized clinical trials that have used current surgical and rehabilitation techniques to compare operative versus nonoperative patient outcomes after ACL rupture without surgery to support one treatment approach over the other.[27] In the face of limited evidence to support nonoperative

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patient management, it is reasonable to question why surgical intervention would not be recommended for the highly active individual with ACL insufficiency.

There is evidence of a differential patient response to ACL injury. Some people are able to regularly participate in high-level activities after injury without complaints of instability.[13,14,20,30,37] We have operationally defined those patients who are able to resume all preinjury activities, including sports, without experiencing further episodes of knee giving way for at least 1 year after ACL injury as copers.[37] In contrast, noncopers are patients who experience knee instability on resumption of preinjury activities,[14,30] and adapters are patients who avoid episodes of knee instability by mitigating their activity levels.[14] Although the reported percentage of copers among the entire population of patients with ACL injury is small,[37] it is clear not all active patients need undergo ACLR to resume premorbid function. Furthermore, there are patients who want to resume demanding activities for a short period of time before undergoing ACLR (eg, the athlete wishing to complete a competitive sports season and people outside of the United States who are placed on a waiting list before they may undergo surgery). Implementation of a clinical decision-making algorithm may be an effective means of advising patients on appropriate activity resumption after ACL rupture without increasing the risk for further injury.

A significant obstacle in the management of patients with ACL injury is development of an algorithm that effectively discriminates soon after injury between those who may and may not succeed with nonoperative care. A screening examination has been developed at the University of Delaware to prospectively identify highly active patients early after ACL injury with good potential for a limited-term return to their preinjury activities with nonoperative management (potential copers).[17] Preliminary work performed by Eastlack et al[14] indicated a combination of self-assessment questionnaires and clinical measures of physical performance was effective in discriminating between known copers and noncopers. Fitzgerald et al[17] subsequently refined the variables that best correlated with prospective classification of patients as either rehabilitation (potential coper) or surgical (noncoper) candidates. A patient was classified as a potential coper versus a noncoper based on the number of giving-way episodes since the index injury in addition to global rating, Knee Outcome Survey–Activities of Daily Living Scale (KOS-ADLS), and single-legged timed hop scores.[17]

Fitzgerald et al[17] tested the effectiveness of the University of Delaware screening examination over a 2-year period (May 1, 1996, to April 30, 1998). Patients were considered eligible for study participation if they were seen within 6 months of the index injury, had an isolated lesion, and were regular participants in International Knee Documentation Committee level I or II activities (≥50 h/y in jumping, cutting, and pivoting sports) (Table 1)[13,22] before the index injury. A total of 93 patients completed the screening examination, including 39 who were classified as potential copers. Twenty-two of 28 subjects (79%) who chose nonoperative management for 6 months or less returned to preinjury activity levels without further episodes of instability, additional injury, or a reduction in functional status.

TABLE 1
Activity Level Classification[13,22]

Level	Sports Activity	Occupation Activity
I	Jumping, cutting, pivoting (basketball, soccer, football)	Activity comparable to level I sports
II	Lateral movements; less jumping, pivoting than in level I (baseball, racket sports)	Heavy manual labor; working on uneven surface
III	Straight-ahead activities; no jumping or pivoting (running, weight lifting)	Light manual work
IV	Sedentary	Activities of daily living

In comparison, other studies have reported return-to-sport success rates ranging from 23% to 39% when patients self-select nonoperative management.[3,15,35] The results reported by Fitzgerald et al[17] suggest the University of Delaware decision-making scheme and screening examination are a better mechanism for selecting patients for return to high-level activity with nonoperative management than is simply attempting this treatment approach on a self-selected basis. The study by Fitzgerald et al,[17] however, was limited to a relatively small sample size and may not be representative of the entire population of highly active patients with ACL injury. The terminal outcomes for potential copers in the study of Fitzgerald et al[17] who elected to pursue nonoperative care have not been reported.

Few reports are available about the characteristics of those with ACL injury that influence surgical decision making. For example, only 1 large demographic study has systematically documented the incidence of concomitant injury.[13] Other reports suggest that most patients with ACL rupture who elect nonoperative management will experience giving way, but these reports are retrospective.[3,6,9,15] A prospective study of subjects with ACL rupture subclassified based on function is needed to determine the characteristics of those who may or may not succeed with delayed surgical reconstruction. Over a 10-year period, we have used the University of Delaware treatment algorithm and screening examination to guide the management of highly active patients with ACL insufficiency. In the first article of this 2-part series, our goal was to (1) characterize and classify the entire population of patients with acute ACL injury from the practice of a single orthopaedic surgeon and (2) describe the outcomes of potential copers who elected to pursue nonoperative management. In part 2 of this series, we will address the determinants of dynamic knee stability that contribute to successful nonoperative return to activities after ACL rupture.

MATERIALS AND METHODS

Subjects

A total of 832 consecutive patients with acute ACL insufficiency seen by a single fellowship-trained orthopaedic

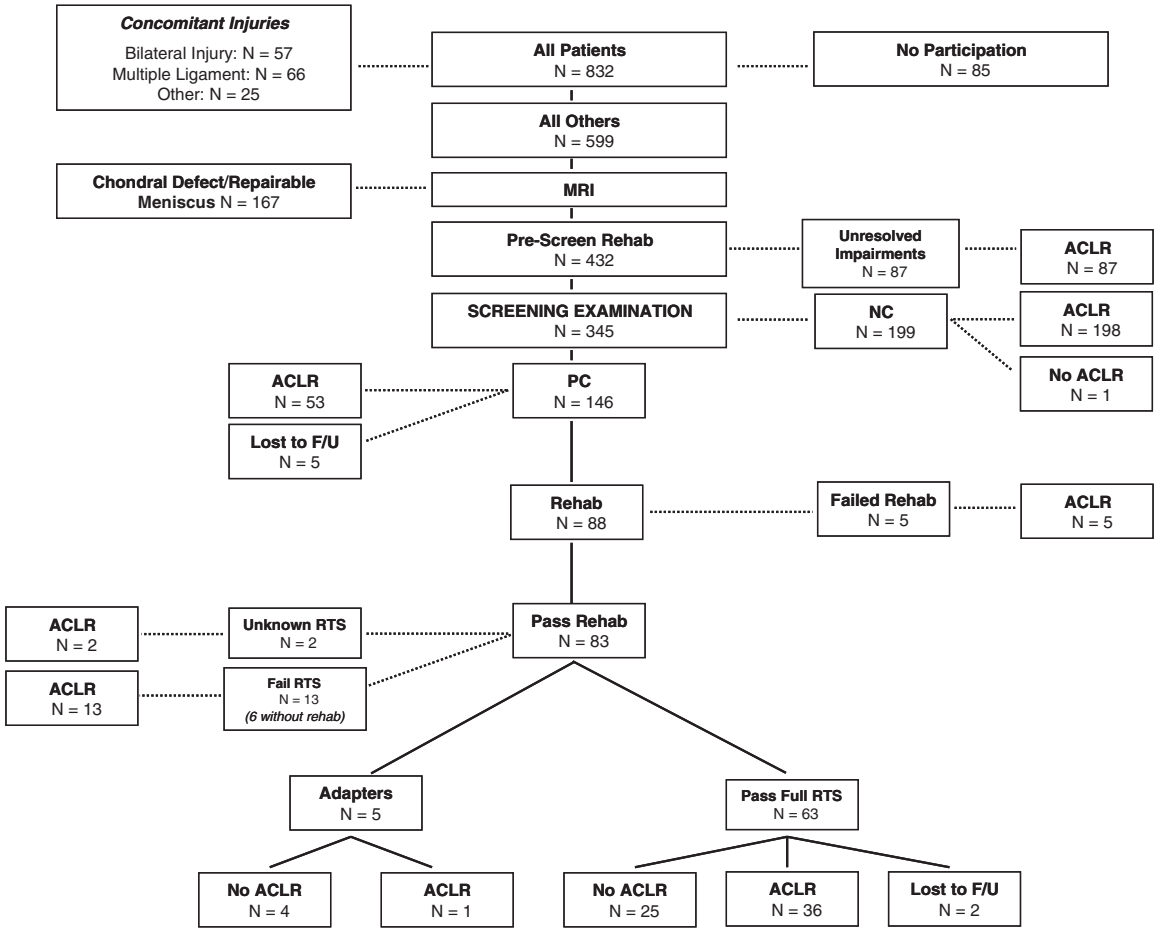

Figure 1. Treatment and screening examination algorithm outcomes. ACLR, ACL reconstruction; F/U, follow-up; NC, noncoper; PC, potential coper; Rehab, rehabilitation; RTS, return to sports.

surgeon (M.J.A.) between May 1, 1996, and April 30, 2006, were initially eligible for study participation. Inclusion criteria were clinical evaluation within 7 months of injury and regular participation in International Knee Documentation Committee level I or II activities (Table 1)[13,22] before the index injury. Presence of ACL insufficiency was determined during clinical examination by the presence of a grade III Lachman test and a side-to-side difference of at least 3 mm[13] during KT-1000 arthrometer testing using a manual maximum anterior pull and later confirmed with MRI.

All eligible subjects were asked to participate in the study at the time of initial visit to the orthopaedic surgeon. There were 85 patients (10%) who did not participate in the classification algorithm because of immediate surgery, distance, missed appointments, or declining to participate in the study. The remaining 747 patients (90%) were entered into the decision-making algorithm. All subjects provided written informed consent approved by the University of Delaware Human Subjects Review Board.

Classification Algorithm

Physical Examination and Imaging Classification Criteria. The first step in the classification algorithm included identification of concomitant injuries during physical examination and/or MRI testing. Physical examination performed by the orthopaedic surgeon identified patients with concomitant ligamentous laxity (grade II-III), bilateral knee involvement, and the presence of any severe lower extremity or low back injury (eg, nerve injury, fracture, disk herniation, etc), and plain radiographs were used to identify the presence of fracture (Figure 1). All patients underwent MRI testing to assess the presence of repairable meniscus tears or full-thickness articular cartilage lesions in the ACL-deficient knee. Patients with any of these findings were excluded from participating in the screening examination. Our rationale for excluding patients from further study participation in the presence of these concomitant injuries was based on evidence that in these patients, there would be a high probability of risking further damage to the knee if nonoperative care were pursued,[3,13] the screening examination could not be safely completed, or a healthy contralateral knee was not available for comparison (Figure 1).

Prescreening Rehabilitation Criteria. Subjects without the described concomitant injuries who had full knee range of motion, had no/minimal knee effusion, had ≥70% isometric quadriceps strength on bilateral comparison using the burst superimposition technique,[36] and could hop on their injured leg without pain underwent screening immediately. Patients participated in physical therapy (Table 2) in

TABLE 2
Impairment Treatment Protocol

Impairment	Intervention
Effusion	Ice; compression; elevation; isometric muscle pumping; retrograde massage
Joint mobility	Supine wall slides (patient places feet on wall and slides foot down the wall to increase knee flexion); flexion and extension active range of motion; patellar mobilizations; stationary cycling (low resistance); low-load prolonged stretching; emphasis of normal knee flexion and extension excursions during gait
Muscle performance	Isometric quadriceps and hamstrings contractions; straight-leg raising; electrical stimulation quadriceps strength training protocol (if indicated by presence of diminished quadriceps contraction, knee extensor lag on straight-leg raising, or an inability to perform a straight-leg raise); resisted leg extensions (90-45°) and leg curls with elastic bands
Weightbearing	Partial squats (0-45°); heel raises; lateral step-ups; trampoline jogging and hopping; encourage walking program and stair climbing
Pain	Electrical and thermal modalities; McConnell taping for patellofemoral pain; physician referral for medication or injection assistance

preparation for the screening examination if they did not meet rehabilitation criteria. Subjects who continued to have impairments after 1 month of rehabilitation were considered to have unresolved impairments and were referred to the orthopaedic surgeon for surgery (Figure 1).

Screening Examination. The screening examination consisted of unilateral hop testing, evaluation of self-assessed knee function, and recording the number of giving-way episodes since the index injury (Table 3).[17] Unilateral hop testing was conducted using the protocol described by Noyes et al[31] and consisted, in order, of (1) single hop for distance, (2) crossover hop for distance in which the subject crosses over a 15-cm-wide tape with each consecutive hop, (3) straight triple hop for distance, and (4) a timed hop in which the subject hops over a 6-m distance as quickly as possible. Measurement reliability of unilateral hop test performance has been reported to be good, with intraclass correlation coefficients ranging from 0.92 to 0.96 for the unilateral,[5,8] crossover,[5,8] and triple hop for distance[6,8] and the 6-m timed hop.[5] The testing protocol included 2 practice trials on each limb immediately before the 2 test trials. The test trials on each limb were averaged, and a hop index was calculated for each test ([injured side score/uninjured side score] × 100) except for the timed hop test ([uninjured side score/injured side score] × 100). To maximize patient safety, all subjects wore a functional derotation knee brace on the injured limb during hop testing. All patients wore shoes during testing, and arm positioning was not constrained.

Immediately after completing the hop testing protocol, self-assessed knee function was evaluated with the KOS-ADLS[24] and a global rating of knee function (Table 3). The KOS-ADLS consists of 14 items with 6 possible answers (each answer weighted from 0-5 points) ranging from not limited or symptomatic to unable to perform the task, and it evaluates symptoms and functional abilities during a variety of daily activities. A score of 100% equates to no symptoms or limitations during activities of daily living. The KOS-ADLS has been established as a valid and reliable tool for evaluating changes in knee function over time.[24] The global rating of knee function is a single number between 0% and 100% that requires subjects to rate their current functional status, including sports activities, compared to their preinjury status. A score of 100% represents a full return to preinjury activity levels.

Data Management. A database was created containing demographic information, clinical test results, and screening examination results. Demographic information, time from injury to the screening examination, and results from clinical testing were also recorded.

Screening Classification Criteria and Counseling. Classification criteria as a potential coper or noncoper were developed in a previous investigation.[17] Based on performance criteria from 2 groups of patients who were preliminarily classified as either rehabilitation (potential copers) or surgical (noncopers) candidates, a multiple regression analysis determined the timed hop, KOS-ADLS, global rating, and number of giving-way episodes accounted for 72% of the classification variance.[17] Cutoff levels to distinguish between the 2 groups were based on values 2 SDs below the group mean for those preliminarily categorized as rehabilitation candidates.[17] This value was selected because it was believed patients scoring below this level would be at high risk of sustaining further knee damage if returned to preinjury activities with nonoperative management.

On the basis of the results of the screening examination, patients were classified as potential copers using the following criteria: (1) ≤1 episode of giving way since the index injury, (2) ≥80% on the 6-m timed hop test, (3) ≥80% on the KOS-ADLS, and (4) ≥60% on the global rating scale (Table 3).[17] Failure to meet any of the criteria resulted in classification as a noncoper. Patients classified as noncopers were referred back to the orthopaedic surgeon as surgical candidates, and potential copers were counseled that as rehabilitation candidates, they had the option to pursue nonoperative versus surgical management.

Postscreening Rehabilitation and Return to Sports

Subjects who were classified as potential copers and elected to pursue a nonoperative return to preinjury activities were encouraged to participate in a structured rehabilitation

TABLE 3
Screening Examination and Classification Algorithm[17]

Screening Examination	Classification Criteria[a]
Unilateral hop tests	
Single hop for distance	[b]
Triple crossover hop	[b]
Straight triple hop	[b]
Timed 6-m hop	≥80%
Self-assessment questionnaires	
KOS-ADLS[c]	≥80%
Global rating	≥60%
Number of giving-way episodes	≤1

[a]Criteria for classification as a potential coper listed. Failure to meet any of the criteria results in classification as a noncoper.
[b]Results not used as component of classification algorithm.
[c]KOS-ADLS, Knee Outcome Survey–Activities of Daily Living Scale.

program. Fourteen of the first 28 potential copers participated in a traditional rehabilitation protocol that included muscle strengthening, cardiovascular, agility, and sport-specific exercises (agility and sport-specific exercises were performed while wearing a functional derotation brace). These subjects were part of a randomized clinical trial[18] evaluating the effectiveness of 2 different rehabilitation programs (traditional vs perturbation-enhanced rehabilitation) on the return-to-sport success rate of potential copers. Subsequently, the standard rehabilitation protocol for potential copers included perturbation training, a specialized form of neuromuscular training.[19] The perturbation-enhanced rehabilitation protocol outlined by Fitzgerald et al[19] includes 10 physical therapy sessions over a 2- to 5-week period. After completing the rehabilitation protocol, all potential copers were required to pass the return-to-sport criteria of the attending orthopaedic surgeon, including scoring ≥90% on all 4 unilateral hop tests and the KOS-ADLS and global rating of knee function questionnaires. Failure of rehabilitation or return to sports activities was defined as having a giving-way episode of the knee.

Data Management and Analysis

A χ^2 test of independence was used to evaluate the distribution of categorical variables ($\alpha = .05$), and descriptive statistics were used to describe the study sample population and outcomes. Medical and physical therapy charts were reviewed to obtain outcome data. An attempt was made to directly contact (telephone) all patients who did not have a documented ACLR early after the index injury. During the follow-up, patients were asked if they had attempted a return to preinjury sports, if they were able to do so at the same level, and if they had experienced any giving way or knee injury during the trial of nonoperative care. Subjects who had not undergone ACLR at follow-up were asked to complete the KOS-ADLS and global rating of knee function questionnaires during a telephone interview conducted by a single investigator (W.J.H.).

RESULTS

Physical Examination and Imaging Tests

Among the 747 patients who were initially eligible and agreed to participate in the study (832 originally eligible; 85 declining participation), 315 (42%) were excluded from further participation secondary to the presence of concomitant injuries associated with their ACL rupture (Figure 1). Physical examination and imaging test results identified 57 subjects with bilateral lower extremity injuries, 66 with concomitant ligamentous laxity, 167 with full-thickness articular cartilage lesions and/or potentially repairable meniscus tears, and 25 with other injuries that precluded participation in the screening examination (Figure 1).

Prescreening Rehabilitation

Of the 432 subjects who received prescreening treatment to address impairments, there were 87 (20%) who had persistent effusion, quadriceps weakness, limited knee motion, or pain that was not resolved after 1 month of physical therapy (Figure 1).

Screening Examination

The remaining 345 subjects who met all inclusion criteria completed the screening examination a mean of 6 weeks (SD, 5 weeks; range, 1-28 weeks) after injury. The mean age for the group was 27 years (range, 13-57 years). The distribution within the sample included significantly more males (n = 216, 62.6%) than females (n = 129, 37.4%; $\chi^2 = 22.96$, expected n = 172.5, $P < .001$). There was also a significant difference in the distribution of potential copers and noncopers within the sample, with more subjects categorized as noncopers (n = 199, 58%; female, n = 82; male, n = 117) than potential copers (n = 146, 42%; female, n = 47; male, n = 99; $\chi^2 = 8.142$, expected n = 172.5, $P = .004$).

Rehabilitation and Return-to-Play Outcomes

After being identified as rehabilitation candidates, 88 of 146 potential copers (60%) elected to pursue a return to high-level sports activities without surgical intervention. Seventy-two percent (63/88) of the potential copers who pursued nonoperative care successfully returned to high-level sports activities, and none sustained additional chondral or meniscal injuries. Five patients experienced a giving-way episode during the agility portion of rehabilitation and were referred for surgery (failed rehabilitation). Eighty-three subjects completed rehabilitation and passed all return-to-sport criteria. Return-to-play outcomes for 2 potential copers were not available, and 13 subsequently experienced a single giving-way episode on return to sports activities (failed return to sports). Six subjects who were unsuccessful with a return to sports had not participated in perturbation-enhanced rehabilitation. Five potential copers who successfully completed rehabilitation elected not to attempt a full return to preinjury activities that included jumping, cutting, or pivoting maneuvers; these subjects were subsequently categorized as adapters.

Terminal outcomes (ACLR vs no ACLR) were obtained for 86 of 88 potential copers who pursued nonoperative management. All subjects who failed rehabilitation and return to sports underwent ACLR, as did the 2 subjects whose return-to-sports outcome was unknown. Four adapters had not undergone ACLR at follow-up, whereas 1 elected to undergo reconstructive surgery 3 years after completing the screening examination because he was no longer satisfied with limited participation in low-level sports activities. Of the 63 potential copers who successfully returned to sports, 25 had not undergone ACLR, 36 had their ACLs surgically reconstructed, and 2 were lost to follow-up. Arthroscopy confirmed that none of the potential copers who elected nonoperative management and later underwent ACLR had extended their original injuries.

Of the 29 subjects classified as potential copers (25 who had a full return to sports plus 4 adapters who reduced their activity levels) who had not undergone ACLR at follow-up, 23 were available for telephone interview (adapters, n = 4; full return to sports, n = 19). One subject who had successfully returned to sports had sustained a new knee injury, had recently undergone meniscus debridement, and did not complete the knee function questionnaires. The adapters' mean KOS-ADLS score was 98% (range, 97%-100%), and their mean global rating of knee function was 81% (range, 70%-90%). The potential copers who had successfully returned to high-level sports activities reported a mean KOS-ADLS score of 97% (range, 87%-100%), and their mean global rating of knee function was 92% (range, 50%-100%).

DISCUSSION

By systematically and prospectively evaluating patients from the practice of a single orthopaedic surgeon over a 10-year period, we were able to characterize an entire population of highly active patients with ACL injury. Fifty-eight percent of patients were classified as noncopers and were not candidates for nonoperative management. These results confirm the belief that on average, the active person with ACL injury requires surgical stabilization to permit a return to high-level activities and minimize the risk of continued knee instability.

Forty-two percent of the study sample were excluded from participating in the screening examination secondary to the presence of concomitant injuries. The most common accessory injury was a repairable meniscus tear, followed by multiple ligament involvement, bilateral lower extremity involvement, and full-thickness chondral defect. Presence of a repairable meniscus tear or full-thickness articular cartilage lesions prohibited participation in the classification algorithm because an injury extension or irreparable damage may have resulted from further giving-way episodes. The presence of concomitant ligamentous laxity has been associated with a greater risk of knee instability and probability of further knee damage compared with isolated ACL injuries.[3,13] Therefore, patients with a concomitant grade II or greater injury to a knee ligament other than the ACL were not considered rehabilitation candidates. Results from the physical examination and imaging components of the treatment algorithm emphasize 2 points. First, ACL ruptures frequently occur in conjunction with other knee or lower extremity injuries. Second, the treatment algorithm is by nature conservative in identification of candidates for nonoperative rehabilitation: any factor contributing to an increased risk for continued knee instability or extending the original injury must be considered as rationale for surgical referral over nonoperative management.

Approximately 10% of subjects eligible for participation in the screening examination did not resolve their impairments in a timely manner despite participating in supervised rehabilitation designed specifically to address range of motion, effusion, muscle weakness, and pain. An extended inflammatory response and inability to regain muscle strength after ACL injury may have been a consequence of knee instability, suggesting these subjects were not good candidates for nonoperative care. Conversely, 1 month of rehabilitation may not have been adequate time to resolve all impairments. Our rationale for a limited rehabilitation trial to meet screening criteria was that most people in the United States who pursue nonoperative care are attempting a rapid return to activities that surgery and postoperative rehabilitation cannot provide. A more extended period of rehabilitation to resolve impairments may result in a missed opportunity to return to the desired activity. Consequently, nonoperative care is no longer considered advantageous. In countries where early surgical intervention is not the standard of care, a more extended period of rehabilitation to prepare for the screening examination may provide insight into the causes of persistent impairments after ACL rupture.

There were statistically more noncopers than potential copers among the sample who completed the screening examination ($P = .004$). The percentage of subjects classified as potential copers, though, was quite large (42%), indicating a trial of nonoperative management is a viable option for many highly active patients with ACL insufficiency. Seventy-two percent of the potential copers who elected nonoperative management were able to successfully return to preinjury sports activities without further episodes of instability or a reduction in functional status. The success rate of this group of patients identified by the University of Delaware algorithm is far greater than those described in previous studies in which a nonoperative return to high-level activities based on patient self-selected basis has ranged from 23% to 39%.[3,15,35] The disparity in outcomes suggests use of our decision-making scheme effectively discriminates between operative and nonoperative candidates, improving the probability of a safe, successful return to preinjury activity levels.

Only 7 subjects who completed a structured rehabilitation program, which included perturbation training, were unsuccessful with their attempts to return to sports. We have previously demonstrated rehabilitation that included neuromuscular exercises described as perturbation training (a specialized form of balance training that requires patients to maintain their balance on an unstable support surface while a rehabilitation specialist manipulates the support surface) to be more effective in returning patients to high-level activities than are standard rehabilitation techniques.[18] Motion analysis studies have indicated there is no single stabilization strategy

implemented by potential copers to avoid giving way after ACL injury.[11] Rather, there are a variety of combinations of muscle activity that result in dynamic knee stability. Perturbation training gradually exposes patients to destabilizing forces, providing the opportunity to safely explore individualized stabilization strategies. Traditional rehabilitation protocols that include resistance training, cardiovascular exercise, and agility drills do not promote the development of stabilization strategies to improve dynamic knee stability. Thus, we strongly encourage all patients identified as potential copers who elect nonoperative management do so only after participating in perturbation-enhanced rehabilitation.

The majority of potential copers ultimately elected to undergo ACLR after successfully returning to preinjury activities. Our intention with development of the screening examination was to identify subjects who might be successful with short-term (ie, 6 months or less) nonoperative management. Consequently, our recommendation was that patients return to their physicians for surgical management at a more convenient time once they had been cleared for a return to activities. There were, however, a number of subjects who chose not to undergo surgery. A limited number of these subjects had a decline in function. Two subjects rated their daily and global function less than 90%, one with a history involving meniscus debridement procedures and the other with poor function attributed to the contralateral knee. In addition, 2 adapters reported their global knee function to be less than 90% because they did not attempt a return to sports, and therefore their knee function was lower than before injury. The remaining subjects who had not undergone ACLR at follow-up rated both their daily and global knee function greater than 90%. Although these results are for a limited number of subjects, it appears there is potential for the screening examination to identify candidates who may have long-term success with nonoperative care. Larger outcome studies are necessary to confirm the consequences of long-term nonoperative management in patients prospectively identified as potential copers.

Using strict criteria from clinical tests that include functional performance, we recommend short-term nonoperative care to select patients. One reason patients who wish to resume high-level activities are counseled against nonoperative care is the increased risk for sustaining a meniscus tear or articular cartilage lesion during a giving-way episode and ultimately developing premature knee osteoarthritis (OA). Yet the incidence of knee OA after ACL rupture occurs at a similar rate whether the injury is managed surgically or nonoperatively.[28,38] Because potential copers are counseled against nonoperative care if they experience even a single additional giving-way episode, we do not believe these patients are at greater risk for experiencing premature degenerative knee damage. Follow-up radiographic studies are necessary, however, to confirm this hypothesis. The risk for developing early knee OA after ACL injury whether the lesion is managed operatively or nonoperatively necessitates patient counseling regarding potential risks and benefits with either treatment approach.

Biomechanical studies provide evidence for the different functional abilities of noncopers and potential copers. Noncopers exhibit profoundly altered movement patterns after ACL injury characterized by a stiffening strategy (ie, lower sagittal plane knee motion and knee moments and higher muscle cocontraction in comparison with their contralateral limbs and uninjured subjects) to maintain knee stability in the absence of ligamentous support.[32-34] Conversely, potential copers have movement patterns that are intermediate to uninjured subjects and noncopers.[11] Because inclusion of both groups in the same sample may obscure genuine differences, investigators evaluating movement patterns after ACL injury have used the classification algorithm to identify a homogeneous subject population.[1,2,7,10,12,23] The classification algorithm has not, however, had an effect on clinical practice patterns in the United States. Early surgical reconstruction continues as the standard of care for the highly active patient who exhibits an increase in anterior tibia translation after ACL injury.[29] In the face of growing evidence that early-onset knee OA is a risk after ACL rupture whether the injury is managed operatively or nonoperatively,[28,38] we must ask if surgical intervention in an asymptomatic person has become more habitual rather than evidence based.

There are inherent limitations to the investigation. There was selection bias. Only patients classified as potential copers were presented with the option of pursuing either surgery or nonoperative care. Readily available resources, the risk of further knee injury, and surgery over nonoperative management as the standard of care in the United States[29] dictated, in part, the study design. It also limited the period of nonoperative care we could recommend for potential copers because long-term (ie, longer than 6 months) consequences of participating in sports activities for this population are unknown. Given these inherent limitations, the current study offers the best available evidence to support the treatment algorithm and screening examination as an effective tool for predicting short-term success in highly active persons identified as rehabilitation candidates who pursue nonoperative management. The ideal study that determines the validity of the screening examination in predicting successful return to sports based on patient classification as either a potential coper or noncoper, and how long potential copers may be successful without surgical intervention, must be performed in countries where nonoperative management is the standard of care early after ACL rupture.

SUMMARY

We performed a large-scale, systematic evaluation of active patients with ACL injury, confirming the opinion of many sports medicine professionals: surgical reconstruction is necessary to permit a return to high-level activities. Our results indicate, however, that a large number of patients identified as rehabilitation candidates using the treatment algorithm and screening examination who elect nonoperative care are able to delay surgery without experiencing further knee instability or extending the original knee injury. Given the differential response to ACL injury, implementation of a clinical decision-making algorithm that provides individualized care should be considered as an alternative to a patient management strategy based on anterior knee laxity, age, and preinjury activity levels.

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