

A Decision-Making Scheme For Returning Patients To High Level Activity With Non-operative Treatment After Anterior Cruciate Ligament Rupture.

G. Kelley Fitzgerald, PhD, PT. Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh, 6035 Forbes Tower, Pittsburgh, PA 15260, United States

Michael J. Axe, MD. First State Orthopaedics. Medical Arts Pavilion, Suite 225, Newark, DE. 19713, United States

Lynn Snyder-Mackler, ScD, P.T. Department of Physical Therapy, University of Delaware, 309 McKinly Laboratory, Newark, DE. United States

The research was performed at the Department of Physical Therapy, University of Delaware, 303 McKinly Laboratory, Newark, DE. United States

Acknowledgements: The work was supported in part by the National Athletic Trainers Association (United States) and the Foundation for Physical Therapy Research (United States). The authors would like to acknowledge Leslie Lear, MPT and Laura Schmitt, BS for their assistance with data collection during the project.

Please address all correspondence to Dr. G. Kelley Fitzgerald, PhD, PT, OCS,
Department of Physical Therapy, School of Health and Rehabilitation Sciences,
University of Pittsburgh, 6035 Forbes Tower, Pittsburgh, PA 15260, United States
Phone: 412-647-1232
Fax: 412-647-1222
e-mail:kfitzger+@pitt.edu

Abstract

The purposes of this report were to: 1) describe the development and current use of decision-making criteria for returning patients to high level physical activity with non-operative management of anterior cruciate ligament ruptures, and 2) present the results of treatment for patients who met our criteria as candidates for non-operative rehabilitation and attempted to return to high level physical activity with non-operative management. The screening examination consists of four one legged hop tests, the incidence of knee giving way, a self report functional survey, and a self report global knee function rating. Ninety three consecutive patients with acute unilateral anterior cruciate ligament rupture were screened. Patients were classified as either candidates or non-candidates for non-operative management. Forty two percent (39/93) of the patients were categorized as candidates and fifty eight percent (54/93) were non-candidates. Twenty eight of thirty nine rehabilitation candidates elected non-operative management and returned to pre-injury activity levels. Twenty two of twenty eight (79%) subjects returned to pre-injury activity levels without further episodes of instability or a reduction in functional status. No subject sustained additional articular or meniscal damage as a result of rehabilitation or return to activity. The decision-making scheme described in this study shows promise in determining who can safely postpone surgical reconstruction and temporarily return to physically demanding activities. Continued study to refine and further validate the decision-making scheme is recommended.

Key words: Anterior cruciate ligament, screening examination, rehabilitation, Knee injuries

Anterior cruciate ligament rupture predictably leads to knee instability and loss of function in the majority of those who regularly participate in strenuous physical activity. The evidence suggests that non-operative management of anterior cruciate ligament ruptures has yielded limited success in returning individuals to physically active lifestyles. (1,4-6,9,16) Many patients experience continued episodes of instability and reduce their activity levels as a result of their knee condition, even after undergoing rehabilitation. (1,4-6,9,16) Decision making appears to be straight forward: physically active individuals who wish to return to the same activity level should have reconstructive surgery.

Specific circumstances, however, make decisions regarding the timing of surgery difficult. This is especially true in the case of pre-season or early season anterior cruciate ligament injury. The athlete who has exhausted eligibility, who needs to compete in order to demonstrate worthiness for athletic scholarships or an all-star team, or an individual facing a major competition or event (e.g. regional tennis club championships) may wish to try to "play through the season." Construction workers or seasonal laborers who must subject the knees to climbing, lifting, and working on uneven surfaces and would like to postpone surgery until the busy season is over also fall into this category. Traditionally, many of these patients have self elected non-operative management and their rate of success with this approach has been unacceptable. (1,9,16) The need has been recognized in the literature for establishing

useful evaluation criteria to identify patients who could rehabilitate and continue to work, or compete, at least temporarily, with minimal risk of re-injuring the knee. (1,9) Establishment of these criterion measures would be helpful to patients and their physicians in determining the risk/benefit relationship of non-operative management.

Passive anterior knee joint laxity (excessive anterior tibial translation) is not well correlated with functional outcome after anterior cruciate ligament injury, (9,11,13,16,17) and does not appear to be useful for predicting potential for successful outcome. Andersson, (1) however, reported that patients with multi-directional instability, resulting from multiple knee ligament injury, did poorly with non-operative management of their injuries. Therefore, the presence of multiple ligament rupture would seem to be an exclusion criterion for non-operative management.

Several other measurable factors may be useful in assisting to determine a patient's potential for success with non-operative management of an anterior cruciate ligament rupture. Quadriceps femoris muscle strength has been reported to be related to functional ability in anterior cruciate ligament deficient patients. (8,13) Eastlack (8) found the composite of a global rating of knee function, the single leg cross-over hop test, and the Knee Outcome Survey-Sports Activity Scale correlated with the level of functional recovery in patients with anterior cruciate ligament rupture. If these types of measurements could be taken relatively early after the incident of injury, it may be possible to use these measurements to establish criteria for identifying patients who

have a reasonable chance to succeed in returning to high level physical activity following non-operative ACL rehabilitation.

The number of “giving way” episodes at the knee during functional activity may also be useful in predicting success with non-operative treatment in patients with acute anterior cruciate ligament rupture. An episode of giving way is defined as buckling, or subluxation of the tibiofemoral joint that results in pain and joint effusion. Recurrent episodes of giving way have been associated with the severity of arthritic changes (15) and with an increase incidence of additional meniscal damage over time. (16) If patients report recurring episodes of giving way with activities of daily living early after anterior cruciate ligament rupture, then it seems likely that they would be at risk for extending damage to the knee if they return to high level activity without reconstructive surgery. The frequency of giving way episodes, therefore, would appear to be an important predictive factor for determining who may be able to succeed and who may be at high risk for experiencing further knee damage in returning to high level activity with non-operative management after acute anterior cruciate ligament rupture.

We have recently developed and are currently using decision-making criteria for selecting patients we believe can attempt a return to high level physical activity following non-operative rehabilitation with minimal risk of reinjury. The criteria are based on the results of an inexpensive and easily administered screening examination that includes a series of functional hop tests, a self-report knee function survey, a global rating of knee function, and the frequency of giving way episodes at the knee during activities of daily living. The purposes of this report are to: 1) describe the development and current use our decision-making criteria, and 2) present the results of treatment for

patients who met our criteria as candidates for non-operative rehabilitation and attempted to return to high level physical activity with non-operative management.

PATIENTS AND METHODS

Population/Subjects

All patients (N=181) with first time anterior cruciate ligament ruptures (N=164) or acute ruptures of anterior cruciate ligament grafts (N=17) seen by one orthopaedic surgeon (MJA) from May 1, 1996 to April 30, 1998, who were regular participants (>100 hours/year) in Level I (i.e., football, basketball, soccer) (6) and Level II (i.e. racquet sports, skiing, manual labor occupations) (6) activities, were potential subjects for this study. The first level of excluding patients from attempting non-operative management was the presence of concomitant injuries associated with the anterior cruciate ligament rupture. We believed, based on evidence in the literature, (1,6) that there would be a high probability of risking further damage to the knee if these patients participated in non-operative management of their injuries. Twenty three subjects were excluded because they had concomitant, grade II or greater, injury to one or more additional knee ligaments (medial collateral ligament, N=16; lateral collateral ligament, N=1; posterior cruciate ligament, N=3; posterior cruciate ligament plus medial collateral ligament, N=2; posterior cruciate ligament plus lateral collateral ligament, N=1). Twelve subjects were excluded because they had other trauma such as fracture or dislocation associated with the anterior cruciate ligament injury. Twelve subjects were excluded because they had bilateral anterior cruciate ligament injury and did not have a healthy contra lateral extremity for comparison (see Figure 1). All others underwent MRI to screen for repairable meniscal lesions or full thickness cartilage defects and twenty five

patients were excluded by virtue of the imaging study. The remaining one hundred nine patients were allowed to participate in the screening examination. Fifteen subjects in this group were not tested for the following reasons: 1) scheduling problems (N=3), 2) missed referrals (N=4), or 3) refusal to participate (N=8). Ninety four subjects were enrolled in the study and underwent pre-screening rehabilitation. One subject had an unresolved knee flexion contracture after pre-screening rehabilitation and was not tested. Chart review at the conclusion of the study period confirmed that all patients in the original 181 patient cohort who were not screened underwent surgical stabilization.

Thirty one females and sixty two males participated in the screening examinations. Subjects ranged in age from 15 to 57 years (mean= 28.7 ± 10.7), height from 60 to 75 inches (69.1 ± 3.5), and weight from 112 to 275 pounds (175.2 ± 33.7). All subjects participating in the screening examination had side-to-side differences in anterior tibiofemoral laxity of 3 mm or greater (mean = 6.0 ± 2.3) as measured with an arthrometer (KT-1000, Med-Metric, San Diego, CA) by a single examiner (GKF) using maximum manual force. A side-to-side anterior tibiofemoral laxity difference of 3 mm or greater is indicative of unilateral injury to the anterior cruciate ligament. (7) All subjects signed an informed consent form, approved by the institutional Human Subjects Review Board, prior to testing.

Screening Examination

The screening examination included the following tests: 1) single, triple, cross-over, and timed hop tests, (14) 2) quadriceps femoris maximum voluntary isometric strength test, (18) 3) global rating of knee function, 4) the Knee Outcome Survey Activities of Daily Living Scale, (12) and 5) report of the number of knee giving way episodes from the time of injury to the time of testing. These tests were selected as a

basis for the functional screening examination based on results from a previous study that indicated that these tests may be related to functional outcome after anterior cruciate ligament rupture. (8)

The hop tests used in this study have been described by Noyes (14) as performance based measures of knee function. Measurements from these tests have been shown to be reliable. (2,3,10) The tests are all single leg hops and include 1) a single hop for distance, 2) a triple cross-over hop for distance in which the subject must cross over a six inch wide tape with each consecutive hop, 3), a straight triple hop for distance, and 4) a timed hop in which the subject hops a distance of six meters as fast as possible. Subjects performed two practice trials followed by two measured trials of each hop test on both limbs. The hop test score for each limb was reported as the average of the two measured trials. The single hop, cross-over hop, and triple hop scores were expressed as a percentage of the injured extremity score divided by the uninjured extremity score. The timed hop score was expressed as a percentage of the uninjured extremity score divided by the injured extremity score.

A burst-superimposition maximum voluntary isometric quadriceps femoris strength test was used to compare the torque produced during a maximum voluntary isometric contraction of each subject's involved and uninvolved quadriceps femoris muscle. Torque measurements obtained from this technique have been shown to be reliable. (18) Patients were seated on an isokinetic dynamometer (Kin-Com, Chattecx Corp., Chattanooga, TN) and the dynamometer force arm was secured to the ankle. The knee was held in 90 degrees of flexion. Self adhesive electrodes were applied to the quadriceps so that an electrical stimulus could be applied during strength testing. Subjects were asked to exert as much force as possible while extending the knee

against the force arm of the dynamometer. An electrical stimulus (amplitude=130V, pulse duration=600usec, pulse interval=10msec, train duration=1sec) was applied during the contraction to ensure that the muscle was maximally activated during the test. If the voluntary effort from the subject produced a torque that was greater than 95% of the electrically stimulated torque, the test was accepted, and the highest value of torque was recorded. If the voluntary effort produced a torque that was less than 95% of the electrically stimulated torque, then the test was not accepted and additional trials were performed until a voluntary effort of 95% or greater was achieved. The strength test score was expressed as an index representing the injured limb torque divided by the non-injured limb torque.

The Knee Outcome Survey is a self report survey that is used to determine the functional level of patients with knee injuries . (12) This survey has been shown to be a responsive and reliable measure of knee function. (12) The Activities of Daily Living Scale portion of the Knee Outcome Survey assesses how the patient's knee condition affects daily activities, such as ambulation, stair climbing, kneeling, sitting and squatting. (12) A global rating of knee function was also used to assess the patient's overall knee function. Patients rated knee function on a scale of 0% to 100%, with 100% representing pre-injury function.

All patients were treated prior to testing using a rehabilitation program designed to address impairments associated with the initial injury (i.e., pain, joint effusion, limitations in joint motion, and thigh muscle weakness). When the subject met the criteria to be tested (no pain or joint effusion, full joint motion, able to hop on involved leg), the screening examination was performed. Testing was performed within an average of four weeks from the incident injury (median=4 weeks, range =1 week to 4

months). The screening tests were performed in the following order: single hop, cross hop, triple hop, timed hop, quadriceps strength test, report of giving way, Activities of Daily Living Scale, and the global knee rating. Subjects wore a functional knee brace on the involved limb for the hop tests as requested by the referring physician (Legend™, Smith and Nephew-DonJoy, Carlsbad, CA). Earlier observations in development of the screening examination suggested that performing the hop tests first had an impact on the self report functional survey scores. Patients tended to either underestimate or overestimate self report scores if the hop tests were performed after the self report surveys. We believed allowing patients to perform the hop tests first, gave them an opportunity to self evaluate the status of their knees during a physically challenging task, resulting in more accurate ratings of knee function on the self report surveys.

Grouping Variables and Criteria

Data from the first eighteen consecutive subjects participating in this study were used to establish grouping criteria. Six of these subjects were preliminarily categorized as rehabilitation candidates because they had had no incidents of knee instability with activities of daily living. The remaining 12 subjects were preliminarily categorized as non-candidates because they either experienced additional episodes of giving way or reported that their knees were unstable during activities of daily living. A multiple regression analysis, using the preliminary grouping category as the dependent variable, was performed to determine which variables from the screening examination correlated best with group assignment. Four variables accounted for 72% of the variability (Multiple $R^2 = .72$). The four variables included the global rating of knee function, the incidents of giving way, the Activities of Daily Living Scale, and the timed hop test .

Grouping cut-off point criteria were then established for each of these variables.

Cut-off point criteria were created based on values two standard deviations below the group mean for those we preliminarily categorized as rehabilitation candidates. We selected two standard deviations below this group's mean as the criterion value because we believed patients scoring below this level would most likely be at high risk of sustaining further knee damage if returned to pre-morbid activity levels with non-operative management of the injury. Subjects were classified as rehabilitation candidates if they met all four of the following criteria: 1) global rating $\geq 60\%$, 2) no more than one episode of giving way at the knee since the incident injury (not including the episode of giving way at the time of injury) to the time of the screening examination, 3) Activities of Daily Living Scale score $\geq 80\%$, 4) timed hop test $\geq 80\%$. Subjects who failed to meet any one of these criteria were classified as non-candidates.

The screening examinations were continued and a total of ninety three subjects were tested. Subjects who met the criteria for rehabilitation candidacy were given the option of non-operative treatment for the injury. Subjects who did not meet the criteria were classified as non-candidates and were referred back to the surgeon.

RESULTS

Results Of Screening Examinations

Thirty nine subjects (29 males, 10 females) were classified as rehabilitation candidates and fifty four subjects (33 males, 21 females) were classified as non-candidates. All of the subjects classified as non-candidates underwent surgical reconstruction. Twenty eight of the thirty nine rehabilitation candidates attempted to rehabilitate their knees without surgery and eleven rehabilitation candidates elected to

have surgery. Six rehabilitation candidates electing surgery were physically active adults who did not want to risk extending their knee injuries by returning to activity without reconstructive surgery, and five of these subjects were competitive athletes who were in the off season, and had time to recover from surgery before their next athletic season.

Results of Non-operative Management

Non-operative management consisted of lower extremity muscular strengthening, agility skill training (quick start and stops, cariocas, cutting and spinning drills), and sport-specific skill training. The frequency and duration of rehab sessions was two to three times per week for three to five weeks. The type of physical activities in which the twenty eight rehabilitation candidates electing non-operative management participated, is provided in Table 1. Subjects were returned to full activity an average of 4 weeks after the screening examination was performed (median=3 weeks, range = 2 to 10 weeks).

We defined successful treatment outcome as the ability to return to pre-injury levels of activity without experiencing an episode of giving way at the knee. Failure was defined as either having at least one episode of giving way at the knee or a reduction in functional status below that of a rehabilitation candidate based on our screening criteria at the time of follow-up examination. Twenty two of twenty eight (79%) subjects were able to return to pre-injury levels of activity without experiencing an episode of giving way at the knee and six subjects were considered to have failed rehabilitation (21%). Nine of the twenty two subjects successfully returning to high level activity returned to full sport activity for the remainder of their athletic seasons and then underwent reconstructive surgery. One subject returned to full sport activity, but sustained an injury

to the contra lateral anterior cruciate ligament. He decided at that time to undergo surgical reconstruction of both knees. Twelve subjects continued to perform at pre-injury levels of activity and elected not to undergo reconstructive surgery at the time of follow-up examination. Five of six subjects failing rehabilitation had experienced a giving way episode on return to high level activity. One subject did not experience a giving way episode, however, regressed in functional status below our criteria for a rehabilitation candidate at the time of follow-up examination. These six subjects subsequently underwent reconstructive surgery. A comparison of pre-operative MRI to operative reports provided evidence that none of the subjects who eventually had surgery had extended the knee injury as a result of participation in rehabilitation or returning to athletic competition.

Means and standard deviations for follow-up examination Knee Outcome Survey-Sports Activity Scale scores and global ratings of knee function between those who succeeded and those who failed rehabilitation are presented in Table 2. These scores represent the degree to which subjects returned to pre-injury levels of function. The scores demonstrate that subjects who successfully returned to high level activity reported to be performing at an average of over 90% of their pre-injury functional status.

A comparison of screening examination scores between those who successfully returned to pre-injury levels of activity and those who failed was done to determine if there were differences in any of the test variables between these groups. Means and standard deviations for screening variables for each group are provided in Table 3. A standard t test was performed to determine if there were differences in group means, $\alpha = .05$. There were no differences between groups at the time of screening for self-

report measures of function, quadriceps femoris strength, or passive anterior knee laxity. The failed group scored significantly lower on the timed hop test compared with subjects who successfully returned to pre-injury levels of function. Single hop and cross-over hop scores also appeared lower in the failed group, but these differences were not significant (single hop $p=.06$; cross-over hop $p=.08$).

DISCUSSION

Ninety three subjects with unilateral, anterior cruciate ligament rupture or rupture of anterior cruciate ligament grafts were screened in this study to determine if they were candidates for return to high level activity with non-operative rehabilitation. Only 42% (39/93) met our criteria as a candidate for non-operative rehabilitation. Only 30% (28/93) of the subjects screened in this study, actually attempted a return to high level physical activity with non-operative rehabilitation. These findings suggest that the majority of patients who sustain a unilateral anterior cruciate ligament rupture and wish to return to high level physical activity may either not be safe or may not be willing to do so, without surgical reconstruction.

Seventy nine percent (22/28) of our subjects who were classified as rehabilitation candidates and attempted return to activity after non-operative rehabilitation were able to return to pre-injury levels of activity without recurring episodes of giving way or extending the knee injury. In previous studies, subjects attempted to return to high level activity with non-operative management on a self-elected basis, without the use of evaluation criteria to select appropriate patients for non-operative management. (1,9,16) Andersson (1) reported that only thirty percent of subjects electing non-operative management were able to return to pre-injury activity levels within one year

of injury. Engström, et al, (9) reported that only twenty three percent of subjects were able to return to pre-injury activity levels with non-operative management. The best success rate previously reported for returning patients to high level physical activity was by Shelton, et al. (16) Subjects in Shelton, et al's, (16) study self elected non-operative treatment, and were excluded only if multiple ligament or repairable meniscal damage were associated with the anterior cruciate ligament injury. Thirty one out of forty three subjects in Shelton, et al's, (16) study returned to athletic competition. Only twelve of the thirty one subjects (39%) returning to athletic competition were able to do so without experiencing an episode of giving way at the knee. It appears that use of our decision-making scheme allowed for an improvement in the probability of successful return to pre-injury levels of function over simple self-selection for non-operative management.

Only subjects who met all four rehabilitation candidate criteria for non-operative treatment, based on screening examination scores, attempted non-operative management. Although failure of any one criterion measure excluded subjects from classification as a rehabilitation candidate, most non-candidates (42/54) failed by more than one of these criteria. Twelve of the fifty four non-candidates, however, failed only one criterion measure (Activities of Daily Living Scale Score, N=5; Global rating of knee function, N=1; Episodes of giving way, N=2; Timed hop test score, N=4). No one criterion measure was disproportionately represented, which appears to suggest that clustering of the four criterion measures as a test may be more effective in classifying patients for non-operative management than use of any single criterion measure. The validity of our decision-making scheme can only be fully determined by observing the outcome of patients classified as non-candidates who elect non-operative treatment. While our decision-making scheme does not guarantee success, it does have promise

as a mechanism for improving the probability of successful return, at least temporarily, to pre-injury levels of function with non-operative ACL rehabilitation.

The self report measures of function at follow-up examination for subjects who successfully returned to pre-injury levels of activity indicated that these subjects were performing at greater than 90% of pre-injury levels of function. Subjects were satisfied that they were able to perform without modifying the intensity of physical activity. We only studied situations where patients wished to temporarily delay surgical treatment to play through an athletic season or temporarily return to a physically demanding occupation until a time when having reconstructive surgery was more convenient. Our data cannot, therefore, be generalized to support long-term participation in high level activity with non-operative management. The evidence that patients with anterior cruciate deficient knees are at high risk of extending damage to their knees with long term participation in high level physical activity is strong. (6,9)

Subjects who failed rehabilitation had lower timed hop test scores at the time of the screening examination compared with those that successfully returned to high level activity. This may indicate that the timed hop test criteria in the clinical decision-making scheme is not high enough and is in need of revision. The present timed hop test cut-off criteria is 80% (uninvolved limb score/involved limb score). Subjects successfully returning to pre-injury levels of activity had a screening examination mean hop test score of 95% compared with the failed rehabilitation mean of 85%. Raising the hop test criteria in the decision-making scheme may result in higher probabilities of success. The disparity in numbers of subjects who succeeded (N=22) versus those who failed (N=6) prevents us from accurately determining an appropriate cut-off score for the hop tests from our present data. Continued observation on larger numbers of subjects is

needed to accurately revise the timed hop test criteria for our decision-making scheme.

Another issue concerning the hop test examinations is the time frame at which these tests were administered in our study. The hop tests were administered at an average of four weeks from the time of the incident injury. It may be argued that if given more time, some subjects may have performed better on the hop tests and would therefore be better able to meet the criteria of a rehabilitation candidate. In some situations, where there is ample available time to make a decision, delaying the screening examination may improve the likelihood that an individual would meet the criteria for non-operative rehabilitation. However, in many instances, the decision to determine whether or not an individual is safe to try non-operative rehabilitation to complete the remainder of the athletic season must be made in a relatively short time period. Thus, patients in our study performed the hop tests as soon as they met the criteria for testing (no pain or joint effusion, full joint motion, and the ability to hop on the involved leg). We would argue that if patients were unable to perform the hop tests to within at least 80% of the uninvolved limb in this time frame, then it would be doubtful that they could successfully rehabilitate their knee in time to complete the remainder of the athletic season.

The results of this study are limited to patients with an isolated rupture of the anterior cruciate ligament who wish to return to regular participation in Level I (i.e. football, basketball, soccer)(6) and II (i.e. racquet sports, skiing, manual labor occupations)(6) activities. Patients with multiple ligament damage or repairable meniscal tears associated with the anterior cruciate ligament rupture were not tested. Existing evidence indicates that patients with multiple structural damage associated with an ACL rupture are at high risk of further knee damage with continued participation

in high level activity. (1,6,9) It is unlikely that our criteria would improve the probability of successful return to high level activity with non-operative management for these patients. Patients who were willing to modify physical activity to avoid surgery were also not tested in our study. In studies where subjects were willing to modify physical activity levels as part of the non-operative management, some subjects continued to be dissatisfied with treatment outcome and experienced episodes of giving way, even after rehabilitation. (4,5) It would be interesting to determine if our criteria, or a modification of our criteria, could be used to improve successful treatment outcome in this patient population.

The criterion measures used in our decision-making scheme require no expensive equipment; only a stopwatch, tape measure, and questionnaire are required. The tests take less than one hour to administer. These qualities allow for easy application of the screening examination in the clinic environment. It should be emphasized that all of our rehabilitation candidates who successfully returned to full activity without surgery, did so only after an intensive rehabilitation program. The role of the screening examination in the clinical decision making process is to determine who may have a chance to succeed after undergoing rehabilitation. Patients should not be returned to high level activity solely on the basis of the screening examination. It should also be emphasized that the purpose of the screening examination is to identify potential candidates for *short term* (i.e., to finish the remainder of the season) return to high level activity. The consequences of long term participation in high level physical activity with non-operative ACL rehabilitation cannot be determined from our data.

The decision-making scheme presented in this report allowed for an improvement in the probability of successful return to high level activity with non-

operative management of ACL ruptures over what has been previously reported for subjects who self-elected non-operative management. Further study is needed to refine the decision-making criteria and to further validate its value in distinguishing between candidates and non-candidates for non-operative management. The effects of long term participation in high level activity without reconstructive surgery also needs to be more clearly defined in those patients who are classified as candidates for non-operative management. We believe that our decision-making scheme shows promise in offering a better mechanism for selecting patients for return to high level activity with non-operative management than simply attempting this treatment approach on a self-elected basis.

References

1. Andersson AC (1993): Knee laxity and function after conservative treatment of anterior cruciate ligament injuries: A prospective study. *International Journal of Sports Medicine*, 14:150-153.
2. Bolgia LA and Keskula DR (1997): Reliability of lower extremity functional performance tests. *Journal of Orthopaedic & Sports Physical Therapy*, 26:138-142.
3. Booher, L.D., Hensch, K.M., Worrell, T.W., and Stikeleather, J. (1994): Reliability of three single-leg hop tests. *Journal of Sport Rehabilitation*, 165-170.
4. Buss DD, Min R, Skyhar M, Galinat B, Warren RF, and Wickiewicz TL (1995): Nonoperative treatment of acute anterior cruciate ligament injuries in a selected group of patients. *American Journal of Sports Medicine*, 23:160-165.
5. Ciccotti MG, Lombardo SJ, Nonweiler B, and Pink M (1994): Non-operative treatment of ruptures of the anterior cruciate ligament in middle-aged patients. *Journal of Bone & Joint Surgery - American Volume*, 76-A:1315-1321.
6. Daniel DM, Stone ML, Dobson BE, Fithian DC, Rossman DJ, and Lephart SM (1994): Fate of the ACL-injured patient: A prospective outcome study. *American Journal of Sports Medicine*, 22:632-644.
7. Daniel DM, Stone ML, Sachs R, and Malcolm L (1985): Instrumented measurement of anterior laxity in patients with acute ligament disruption. *American Journal of Sports Medicine*, 13:401-407.
8. Eastlack ME, Axe MJ, and Snyder-Mackler L (1999): Laxity, instability, and functional outcome after anterior cruciate ligament injury: Copers vs non-copers. *Medicine & Science in Sports & Exercise*, 31:210-215.
9. Engstrom B, Gornitzka J, Johansson C, and Wredmark T (1993): Knee function after anterior cruciate ligament ruptures treated conservatively. *International Orthopaedics*, 17:208-213.

10. Greenberger HB and Paterno MV (1995): Relationship of knee extensor strength and hopping test performance in the assessment of lower extremity function. *Journal of Orthopaedic & Sports Physical Therapy*, 22:202-206.
11. Harilainen A, Alaranta H, Sandelin J, and Vanhanen I (1995): Good muscle performance does not compensate instability symptoms in chronic anterior cruciate ligament deficiency. *Knee Surgery, Sports Traumatology, Arthroscopy*, 3:135-137.
12. Irrgang JJ, Snyder-Mackler L, Wainner RS, Fu FH, and Harner CD (1998): Development of a patient-reported measure of function of the knee. *Journal of Bone & Joint Surgery - American Volume.*, 80-A:1132-1145.
13. Lephart SM, Perrin DH, and Fu FH (1992): Relationship between selected physical characteristics and functional capacity in the anterior cruciate ligament-insufficient athlete. *Journal of Orthopaedic & Sports Physical Therapy*, 16:174-181.
14. Noyes, F.R., Barber, S.D., and Mangine, R.E. (1991): Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *American Journal of Sports Medicine*, 19:513-518.
15. Noyes, F.R., Mooar PA, and Matthews DS (1983): The symptomatic anterior cruciate-deficient knee. Part I: The long-term functional disability in athletically active individuals. *Journal of Bone & Joint Surgery - American Volume.*, 65-A:154-162.
16. Shelton WR, Barrett GR, and Dukes A (1997): Early season anterior cruciate ligament tears. *American Journal of Sports Medicine*, 25:656-658.
17. Snyder-Mackler L, Fitzgerald GK, Bartolozzi AR, and Ciccotti MG (1997): Relationship between passive joint laxity and functional outcome after anterior cruciate ligament injury. *American Journal of Sports Medicine*, 25:191-195.
18. Snyder-Mackler, L., Binder-Macleod, S.A., and Williams, P.R. (1993): Fatigability of human quadriceps femoris muscle following anterior cruciate ligament reconstruction. *Medicine & Science in Sports & Exercise*, 25:783-789.

Table 1 Number Of Participants In Various Physical Activities From Sample Of Rehabilitation Candidates Electing Non-Operative Management. *A* Completed season, did not have surgery; *B* Completed season, had surgery in post season; *C* Unable to complete season; *D* Returned to full activity, injured contralateral knee, has surgery. ^a One subject also worked as construction worker (Level II occupation); ^b One subject was also a candidate for local police academy (Level II occupation).

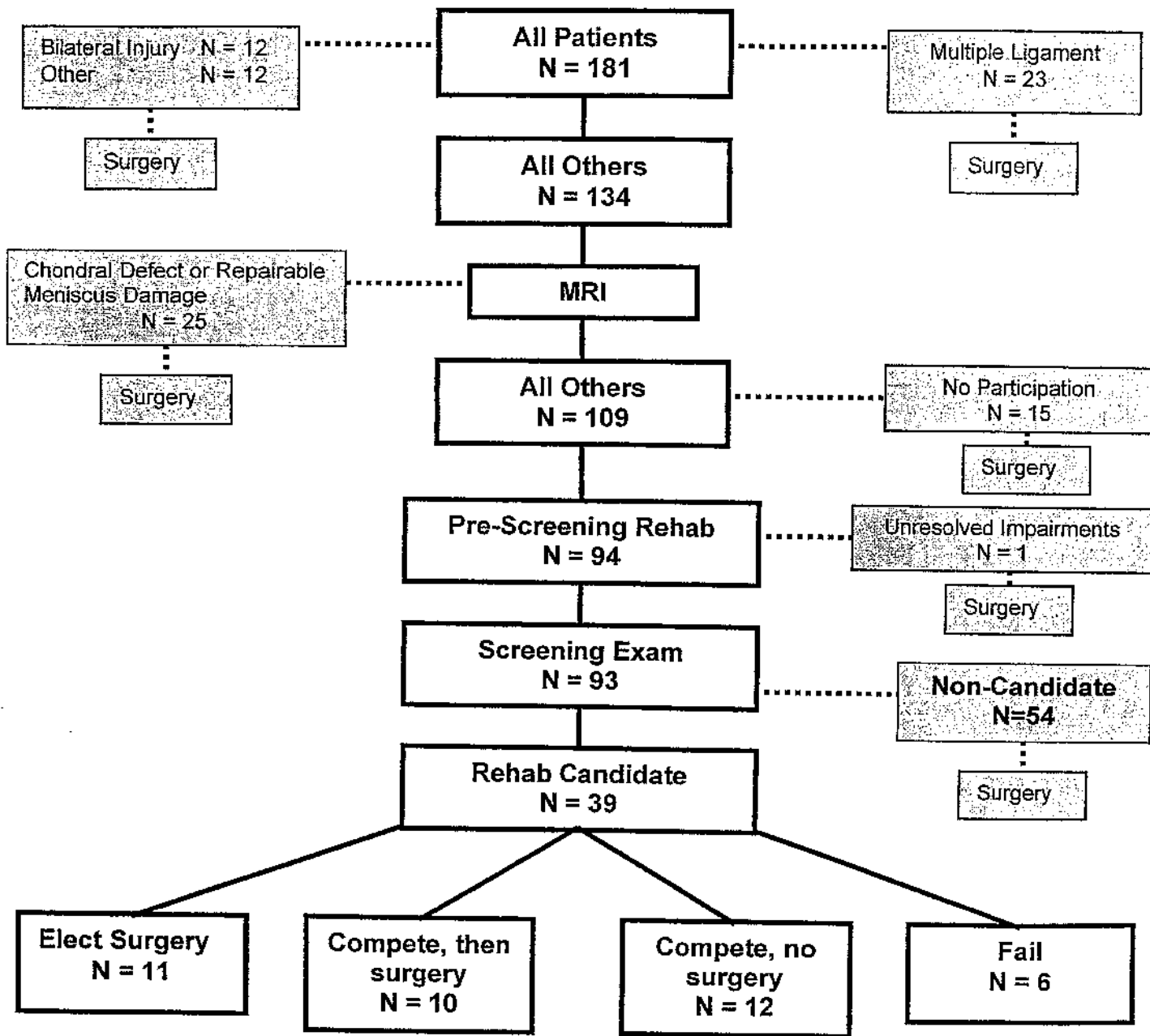
Activity	A	B	C	D
Collegiate Football	1	2	1	
Collegiate LaCrosse			1	
Collegiate Field Hockey		1		
Collegiate Track/Soccer	1			
High School Basketball		1	1	
High School Softball		1		
High School Field Hockey		1		
Semi-Pro Soccer				1
Semi-Pro Baseball		1		
Senior Olympic Volleyball	1			
Basketball	3 ^a		2 ^a	
Hockey	2			
Tennis		1	1	
Softball	3 ^b			
Volleyball		1		
Skiing	1			

Table 2 Means and standard deviations of follow-up Sports Activity Scale (SAS) scores and global ratings of knee function (Global R) for subjects who successfully returned to high level activity (Success) and subjects who failed rehabilitation (Fail).

Self Report Survey	Success	Fail
SAS	95.9 ± 4.4	58.0 ± 29.4
Global R	92.9 ± 6.2	60.8 ± 18.5

Table 3 Mean and standard deviations for screening exam scores between subjects who successfully returned to high level activity (Success) and subjects who failed rehabilitation (Fail). *ADLS* Activities of Daily Living Scale, *Global R* Global rating of knee function, *SHP* single hop for distance, *TRH* triple hop for distance, *XHP* cross-over hop for distance, *THP* timed hop, *MVIC* quadriceps femoris maximum voluntary isometric torque index, *Laxity* side to side difference in passive anterior knee laxity. * significantly different at $p < .01$.

Test	Success	Fail
ADLS	91.4 ± 6.2	90.9 ± 4.6
Global R	78.0 ± 8.0	75.8 ± 11.1
SHP	91.9 ± 8.9	82.5 ± 9.4
TRH	94.5 ± 7.4	89.6 ± 8.6
XHP	93.8 ± 8.4	83.0 ± 12.4
THP	95.1 ± 6.6*	85.4 ± 4.1*
MVIC	88.7 ± 16.9	85.0 ± 11.9
Laxity	5.8 ± 2.3	5.3 ± 2.8



Legends To Figures

Figure 1. Algorithm for clinical decision-making used in this study.