Anterior Cruciate Ligament Injured Copers and Noncopers: A Differential Response to Injury

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Contents

Aims

1. To review the dilemma whether ACL-injured individuals need to undergo Anterior cruciate ligament reconstruction (ACLR) or not.
2. To highlight the current research regarding the reliability of a treatment algorithm and screening examination in order to detect Anterior cruciate ligament deficient (ACLD) copers and noncopers.
3. To explore the terms "copers," and "noncopers," as well as to review the researched evidence that has exposed the differences between them.
4. To present the available evidence regarding the question of whether potential copers and noncopers can undergo rehabilitation in order to be reclassified as true copers and therefore avoid reconstruction surgery.

Background

ACL rupture is the most common cause of acute, traumatic hemarthrosis of the knee, an isolated rupture found in about 38% of individuals with acute knee hemarthrosis [19]. Continued high athletic demands after an ACL rupture have been reported to eventually lead to meniscal damage, articular cartilage damage, and degenerative arthritis [37, 44], although this has not been clearly demonstrated [31, 38, 42]. Two opposing treatment strategies are available to the ACLD individual: conservative management and reconstructive surgery [8]. Controversy exists as to which intervention results in a superior functional outcome for the ACLD individual. In the past, studies have reported poor individual outcomes after nonoperative management of ACL injury, further reinforcing a bias toward surgical management of this injury [1, 3, 20, 26]. Nearly 25 years ago, the well-known rule of thirds was proposed for chronic ACL injuries treated with rehabilitation [37]. It stated that one third of the individuals can resume previous recreational activities without reconstruction, one third can manage without reconstruction by

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modifying/lowering their activity level, and one third would require reconstruction because of recurrent "giving-way" episodes even in activities of daily living. Despite thousands of published articles about ACL injuries as well as the growing and widespread use of ACL reconstruction, the benefit (both efficacy and cost-effectiveness) of ACLR still needs to be established [2, 43]. In 2005, a Cochrane review on the subject was published by a Finnish group [28]. They concluded that there was 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. A more recent systematic review explored the prognosis of conservatively managed ACL injury [34]. The authors concluded that on average, individuals with mixed or isolated ACLD knees reported good knee function (87/100 Lysholm knee scale) at a follow-up duration of 12–66 months. On average, functional performance assessed with the hop-for-distance test, was in the normal range. From preinjury to follow-up, there was a reduction in Tegner activity level of 21.3%. According to the methods used in the assessed studies, conservatively managed ACLD knees have a good short- to mid-term prognosis in terms of self-reported knee function and functional performance. However, individuals reduced their activity levels on average by 21% following injury.

There are very few randomized or quasi-randomized studies that address the basic question as to whether ACL ruptures should be operated on or not. Despite this, the vast majority of orthopedic surgeons in the United States (where over 100,000 ACLRs are done annually) advocate early surgical intervention when managing patients with ACL rupture, who wish to resume high-level sports activities [30]. This practice pattern is influenced by ready access to surgical facilities, widespread private health insurance coverage of 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 [24]. Nevertheless, there is no evidence to date that clearly establishes that noncopers (see below) following an ACL injury, should be excluded as rehabilitation candidates [32].Despite the above, a closer look at the literature regarding the sports population reveals an interesting picture. At a 6–11 year follow-up, it was shown that 20 out of 22 (91%) competitive handball players treated without reconstruction were capable of returning to their preinjury activity level, compared with 33 out of 57 (58%) in the reconstructed group [11]. In a group of 38 former college or high school athletes with chronic ACL injury, a low rate of functional limitations was reported [48]. In a review of follow-up studies on the treatment of ACL injuries, return to preinjury activity level ranged from 8% to 82% in patients undergoing reconstruction, and from 19% to 82% in injured patients without reconstruction [35]. No consensus exists on objective criteria to decide when, or if at all, an individual should return to high-level sports after ACLR or nonoperative treatment [32]. Therefore, the benefit of early ACLR to regain the desired activity level and contribute to subjective well being, as well as reducing the risk of osteoarthritis (OA), is thus not obvious. It seems apparent from the literature that the primary indication for ACL-injured subjects to go through ACLR is to restore knee stability and enable the subjects to return to the desired activity level [17, 18]. However, no studies have shown that ACLR actually restores dynamic knee stability or enables full return to preinjury activity level in most individuals [13, 45].

The Screening Examination

ACL injury has deleterious effects on knee muscle function, knee kinematics, and proprioception [27]. While the majority of individuals with ACLD lack dynamic knee stability, some of the unoperated individuals seem to have the ability to dynamically stabilize their knee even during pivoting sports activities [6, 14, 24, 36]. These individuals may be defined as "copers" and are able to resume all preinjury activities, including sports, without experiencing further episodes of knee giving-way [40, 46]. Numerous researchers have added their own additions to this basic definition. The Delaware group stipulated this situation must continue to at least 1 year after ACL injury [22], whilst a Swedish group further added that the copers must be able to return to function at a high level (Level I sports [9, 12]) at least weekly after injury, without complaint of instability [14, 24, 30]. Noncopers on the other hand have been defined as individuals who had either not returned to their previous activity level and/or had experienced giving-way episodes on resumption of preinjury activities [11, 32, 40, 41, 46]. There is a third category, described as "adapters" [10]. These individuals have been defined as those who demonstrate more than 3 mm of difference in side-to-side laxity at initial examination but cope with their injuries without ligament surgery. Adapters represent the vast majority of ACLD individuals who are managed nonoperatively and are those who are able to avoid evoking episodes of instability by modifying their activity levels [33]. Knowing that some individuals will manage well without an ACLR, a significant obstacle in the management of patients with ACL injury is the development of an algorithm or screening examination that effectively discriminates soon after injury between copers and noncopers [22]. The intention behind the development of a screening examination is essentially to create a tool that can identify which individuals with an ACLD knee early after injury have the potential of returning to preinjury activity level for a limited period [15].The question arises whether this examination is

sensitive enough to detect these individuals. The author found three published papers in the literature that attempted to use an algorithm and screening examination involving ACL-injured individuals over varying periods. The first is from a Swedish group, [27] who followed 200 ACL-injured individuals over a 15 year period and reported on the unilateral non-reconstructed individuals following this period (Fig. 1). Their main hypothesis was that good knee function and a satisfactory activity level could be achieved by early activity modification and neuromuscular rehabilitation, thereby limiting the need for reconstruction.

Their principal findings were, that good subjective results and a satisfactory activity level can be achieved in the majority of the patients, limiting the need for ACL reconstruction to only 23%. The results achieved using their specific treatment algorithm are similar to those presented in studies of surgically treated individuals, both at medium and long-term follow-up [29, 47]. Early activity modification, neuromuscular rehabilitation, and a gradual return, resulted in good knee function and an acceptable activity level. Approximately 60% of the patients could resume preinjury activity level within 3 years of injury and an additional 12% decreased their activities by just one level. They concluded that since a high proportion of patients can cope without reconstructive surgery, it is better to adopt a restrictive attitude toward early reconstruction.

The Delaware group [22] published a 10-year prospective study involving by far the largest group (832) of highly active individuals with subacute ACL tears. Their main objective was to utilize a treatment algorithm and screening

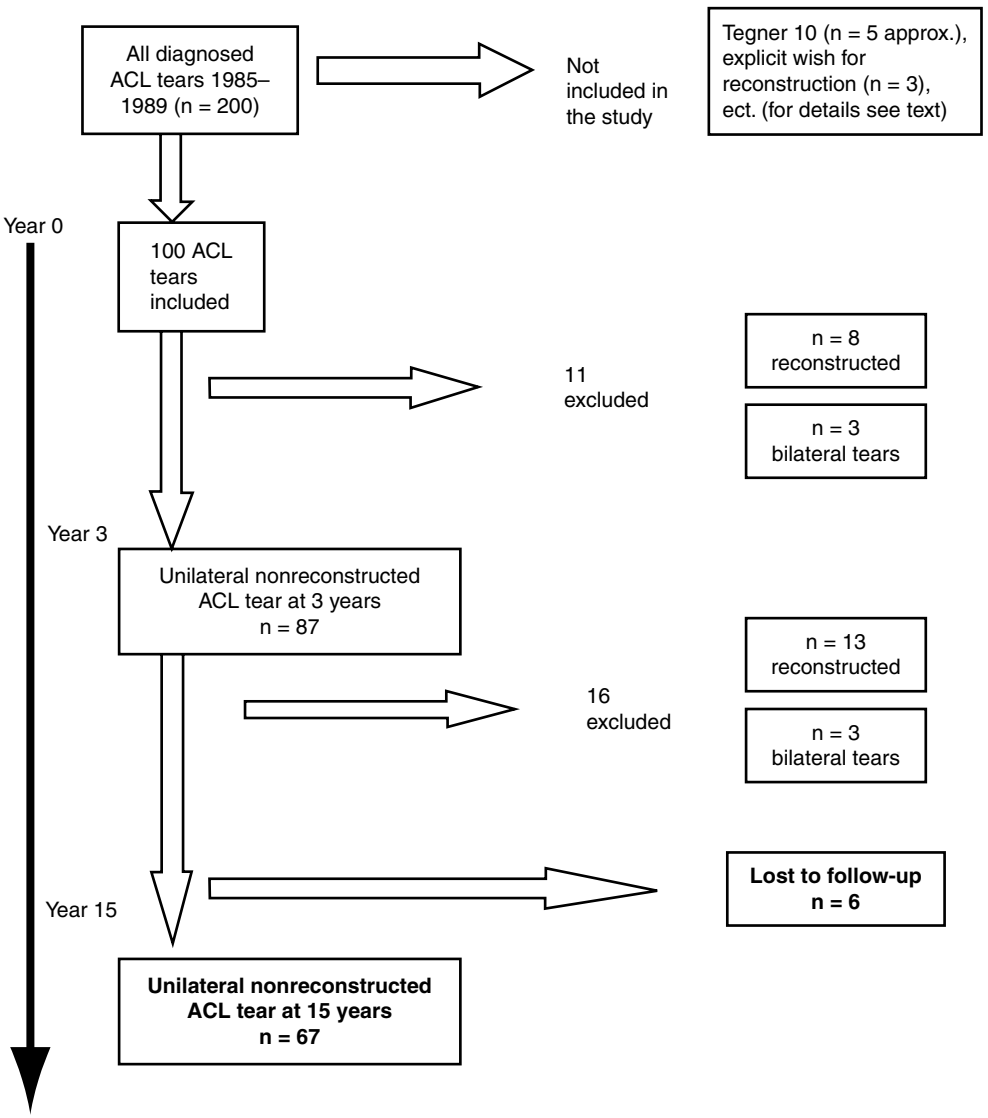

Fig. 1 Flow chart showing patient's movement through the study (Reprinted with permission of Kostogiannis et al. [27]. Copyright Clearance LN: 2197461388813)

examination to guide individual management and determine potential for highly active individuals to succeed with nonoperative care. 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 (Fig. 2). The individuals who met all inclusion criteria completed the screening examination a mean of 6 weeks after injury. Potential copers were classified as individuals who met all of the following criteria at the screening examination: (1) hop test index of 80% or more for the timed 6-m hop test, (2) Knee Outcome Survey-Activities of Daily Living Scale (KOS-ADLS) score of 80% or greater, (3) global rating of knee function of 60 or greater, and (4) no more than one episode of giving-way since the injury [14]. Potential noncopers were classified as those who did not fulfill the above criteria.

There were 199 (58%) subjects who were classified as noncopers and 146 (42%) as potential copers. On completion of the study, only 25 (39%) of those who returned to sports, did not undergo surgical reconstruction. The final figures show that 89% (308/345) of the initial group were known to have gone on to surgery, where as only 7% (25/345) did not. The other 4% were lost to follow-up. They concluded that their classification algorithm is an effective tool for prospectively identifying individuals early after ACL injury who want to pursue nonoperative care or must delay surgical intervention and have good potential to do so. 72% 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. 36 (57%) of these had reconstruction. Despite this, they strongly encourage all patients identified as potential copers who elect nonoperative management, to do so only after participating in perturbation-enhanced rehabilitation. Their stated intention with development of the screening

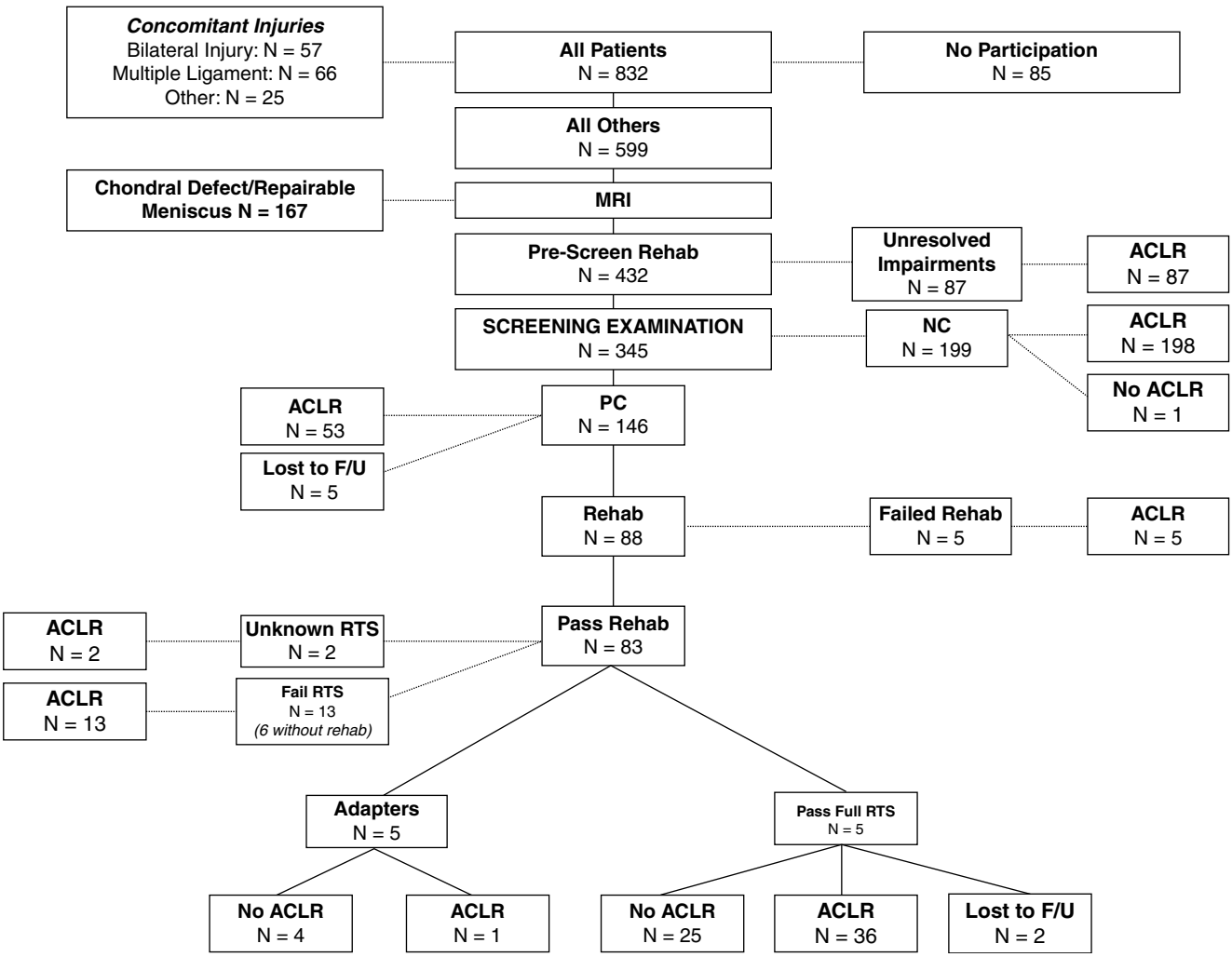

Fig. 2 Treatment and screening examination algorithm outcomes. *ACLR* ACL reconstruction, *f/u* follow-up, *NC* noncoper, *PC* potential coper, *Rehab* rehabilitation, *RTS* return to sports (Reprinted with permission of Hurd et al. [22]. Copyright Clearance LN: 2193211155058)

examination was to identify subjects who might be successful with short-term (i.e., 6 months or less) nonoperative management.

The third and final group [33] carried out a 2-year prospective cohort study (Fig. 3) consisting of 125 ACL-injured subjects who had participated in level I and II sports [21].

Their screening examination was performed within 6 months post injury, and consisted of (1) the timed 6-m hop test [14] ,(2) the Knee Outcome Survey activities of daily living scale (KOS-ADLS) [23], (3) the global rating of knee function assessed by a visual analogue scale (VAS) [43] and (4) determining the number of episodes of giving-way since the injury [14]. On analysis, the positive predictive value of classification as a potential coper at the screening examination was 60% (95% CI: 41–78%), while the negative predictive value of the classification at the screening examination was 30% (95% CI: 16–49%). This showed that for all elements of the prognostic accuracy profile, the results were not statistically significant, as the 95% CIs include the null values for the statistics. The null values for sensitivity, specificity, and positive and negative predictive values were all 50%, showing that the level of prognostic accuracy was no different than random chance. The screening examination thus had poor predictive value for correctly classifying copers and noncopers at the 1-year follow-up, bringing into question the use of this screening examination to determine who should have surgery post ACL injury. Their investigation establishes support for an assumption that a significant proportion of potential noncopers have the possibility of regaining dynamic knee stability similar to potential copers. One year after the screening examination, 60% of the potential copers were true copers and at the 1-year follow-up examination, 70% of the subjects initially classified as potential noncopers were true copers. Individuals who underwent ACLR as well as those who followed a conservative rehabilitation program showed excellent results on functional questionnaires at the 1-year follow-up exam. Their study provided a scientific rationale for not excluding potential noncopers from nonoperative treatment.

Copers vs. Noncopers

There are numerous studies that have investigated whether differences exist between coper and noncoper populations. It has been reported that true copers had significantly less knee joint laxity, fewer giving-way episodes, significantly higher activity levels, and greater improvement in KOS-ADLS and IKDC2000 scores compared to true noncopers at the 1-year follow-up [32]. Evidence has been provided that potential copers identified by the screening examination have movement patterns that are consistent with people who have more knee stability than noncopers [7]. ACLD copers performed better (P <0.05) than noncopers on all four hop tests[11]. Diminished quadriceps control was observed when people with ACL deficiency performed static and dynamic tasks [49]. The most striking feature of this impaired control was failure to turn the quadriceps "off" when performing flexion tasks in which the knee extensors are usually "silent." Their findings suggest that quadriceps dyskinesia after ACL injury is relatively global. Noncopers exhibit a stiffening strategy (i.e., lower sagittal plane knee motion and knee moments and higher muscle co-contraction in comparison

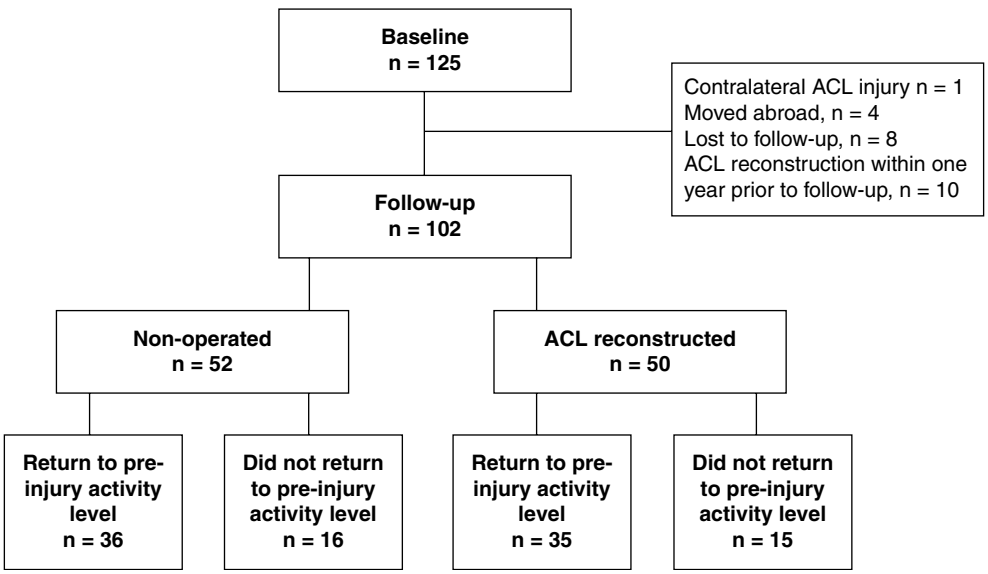

Fig. 3 Flow chart of the subject throughout the study (Reprinted with permission of Moksnes et al. [33])

with their contralateral limbs and uninjured subjects) to maintain knee stability in the absence of ligamentous support. Conversely, potential copers have movement patterns that are intermediate to uninjured individuals and noncopers [41].In a recent publication [5], it was shown that at 4 months post-injury noncopers had an inferior gait performance compared to copers for kinematics and time-distance variables. Laxity measurements have little predictive value in differentiating ACLD copers and noncopers [11,40,46]. Interpretation of these findings infers that ACLD copers and noncopers should therefore have the same probability of instability, a factor refuted by the characteristic superior dynamic stability evident in copers [40, 41]. It may therefore be concluded that static measurements are incapable of predicting the dynamic stability of the ACLD patient.

Can Noncopers Become Copers?

The question whether noncopers can become copers has had little exposure in the literature and is surely one that merits more extensive research. Currently, most noncopers are referred for surgery [22, 32], without testing whether it is possible to "convert" them into true copers and thus avoiding surgical procedure and the lengthy rehabilitation process that follows. The first published randomized clinical trial (RCT) indicated that noncopers who received perturbation training combined with a standard nonoperative ACL rehabilitation program reported a greater increase in Lysholm Knee Rating Scale scores after training than subjects who received only the standard program [4]. In a more recent RCT, comprising 26 individuals with an acute ACL injury or ruptures of ACL grafts, individuals were randomly assigned to either a group that received a standard rehabilitation program (standard group) or a group that received the standard program augmented with a perturbation training program (perturbation group) [16]. Their results lead to the conclusion that augmenting nonoperative ACL rehabilitation programs with perturbation training techniques enhances the probability of a successful return to high-level physical activity by reducing the risk of continued episodes of giving-way of the knee during athletic participation. This allows individuals to maintain their functional status for longer periods.

Discussion

If we analyze the number of individuals who went on to have ACLR in the three above studies [22, 27, 33], it is strikingly evident that surgeons in the United States are far more reluctant to agree to nonoperative care than their European counterparts. This fact poses a research problem for those in the United States who want to introduce an algorithm or screening examination that effectively discriminates soon after injury between true copers and noncopers. 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 [29, 47], we must ask if surgical intervention in an asymptomatic individual has become more habitual rather than evidence based. In a review of the literature, it was concluded that the role of ACLR in the prevention of joint degeneration is far from clear [25]. It seems that the resumption of the previous activity level may increase the risk of future OA regardless of whether the ACL is reconstructed or not. [12, 29, 36, 39]. We still do not have the optimal clinical tests to correctly assign individuals with an ACL tear to the correct treatment early after injury. No single knee-measuring tool is sufficient in determining the functional status of the ACLD individual. Consequently, KOS-Sport, Global Knee Function Rating, hop tests, and Quadriceps Index should all be included when assessing these patients. The results presented above do in fact indicate that a large number of individuals identified as rehabilitation candidates using the treatment algorithm and screening examination and who elect nonoperative care, are able to delay surgery without experiencing further knee instability or extending the original knee injury. Individuals with the highest preinjury activity level seem to have a higher probability of not returning to preinjury activity level. The development of sufficient knee function in nonoperatively treated subjects takes time and the concern exists that excluding potential noncopers from nonoperative treatment may in fact lead to unnecessary surgery for a number of individuals or exclude the potential noncopers from significant preoperative rehabilitation.

Conclusion

There is a need for good quality and well reported RCTs evaluating the effectiveness and cost-effectiveness of current methods of surgical treatment versus nonsurgical treatment. More studies need to be undertaken to see whether in fact noncopers at screening examination, may indeed be "converted" to copers by adjusting traditional rehabilitation protocols and methodologies. There exists the need for long-term prospective studies including performance-based functional outcomes in order to predict the outcome of treatment decisions and to establish functional criteria in the guidance of treatment of ACL-injured individuals. The follow up of such trials should be at least 10 years so that the long-term effects including degenerative changes can be established. Larger outcome studies are necessary to confirm the consequences

of long-term nonoperative management in individuals prospectively identified as potential copers. Since a high proportion of patients can cope without reconstructive surgery, it is better to adopt a restrictive attitude toward early reconstruction. It may be proposed that ACL-injured individuals should be informed and given the possibility of nonoperative treatment as an alternative to ACL reconstruction, provided that they perform well on single-legged hop tests, IKDC 2000, and have not experienced giving-way episodes. Surgical treatment as opposed to nonsurgical treatment is a complex decision. It depends on lower extremity function/dynamic stability, on the type and level of sport activities, and the individual's own interest in modifying his/her activity level. For those who choose to return to pivoting sports, especially at high level, surgery still seems to be the preferred treatment. Despite this, there are some, however, even at high level, that will do well without surgery. There still remains no wide consensus as to how this cohort may accurately be detected. This remains the ultimate challenge of future research.

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