
THE ORTHOPAEDIC FORUM

Early Versus Delayed Reconstruction of the Anterior Cruciate Ligament

A Decision Analysis Approach

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Background: A recent randomized controlled trial compared early anterior cruciate ligament reconstruction with a program of initial rehabilitation, with delayed anterior cruciate ligament reconstruction if needed. The authors reported that the improvement in Knee Injury and Osteoarthritis Outcome Scores was nearly identical in both groups and concluded that in young, active adults with acute ACL (anterior cruciate ligament) tears, a strategy of rehabilitation plus early ACL reconstruction was not superior to a strategy of rehabilitation plus optional delayed ACL reconstruction. Yet, in making that assessment, the authors did not account for the fact that there were more meniscal injuries in the group with delayed anterior cruciate ligament surgery. Establishing the true superiority of one strategy requires consideration of meniscal injury, as well as a further determination if the apparent protective effect regarding meniscal tears found in the cohort of patients with early anterior cruciate ligament reconstruction is offset by the costs of additional reconstructive surgery. That analysis of offsetting utility, omitted in the randomized controlled trial noted above, is provided in the present study.

Methods: A decision analysis model considering the options and probabilities described in the randomized controlled trial was constructed: the functional outcome of all groups was assumed to be equal, the likelihood of a patient eventually needing surgery despite initially choosing a program of rehabilitation was 37%, and the likelihood of needing a meniscectomy was 23% for the early surgery group and 35% for the rehabilitation and deferred anterior cruciate ligament reconstruction group.

Results: The early surgery option is the preferable therapeutic approach as long as the costs of a potential meniscal tear are at least 5.25 times the costs of reconstructive surgery.

Conclusions: Early surgery for anterior cruciate ligament tears may be the preferred approach for some patients, on the basis of the utility values they assign to the possible treatment outcomes. The reported randomized controlled trial did not establish a dominant strategy. Indeed, early surgery may be the more effective approach overall.

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A young and active patient who has sustained an acute rupture of the anterior cruciate ligament (ACL) is typically offered one of two treatment options: imminent reconstruction of the ligament or a program of rehabilitation, with surgery to be done at a later date only if symptomatic instability is present. Until recently, the selection of one treatment option over another relied on suboptimal research evidence, as there were no randomized trials comparing the outcomes of these two treatment options.

In 2010, Frobell et al.¹ reported a randomized controlled trial involving young, active adults with an acute ACL injury. In the trial, sixty-two subjects were assigned to receive early ACL reconstruction, and fifty-nine were randomized to receive initial rehabilitation, with the option of later ACL reconstruction if needed. The primary outcome studied was the change from baseline in four subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS).

In the trial, the authors reported that the improvement in outcome scores was nearly identical in the two groups, with a gain of 39.2 points for those assigned to early ACL reconstruction and a 39.4-point gain for those assigned to rehabilitation and optional delayed reconstruction. The authors concluded that “in young, active adults with acute ACL tears, a strategy of rehabilitation plus early ACL reconstruction was not superior to a strategy of rehabilitation plus optional delayed ACL reconstruction.”¹

Close scrutiny of the data, however, reveals a salient difference between the two groups. While it is true that similar outcomes in both groups were found in terms of the main study metric (the KOOS score), there were more meniscal injuries in the delayed surgical group. As such, a claim that the two strategies are equivalent is invalid—unless the apparent protective effect of the meniscus found in the cohort that had early ACL reconstruction is offset by the costs of additional reconstructive

surgery in that group. This analysis of the values of outcomes was not included in the randomized controlled trial report.

To address that deficit, a more complete decision analysis model is reported in the present study. With use of the probabilities reported by Frobell et al.¹, an expected value calculation can be produced. (An expected value calculation multiplies the value of an outcome by the probability of reaching that outcome.) From that calculation, one can further determine the circumstances under which either treatment strategy may be deemed superior.

Materials and Methods

A decision tree was created with use of the treatment choices and probability values established by the ACL trial. In this model, a patient with an acutely torn ACL faces a choice: to have early ACL reconstruction or to undergo rehabilitation initially, with ACL reconstruction later if symptomatic instability occurs. Each of these choices subjects the patient to an element of chance: patients in the rehabilitation group may need ACL reconstruction after all and there is a risk for patients in both groups that a meniscectomy will be needed as well.

For the purpose of this analysis, the costs of a meniscal tear and submission to ACL reconstruction were the only utilities considered. Other factors no doubt will influence patient decisions, yet insufficient data were provided in the randomized controlled trial report to include these factors. (As noted below, if the simplified decision model omits factors that may favor early surgery, and yet early surgery would nonetheless be found preferable, *a fortiori* with the inclusion of these factors, early surgery would be even more preferable.)

In the simplified decision tree, there are two possible outcomes that may result from the decision to have early surgery: ACL reconstruction with meniscectomy, and ACL reconstruction without meniscectomy. There are four possible outcomes that may result from the decision to choose rehabilitation: complete avoidance of reconstructive surgery, with or without a meniscectomy, and delayed reconstructive surgery, with or without a meniscectomy. This decision tree is shown in Figure 1.

The probabilities associated with attaining any of these outcomes were quoted or derived from the report on the randomized controlled trial. It was noted that the risk of ultimately requiring surgery despite selecting early rehabilitation was 37%. For the risk of meniscectomy, the rate was derived as

TABLE 1 Outcomes, Utilities, and Probabilities

Outcome	Utility Value of Outcome*	Probability of Attaining This Outcome, Given the Initial Treatment Option Selected
Rehabilitation outcomes		
Rehabilitation chosen, reconstructive surgery ultimately needed, with meniscal tear encountered	Utility (outcome—ACL surgery-meniscal tear)	0.13
Rehabilitation chosen, reconstructive surgery ultimately needed, without meniscal tear encountered	Utility (outcome—ACL surgery)	0.24
Rehabilitation chosen, no reconstructive surgery needed, with meniscal tear encountered	Utility (outcome—meniscal tear)	0.22
Rehabilitation chosen, no reconstructive surgery needed, no meniscal tear encountered	Utility (outcome)	0.41
Early surgery outcomes		
Reconstructive surgery chosen, meniscal tear present	Utility (outcome—ACL surgery-meniscal tear)	0.23
Reconstructive surgery chosen, meniscal tear absent	Utility (outcome—ACL surgery)	0.77

*ACL = anterior cruciate ligament.

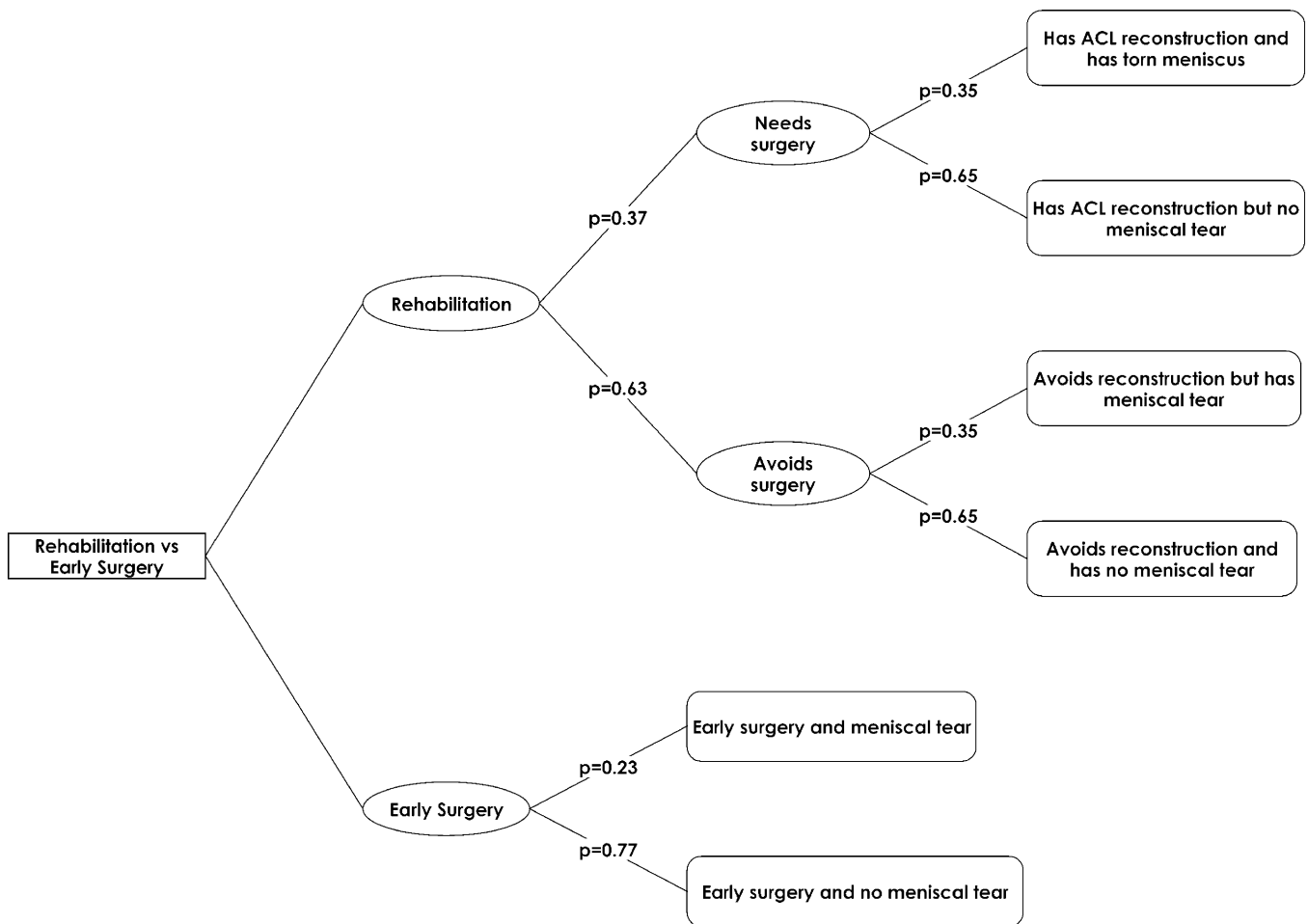


Fig. 1

A decision tree illustrating the two treatment options and the six possible outcomes in the terminal nodes (shown as rounded rectangles at the right): (1) rehabilitation is chosen, yet delayed reconstructive surgery is ultimately needed and a meniscal tear is encountered; (2) rehabilitation is chosen, delayed reconstructive surgery is ultimately needed, but no meniscal tear is encountered; (3) rehabilitation is chosen, no reconstructive surgery is needed, but a meniscal tear is encountered; (4) rehabilitation is chosen, no reconstructive surgery is needed, and no meniscal tear is encountered; (5) early reconstructive surgery is chosen, and a meniscal tear is present; and, last, (6) reconstructive surgery is chosen, and no meniscal tear is encountered.

the number of meniscectomies per group, divided by twice the number of subjects, as each patient has two menisci. (Because no per-patient data were provided in the original report¹, rates were calculated as a function of the number of torn menisci, although this omits the qualitative and quantitative difference between a single patient sustaining a medial and lateral meniscal tear and two distinct patients having a single meniscal tear each.) As reported, there were twenty-nine resected menisci (23%) among sixty-two patients in the early surgery group and forty-one resected menisci (35%) among fifty-nine patients in the rehabilitation group.

The value of each possible outcome was then considered, with all patients assumed to have attained the same functional outcome: that equivalence was the main finding of the randomized controlled trial. In addition, some patients were exposed to additional costs: ACL reconstruction or meniscal tear surgery, or both. Accordingly, the outcomes listed on the terminal nodes of the decision tree—the six possible outcome states—have the utility values and associated probabilities as shown in Table I.

Results

The utility value for the early surgery option is $(0.23 \times \text{utility} [\text{outcome—ACL surgery—meniscal tear}]) + (0.77 \times \text{utility}$

$[\text{outcome—ACL surgery}])$. Those two terms in the sum represent the expected value—i.e., probability multiplied by utility—for the two possible outcomes, namely, having surgery with or without a meniscal tear, respectively. (The term *utility [outcome]* refers to the value of treating the ACL tear itself, a gain of approximately 39 points on the KOOS score, an outcome attained independent of the treatment option.)

For the rehabilitation option, the net value is the sum of four terms $(0.63 \times 0.65 \times \text{utility} [\text{outcome}]) + (0.63 \times 0.35 \times \text{utility} [\text{outcome—meniscal tear}]) + (0.37 \times 0.65 \times \text{utility} [\text{outcome—ACL surgery}]) + (0.37 \times 0.35 \times \text{utility} [\text{outcome—ACL surgery—meniscal tear}])$.

The set of utility values for which the two treatments provide identical expected costs and benefits can be determined by setting the term representing the expected value of the early surgery treatment option to be equal to the term representing the expected value of the rehabilitation-delayed surgery treatment option. By algebraic manipulation, the two terms are

TABLE II Factors Omitted from the Decision Tree That May Favor Early Surgery

- After two years, more meniscal tears in the rehabilitation group eventually would be found⁶.
- A subsequent meniscal tear is itself painful, inopportune, and impairing (i.e., there is negative utility for the event of tearing the meniscus apart from the long-term consequences of having a meniscal tear).
- The cost of anterior cruciate ligament surgery is included in the model, but the cost of initial rehabilitation was not.
- There is a psychological cost of knowing that the knee may give out; that possibility hangs over the head of the patient like a sword of Damocles⁷.
- Instability, which the rehabilitation group was more prone to suffer, may also lead to articular damage² or injury to other structures.
- Because of the psychological phenomenon of loss aversion⁸, patients may be more eager to have a procedure that helps to avoid the future possibility of meniscal tear.

equal to each other when the value of avoiding meniscal tear is 5.25 times the cost of ACL surgery. That is, if the value of preventing a meniscal tear is >5.25 times the cost of reconstruction, the strategy of early surgical reconstruction is preferable on that basis alone, and vice versa.

Discussion

In the report on the trial in which early ACL reconstruction is compared with rehabilitation with the option of later ACL reconstruction if needed, the two strategies were shown to produce nearly identical improvement in KOOS scores. Accordingly, the authors said, neither strategy can be said to be superior. Yet, in point of fact, the early surgery strategy was shown to be associated with fewer meniscal tears, a finding consistent with a prior review of 6576 active-duty army personnel². As such, the two approaches are therapeutically distinct—one or the other may be deemed preferable, on the basis of patient utility value assignments. Specifically, patients who are particularly reluctant to expose themselves to the loss of the meniscus may prefer a plan of early surgery (despite the risk of submitting to what might have been unnecessary treatment).

The key element to determine the superiority of a given strategy in the management of ACL tears is the relative values assigned to the two possible negative outcomes, i.e., what meniscal tear or unnecessary reconstructive surgery really costs. In the decision analysis in the present report, it was found that when the cost of a meniscal tear exceeds the cost of surgery by more than a factor of 5.25, early surgery should be the plan of action, and vice versa. That is, if decision-makers—patients, surgeons, and society—deem it worthwhile to perform 5.25 reconstructions to save one meniscus, then early surgery is the strategy of choice on that basis alone.

It must be noted that the decision analysis rendered in the present study relies entirely on the data of the reported trial, and therefore any limitations imputed to that study likewise hinder this investigation. Nonetheless, even with that in mind, this decision analysis refutes the assertion that early surgery and rehabilitation are fungible options. Indeed, they are not: the former exposes the patient to surgery that may have been unnecessary, and the latter exposes the patient to an increased risk of a meniscal tear. The superiority of one strategy over the other hinges on the relative values assigned to the outcomes—a point omitted in the report of the trial.

Furthermore, the decision tree suggested in the present study contains certain omissions and assumptions that might tend to favor the “rehabilitation with delayed reconstruction” option as well. Specifically, the attributes listed in Table II might reasonably be imputed to the rehabilitation option, yet were not considered in the randomized controlled trial. Given these omissions, it is possible that the model undervalues early surgery, beyond its role in meniscal preservation.

Contrary to the news media interpretation of the study (e.g., the www.sciencedaily.com release entitled “More Than Half of All ACL Reconstructions Could Be Avoided, Swedish Study Finds³”), the randomized controlled trial did not genuinely establish the equivalence of the two treatment approaches. Rather, it provided the substrate with which surgeons can help patients to understand their options and make wise choices accordingly—a major contribution, no doubt, but not the last word.

Excellent medical care, according to the Institute of Medicine’s 2001 report, “Crossing the Quality Chasm,”⁴ is based on a patient-centered approach—a method that respects and responds to “patients’ wants, needs and preferences, so that they can make choices in their care that best fit their individual circumstances.”⁵ Excellent care of the acutely torn ACL demands a therapeutic plan that considers patient preferences. Along those lines, the editorial⁶ accompanying the report of the randomized controlled trial noted, correctly, that “the decision about whether to reconstruct an ACL-deficient knee, and the timing of surgery when reconstruction is indicated, should be individually tailored to address the unique characteristics of each injured knee and to meet the specific needs of each patient.”

The specific needs of a patient with a torn ACL no doubt include consideration of his or her preferences regarding risk tolerance and utility for a possible meniscal tear. It is demonstrated in this report that consideration of this aspect of patient preferences may make the option of early ACL reconstruction the more desirable choice for some patients.

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