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Appendix E-1

TABLE E-1 Key Conclusions of Studies Included in the Section "Outcomes of Early Versus Delayed ACL Reconstruction"

Study	Design	Key Conclusions*
Ericsson et al.[74]	Prospective cohort study	"Poor physical performance at the end of rehabilitation predicted worse patient-reported outcomes at 2 and 5 years regardless of treatment."
Frobell et al.[49]	Randomized controlled trial	"A strategy of rehabilitation plus early ACL reconstruction did not provide better results at 5 years than a strategy of initial rehabilitation with the option of having a later ACL reconstruction."
Frobell et al.[13]	Randomized controlled trial	"A strategy of rehabilitation plus early ACL reconstruction was not superior to a strategy of rehabilitation plus optional delayed ACL reconstruction. The latter strategy substantially reduced the frequency of surgical reconstructions."
Smith et al.[76]	Meta-analysis	"There was no difference in clinical outcome between patients who underwent early compared to delayed ACL reconstruction."
Meighan et al.[77]	Randomized controlled trial	"There is no functional advantage to be gained by early reconstruction of the ACL."
Neuman et al.[39]	Prospective cohort trial	"In patients with ACL injury willing to moderate activity level to avoid reinjury, initial treatment without ACL reconstruction should be considered."
Kennedy et al.[78]	Retrospective analysis	"There is a significant relationship between the duration of the instability of their knee and the subsequent incidence of both chondral changes and meniscal tears."
Tandogan et al.[79]	Retrospective analysis	"Multivariate analysis demonstrated that TFI and age were equally important predictors of lateral meniscal tears and of grade 3 or 4 chondral lesions; however, TFI was the better predictor of medial meniscal tear."
Laxdal et al.[80]	Retrospective analysis	"Concomitant joint damage and a long time period between the injury and reconstruction are major risk factors for inferior outcome after ACL reconstruction."
Church and Keating[81]	Retrospective analysis	"Reconstruction of the anterior cruciate ligament should be carried out within 12 months of injury to minimise the risk of meniscal tears and degenerative change."
Papastergiou et al.[82]	Retrospective analysis	"ACLR should be carried out within the first 3 months post injury in order to minimise the risk of secondary meniscal tears."
Eitzen et al.[75]	Prospective cohort trial	"Conducting the screening examination after ten sessions of progressive exercise therapy gave the overall highest explanatory values, suggesting that the screening examination should be conducted subsequent to a short period of rehabilitation to inform decision making for anterior cruciate ligament reconstruction."
Moksnes et al.[58]	Prospective cohort trial	"The prognostic accuracy of this screening examination for correctly classifying true copers was poor."
Krutsch et al.[83]	Cross-sectional study	"Because of the significantly higher rate of prognostically advantageous meniscal repair, the recommendation for an ACL reconstruction within 6 months after trauma was made to preserve the meniscus and reduce the risk of developing OA."
Borchers et al.[84]	Prospective cohort trial	"These results show a decreased OR of new untreated lateral meniscal tears in revision compared with primary ACL reconstruction. A previous medial or lateral meniscectomy increases the OR of articular cartilage damage in the medial or lateral compartments, respectively."
Brophy et al.[85]	Prospective cohort trial	"Previous partial meniscectomy was associated with a higher rate of chondrosis in the same compartment compared with knees without previous meniscal surgery ($P < .0001$) and knees with previous MR."

*TFI = time from initial injury, OR = odds ratio, ACLR = anterior cruciate ligament reconstruction.

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TABLE E-2 Key Conclusions of Studies Included in the Section "Predicting Outcomes of Nonoperative Treatment"

Study	Design	Key Conclusions*
Noyes et al.[17]	Prospective case series	"Recurrent giving-way injuries, even if occurring only two or three times a year, may in time produce significant damage to the joint. Athletic activities that cause even sporadic reinjuries are to be avoided even when the symptoms between injuries are negligible. The individuals who continued active sports despite symptoms had an over-all poor prognosis. One-third of the patients did not comply with recommended modifications or substitution of activities in order to prevent reinjuries or recurrent symptoms."
Rudolph and Snyder-Mackler[53]	Cross-sectional study	"Only non-copers used significantly different movement patterns on their involved limb compared to controls after they had descended from the step and their involved side accepted the weight of the body. Classifying subjects by functional ability resulted in more pronounced differences in movement patterns between non-copers and copers. Copers moved more like uninjured subjects."
Zabala et al.[54]	Cross-sectional study	"Elapsed time since injury might be an important factor when the function of ACL-injured knees is interpreted as it relates to osteoarthritis."
Rudolph et al.[55]	Cross-sectional study	"Copers used joint ranges of motion, moments and muscle activation patterns similar to uninjured subjects. Non-copers reduced their knee motion, and external knee flexion moments that correlated well with quadriceps strength. Non-copers also achieved peak hamstring activity later in the weight acceptance phase and used a strategy involving more generalized co-contraction."
Houck et al.[56]	Cross-sectional study	"Subjects that are ACL deficient and classified as noncopers use a common abnormal movement pattern of lower knee extensor loading even during unanticipated tasks."
Eastlack et al.[57]	Cross-sectional study	"Copers were not different in any meaningful way from the noncopers before injury, had equal or greater side-to-side laxity differences, and functioned normally. A battery of tests was identified that accurately discriminated noncopers from copers even early after injury."
Moksnes et al.[58]	Prospective cohort trial	"The prognostic accuracy of this screening examination for correctly classifying true copers was poor."
Chmielewski et al.[59]	Cross-sectional study	"Potential copers identified by the screening examination have movement patterns that are consistent with people who have more knee stability than non-copers."
Kaplan[60]	Literature review	"Objective differences exist between copers and noncopers."
Soltani et al.[61]	Cross-sectional study	"The reduced postural control of the non-coper ACL-D knee subjects in bilateral standing could be more evidence of their poor knee stability status."
Shabani et al.[62]	Cross-sectional study	"The findings in this study indicate that ACLD knee may adapt functionally to prevent excessive anterior-posterior translation but they fail to avoid rotational instability."
Alkjær et al.[63]	Cross-sectional study	"The strategy adopted by the copers may resemble an effective way to stabilize the knee joint during walking after an ACL rupture and that the knee kinematics may play a key role for this strategy."
Rudolph et al.[64]	Cross-sectional study	"Non-copers utilize a stabilization strategy which stiffens the knee joint which not only is unsuccessful but may lead to excessive joint contact forces which have the potential to damage articular structures. The copers use a strategy which permits normal knee kinematics and bodes well for joint integrity."
Iliopoulos et al.[65]	Cross-sectional study	"Despite the improved functional and clinical outcome of 'copers,' their walking economy appears similar to that of 'non-copers' but impaired compared with healthy individuals."
Fitzgerald et al.[67]	Case series	"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."
Hurd et al.[66]	Prospective cohort trial	"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."
Moksnes et al.[58]	Prospective cohort trial	"A majority (70%) of subjects classified as potential noncopers were true copers after 1 year of nonoperative treatment. Individuals with nonoperative treatment and ACL reconstruction showed excellent knee function and were highly active at the 1 year follow-up. The prognostic accuracy of this screening examination for correctly classifying true copers was poor."
Johnson et al.[68]	Case series	"A geographic bone bruise found on magnetic resonance imaging indicates substantial damage to normal articular cartilage homeostasis."
Costa-Paz et al.[69]	Case series	"Although long-term clinical implications of these findings are uncertain, a severe occult osteochondral lesion sustained at the time of ACL rupture seems to be persistent on MRI even after a successful reconstruction."
Fithian et al.[50]	Prospective cohort trial	"Relationship between bone contusion on initial magnetic resonance images and the finding of degenerative changes on follow-up radiographs were not detected."
Eggerding et al.[70]	Literature review	"Sex and knee joint laxity tests do not predict the need for ACL reconstruction soon after an ACL rupture."
Nebelung and Wuschech[71]	Case series	"Despite the possibility of return to high-level activity with a definitive unstable knee, this will lead in 95% of cases to meniscal and cartilage damage over the next 20 years. In addition, cartilage damage and progressive osteoarthritis will occur and patients will have a high risk of becoming a candidate for further total joint replacement."
Hawkins et al.[45]	Case series	"Giving way was a problem for 36 (86%) of the nonoperated patients, but pain and swelling were not significant problems for most. Full return to unlimited athletic activities was possible for only 4 (14%) of the patients."
Fink et al.[31]	Prospective cohort trial	"A significant ($p < 0.05$) correlation between participation in high-risk pivoting sports, such as soccer or basketball and osteoarthritic changes could be found for the nonoperative group, only."
Daniel et al.[12]	Prospective cohort trial	"Factors that correlated with patients who had late surgery for a meniscal tear or an ACL reconstruction ($P < 0.05$) were preinjury hours of sports participation, arthrometer measurements, and patient age."
Dunn et al.[47]	Retrospective analysis	"Anterior cruciate ligament reconstruction protected against reoperation in this young, active population; younger subjects were more likely to require late anterior cruciate ligament reconstruction."
Kostogiannis et al.[15]	Prospective cohort trial	"Early activity modification and neuromuscular rehabilitation resulted in a good knee function and an acceptable activity level in the majority of the nonreconstructed patients. The decline in activity level of patients engaged in contact sports at the time of injury affected their subjective quality of life more than patients involved in noncontact sports."
Fridén et al.[72]	Prospective cohort trial	"Articular geometry is of importance for function after an anterior ligament lesion."

*ACLD, ACL-D = anterior cruciate ligament-deficient.

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TABLE E-3 Key Conclusions of Studies Included in the Section "Return to Sports Following Nonoperative ACL Rehabilitation Versus Operative Reconstruction"

Study	Design	Key Conclusions*
Fithian et al.[23]	Review	"Most patients with anterior cruciate ligament (ACL) injuries do well with activities of daily living even after follow-up in the range of 5 to 15 years. Most can participate in some sports activity if they are inclined to do so, but most will have some limitations in vigorous sports, and only a few will be entirely asymptomatic."
Buss et al.[24]	Case series	"In a group of individuals who are older and relatively inactive, nonoperative management of anterior cruciate ligament injuries can yield satisfactory results, provided the patients are willing to accept a modest amount of instability and a slight risk of meniscal injury."
Ciccotti et al.[25]	Retrospective analysis	"Twenty-five (83 per cent) of these thirty middle-aged patients, who had had guided rehabilitation and had modified activity, had a satisfactory outcome without an operation. However, a few patients, who had combined instabilities and who wished to resume competitive sports activity that required pivoting, were dissatisfied. Such patients may need operative reconstruction to achieve their goals."
Bonamo et al.[26]	Retrospective analysis	"Multiple repeat injuries, repeat arthroscopy, isokinetic deficits, and increased length of followup were also associated with poor results."
Segawa et al.[27]	Retrospective analysis	"It should also be noted that modification of sports activity level was the most important factor for avoiding the combined injury of meniscus and osteoarthritis."
Grindem et al.[14]	Prospective pair-matched cohort study	"Anterior cruciate ligament-injured patients following a nonoperative treatment course, including recommendations of activity modifications, and operatively treated patients did not have significantly different rates of returning to pivoting sports after 1 year in this pair-matched cohort study."
Roos et al.[28]	Cross-sectional study	"A comparison of anterior cruciate ligament-injured players, whether treated by surgical reconstruction or not, revealed no difference with regard to the proportion of players still playing soccer after 7 years."
Kessler et al.[29]	Retrospective analysis	"Eleven years after ACL-rupture the physical activity levels are similar for both groups. After ACL-reconstruction, stability is higher as is osteoarthritis, whereby the result is not necessarily perceived as better subjectively."
Ageberg et al.[9]	Randomized controlled trial	"The lack of differences between patients treated with training and surgical reconstruction or training only indicates that reconstructive surgery is not a prerequisite for restoring muscle function."
Tsoukas et al.[21]	Randomized controlled trial	"ACL reconstruction using hamstrings autograft resulted in better functional outcome and laxity measurements than ACL-conservative management. However, the incidence of radiological osteoarthritis was similar between the two groups and independent on the pre-operative grade of laxity and functional status of the patients. Equally, bone bruises were not found as a risk factor for the development of osteoarthritis after ACL rupture."
Wittenberg et al.[30]	Prospective pair-matched cohort trial	"The results of operation are significantly better than after conservative treatment even when ACL reconstruction was carried out late after injury."
Fink et al.[31]	Prospective cohort trial	"A significant ($p < 0.05$) correlation between participation in high-risk pivoting sports, such as soccer or basketball and osteoarthritic changes could be found for the nonoperative group, only."
Engström et al.[33]	Case series	"Few patients were pleased with their subjective knee function after an ACL rupture despite thorough initial rehabilitation."
Barrack et al.[32]	Case series	"Young adults who return to a vocation requiring strenuous physical activity frequently can expect unsatisfactory results after nonoperative treatment of an acute complete tear of the ACL."
Eitzen et al.[34]	Case series	"Short-term progressive exercise therapy programs are well tolerated and should be incorporated in early-stage ACL rehabilitation, either to improve knee function before ACL reconstruction or as a first step in further

		nonoperative management."
Swirtun et al.[35]	Descriptive epidemiological study	"A high preinjury activity level was associated with the choice of ACL reconstruction, but the choice of treatment was not associated with age, gender or the outcome variables measured with KOOS or KT-1000."
Daniel et al.[12]	Prospective cohort trial	"Factors that correlated with patients who had late surgery for a meniscal tear or an ACL reconstruction ($P < 0.05$) were preinjury hours of sports participation, arthrometer measurements, and patient age."
Roessler et al.[36]	Randomized controlled trial	"Psychological aspects, such as motives for participation in sport, can be factors in predicting of patient-reported outcomes 2 years after injury."
Grindem et al.[37]	Prospective cohort trial	"There were few differences between the clinical courses following nonsurgical and surgical treatment of ACL injury in this prospective cohort study."

*KOOS = Knee injury and Osteoarthritis Outcome Score.

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TABLE E-4 Key Conclusions of Studies Included in the Section "Risk of Additional Knee Damage Following Operative Reconstruction Versus Nonoperative Treatment"

Authors	Design	Key Conclusions*
Neuman et al.[39]	Prospective cohort trial	"In patients with ACL injury willing to moderate activity level to avoid reinjury, initial treatment without ACL reconstruction should be considered."
Maffulli et al.[40]	Case series	"Patients with a symptomatic ACL-deficient knee and an associated tear of the medial meniscus are at high risk of having a lesion of the articular surface of the weight bearing area of the knee."
Øiestad et al.[38]	Systematic review	"No universal methodological radiologic classification method exists, making comparisons of the studies and stating firm conclusions on the prevalence of knee osteoarthritis more than 10 years after anterior cruciate ligament injury difficult."
Badlani et al.[41]	Case-control study	"Knees with meniscus tears with greater radial involvement and extrusion are at greater risk for later development of radiographic OA."
Ahn et al.[42]	Cadaver study	"An MMPH longitudinal tear in an ACL-deficient knee alters the knee kinematics, particularly the anterior-posterior tibial translation. MMPH repair significantly improved anterior-posterior tibial translation in ACL-deficient knees."
Shybut et al.[43]	Cadaver study	"This study shows that lateral meniscal root injury further destabilizes the ACL-deficient knee and thus advances the concept that the lateral meniscus is a secondary stabilizer of the knee under pivot-shift loading."
Daniel et al.[12]	Prospective cohort trial	"Factors that correlated with patients who had late surgery for a meniscal tear or an ACL reconstruction ($P < 0.05$) were preinjury hours of sports participation, arthrometer measurements, and patient age."
Buss et al.[24]	Case series	"In a group of individuals who are older and relatively inactive, nonoperative management of anterior cruciate ligament injuries can yield satisfactory results, provided the patients are willing to accept a modest amount of instability and a slight risk of meniscal injury."
Barrack et al.[32]	Case series	"Young adults who return to a vocation requiring strenuous physical activity frequently can expect unsatisfactory results after nonoperative treatment of an acute complete tear of the ACL."
Shelton et al.[44]	Case series	"Thirty patients (31 tears) returned to play with rehabilitation and a brace at an average of 5.7 weeks after injury: Only 12 patients returned to their sports without recurrent buckling of their injured knees; 18 patients (19 knees) had recurrent buckling during play. Thirteen patients could not return to play."
Hawkins et al.[45]	Case series	"Giving way was a problem for 36 (86%) of the nonoperated patients, but pain and swelling were not significant problems for most. Full return to unlimited athletic activities was possible for only 4 (14%) of the patients."
von Eisenhart-Rothe et al.[46]	Cross-sectional study	"This study shows a significant increase of translation of the medial femoral condyle in ACL-deficient knees, whereas menisco-tibial translation remains almost unchanged. This difference in translation patterns indicates that the posterior horn of the medial meniscus might encounter shear, potentially explaining the high rate of secondary medial meniscal tears in patients with ACL-deficiency."
Mihelic et al.[48]	Retrospective analysis	"94% of patients who underwent ACL reconstruction had stable knees after 15-20 years and there was a significantly lower percentage of osteoarthritis in comparison to conservatively treated patients."
Frobell et al.[49]	Randomized controlled trial	"A strategy of rehabilitation plus early ACL reconstruction did not provide better results at five years than a strategy of initial rehabilitation with the option of having a later ACL reconstruction."
Tsoukas et al.[21]	Randomized controlled trial	"ACL reconstruction using hamstrings autograft resulted in better functional outcome and laxity measurements than ACL-conservative management. However, the incidence of radiological osteoarthritis was

		similar between the two groups and independent on the pre-operative grade of laxity and functional status of the patients. Equally, bone bruises were not found as a risk factor for the development of osteoarthritis after ACL rupture."
Fithian et al.[50]	Prospective cohort trial	"Relationship between bone contusion on initial magnetic resonance images and the finding of degenerative changes on follow-up radiographs were not detected."
Kessler et al.[29]	Retrospective analysis	"Eleven years after ACL-rupture the physical activity levels are similar for both groups. After ACL-reconstruction, stability is higher as is osteoarthritis, whereby the result is not necessarily perceived as better subjectively."
von Porat et al.[52]	Retrospective analysis	"A high prevalence of radiographic knee osteoarthritis was seen in male soccer players 14 years after an ACL disruption. The injury and the osteoarthritis, irrespective of the treatment provided to these patients, often result in knee related symptoms that severely affect the knee related quality of life by middle age."
Grindem et al.[37]	Prospective cohort trial	"There were few differences between the clinical courses following nonsurgical and surgical treatment of ACL injury in this prospective cohort study."
Potter et al.[51]	Prospective cohort trial	"All patients with acute, traumatic ACL disruption sustained a chondral injury at the time of initial impact with subsequent longitudinal chondral degradation in compartments unaffected by the initial 'bone bruise,' a process that is accelerated at 5 to 7 years' follow-up."

*MMPH = medial meniscus posterior horn.

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TABLE E-5 Key Conclusions of Studies Included in the Section "Rehabilitation Regimens for Patients with Nonoperatively Treated ACL Injuries"

Authors	Design	Key Conclusions
Risberg et al.[86]	Case series	"After rehabilitation the ACL-injured subjects showed a significantly improved clinical outcome, but lower extremity biomechanics were still significantly impaired during both walking and hopping. The rehabilitation programme influenced knee joint loading during walking, but not during hopping."
Chmielewski et al.[87]	Prospective cohort trial	"Perturbation training reduced quadriceps femoris-hamstring muscle and quadriceps femoris-gastrocnemius muscle co-contractions and normalized knee kinematics in individuals with ACL rupture who were classified as potential copers. Findings from this study provide evidence for a mechanism by which perturbation training acts as an effective intervention for promoting coordinated muscle activity in a select population of people with ACL rupture."
Hartigan et al.[88]	Randomized controlled trial	"Non-copers strength and knee excursions were more symmetrical 6 months postoperatively in the group that received perturbation training and progressive quadriceps strength training than the group who received strength training alone."
Fitzgerald et al.[89]	Randomized controlled trial	"Although both the standard program and the perturbation training program may allow subjects to return to high-level physical activity, the perturbation training program appears to reduce the risk of continued episodes of giving way of the knee during athletic participation and allows subjects to maintain their functional status for longer periods."
Fitzgerald et al.[90]	Proposed practice guideline	"The rehabilitation program consisting of lower extremity muscle strength training, cardiovascular endurance training, agility and sport-specific skill training, and a training program using balance perturbations is described."
Fleming et al.[91]	Case series	"A functional knee brace can protect the anterior cruciate ligament during anterior-posterior shear loading in the nonweightbearing and weightbearing knee and during internal torques in the nonweightbearing knee."
Beynnon et al.[92]	Cross-sectional study	"This study explains why subjects with anterior cruciate ligament tears gain partial control of pathologic anteroposterior laxity with the use of a brace but may continue to experience abnormal translations during activity."
Ramsey et al.[93]	Cross-sectional study	"No consistent reductions in anterior tibial translations were observed as a function of the knee brace tested."
Lam et al.[94]	Case series	"Wearing a functional knee brace facilitated hamstring muscle reflex, but muscle fatigue lengthened the hamstring reflex latency. Subjects with ACL deficiency should not rely on the knee brace to facilitate hamstring reflex for joint protection during prolonged sporting activities when muscles are fatigued."
Kocher et al.[95]	Prospective cohort trial	"A significantly higher proportion of injuries occurred in nonbraced skiers compared with braced skiers (P = .005). The risk ratio for subsequent knee injury comparing nonbraced with braced skiers was 6.4 (13% and 2%, respectively)."
Swirtun et al.[96]	Randomized controlled trial	"When using the brace the subjects in the brace group experienced less (P = 0.047) sense of instability, evaluated with visual analogue scale, than the control group. However, bracing had no effect on any of the variables in Knee Osteoarthritis Outcome Score or Cincinnati knee score and no effect on quadriceps or hamstring muscle peak torque."
Chew et al.[97]	Literature review	"It has been shown that functional bracing may be effective in controlling anteroposterior translation in ACL-deficient knees under low loading conditions, but it may not be effective under high loading conditions that occur during athletic activities. The danger is when ACL-deficient patients are led to have a false sense of security by the use of the brace, especially when normal knee stability is not restored under higher loading conditions. Subjective improvements in knee stability and function are frequently

		reported, but objective evidence has yet to prove its effectiveness. The effectiveness of the functional brace in ACL-deficient knees depends heavily on appropriate rehabilitation programs. The decision to use functional knee braces after ACL reconstruction depends greatly on the surgical outcome in terms of stability and the patient's physiologic factors."