CLINICAL GUIDELINES

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Knee Pain and Mobility Impairments / Meniscal and Articular Cartilage Lesions

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association

J Orthop Sports Phys Ther. 2010:(_):A_-A_. doi:…………

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Recommendations*

Clinical Course: Knee pain and mobility impairments associated with meniscal and articular cartilage tears can be the result of a contact or noncontact incident, which can result in damage to 1 or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified meniscal or articular cartilage pathology following meniscal or chondral surgery. (Recommendation based on weak evidence.)

Risk Factors: Clinicians should consider time from injury and age as predisposing factors for having a meniscal injury. Patients who participated in high-level sports or had increased knee laxity after an ACL injury are more likely to have late meniscal surgery. (Recommendation based on weak evidence.)

Clinicians should consider the patients' age and presence of a meniscal tear for the odds of having a chondral lesion. Patients' age and time from initial ACL injury are predictive factors of the severity of chondral lesions and time from initial ACL injury is significantly associated with the number of chondral lesions. (Recommendation based on weak evidence.)

Diagnosis/Classification: Knee pain, mobility impairments, and effusion are useful clinical findings for classifying a patient with knee pain and mobility disorders into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: tear of the meniscus and tear of the articular cartilage; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category knee pain (b28016 Pain in joint) and mobility impairments (b7100 Mobility of a single joint). (Recommendation based on moderate evidence.)

Differential Diagnosis: Clinicians should consider diagnostic classifications associated with serious pathological conditions or psychosocial factors when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline, or, when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function. (Recommendation based on weak evidence.)

Examination – Outcome Measures: Clinicians should use a validated patient-reported outcome measure, a general health questionnaire, and a validated activity scale for patients with knee pain and mobility impairments. These tools are useful for identifying a patient's baseline status relative to pain, function, and disability and for monitoring changes in the patient's status throughout the course of treatment. (Recommendation based on weak evidence.)

Examination – Activity Limitation Measures: Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, 6-minute walk test, or timed up and go test, to assess activity limitation and participation restrictions associated with their patient's knee pain or mobility impairments and to assess the changes in the patient's level of function over the episode of care. (Recommendation based on weak evidence.)

Interventions – Progressive Knee Motion: Clinicians may utilize early progressive knee motion following knee meniscal and articular cartilage surgery. (Recommendation based on weak evidence.)

Interventions – Progressive Weight Bearing: There are conflicting opinions regarding the best use of progressive weight bearing for patients with meniscal repairs or chondral lesions. (Recommendation based on conflicting evidence.)

Interventions – Progressive Return to Activity: Clinicians may utilize early progressive return to activity following knee meniscal repair surgery. (Recommendation based on weak evidence.)

Clinicians may need to delay return to activity depending on the type of articular cartilage surgery. (Recommendation based on theoretical evidence.)

Interventions – Supervised Rehabilitation: Clinicians should consider a clinic-based program for patients following arthroscopic meniscectomy to increase quadriceps strength and functional performance. (Recommendation based on moderate evidence.)

Interventions – Neuromuscular Reeducation (Functional Exercise): Clinicians can consider neuromuscular reeducation (functional exercise) for patients following meniscectomy to increase quadriceps endurance, hamstring strength, and functional performance. (Recommendation based on weak evidence.)

Interventions – Neurmuscular Electrical Stimulation: Neuromuscular electrical stimulation can be used with patients following meniscal or chondral injuries to increase quadriceps muscle strength. (Recommendation based on weak evidence.)

Interventions – Therapeutic Exercises: Clinicians can use isokinetic strength training to increase quadriceps and hamstrings strength following meniscectomy. (Recommendation based on weak evidence.)

*These recommendations and clinical practice guidelines are based on the scientific literature published prior to July 2009.

Introduction

AIM OF THE GUIDELINE

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based practice guidelines for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International Classification of Functioning, Disability, and Health (ICF).[56]

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice including diagnosis, prognosis, intervention, and assessment of outcome for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

This guideline is not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made in light of the clinical data presented by the patient, the diagnostic and treatment options available, and the patient's values, expectations, and preferences. However, we suggest that the rationale for significant departures from accepted guidelines be documented in the patient's medical records at the time the relevant clinical decision is made.

Methods

The Orthopaedic Section, APTA appointed content experts as developers and authors of clinical practice guidelines for musculoskeletal conditions of the knee which are commonly treated by physical therapists. These content experts were given the task to identify impairments of body function and structure, activity limitations, and participation restrictions, described using ICF terminology, that could 1) categorize patients into mutually exclusive impairment patterns upon which to base intervention strategies, and 2) serve as measures of changes in function over the course of an episode of care. The second task given to the content experts was to describe the supporting evidence for the identified impairment pattern classification as well as interventions for patients with activity limitations and impairments of body function and structure consistent with the identified impairment pattern classification. It was also acknowledged by the Orthopaedic Section, APTA that a systematic search and review solely of the evidence related to diagnostic categories based on International Statistical Classification of Diseases and Health Related Problems (ICD)[55] terminology would not be sufficient for these ICF-based clinical practice guidelines as most of the evidence associated with changes in levels of impairment or function in homogeneous populations is not readily searchable using the current terminology. For this reason, the content experts were directed to also search the scientific literature related to classification, outcome measures, and intervention strategies for musculoskeletal conditions commonly treated by physical therapists. Thus, the authors of this clinical practice guideline systematically searched MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews (1966 through July 2009) for any relevant articles related to classification, outcome measures, and intervention strategies for meniscal and chondral injuries of the knee. Additionally, when relevant articles were identified their reference lists were hand-searched in an attempt to identify other articles that might have contributed to the outcome of this clinical practice guideline. This guideline was issued in 2010 based upon publications in the scientific literature prior to July 2009. This guideline will be considered for review in 2014, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA website: www.orthopt.org.

Levels of Evidence

Individual clinical research articles will be graded according to criteria described by the Center for Evidence-Based Medicine, Oxford, United Kingdom (http://www.cebm.net/index.aspx?o=1025) for diagnostic, prospective, and therapeutic studies.[101] An abbreviated version of the grading system is provided below (Table 1). The complete table of criteria and details of the grading can be found on the web at http://www.cebm.net/index.aspx?o=1025

I	Evidence obtained from high quality diagnostic studies, prospective studies, or randomized controlled trials.
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, or, randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, <80% follow-up).
III	Case controlled studies or retrospective studies

IV	Case series
V	Expert opinion

Grades of Evidence
The overall strength of the evidence supporting recommendations made in this guideline will be graded according to guidelines described by Guyatt et al[45] as modified by MacDermid and adopted by the coordinator and reviewers of this project. In this modified system, the typical A, B, C, and D grades of evidence have been modified to include the role of consensus expert opinion and basic science research to demonstrate biological or biomechanical plausibility. (Table 2)

Grades of Recommendation		Strength of Evidence
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies including statements of consensus by content experts support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles or from basic sciences/bench research support this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

Review Process
The Orthopaedic Section, APTA also selected consultants from the following areas to serve as reviewers of the early drafts of this clinical practice guideline:
- Claims review
- Coding
- Epidemiology
- Orthopaedic Section of the APTA, Inc
- Medical practice guidelines

- Orthopaedic physical therapy residency education
- Orthopaedic surgery
- Rheumatology
- Physical therapy academic education
- Sports physical therapy residency education

Comments from these reviewers were utilized by the authors to edit this clinical practice guideline prior to submitting it for publication to the *Journal of Orthopaedic & Sports Physical Therapy*.

Classification

The primary ICD-10 and conditions associated with knee pain and mobility disorders are: S83.2 Tear of meniscus, current, M23.2 Derangement of meniscus due to old tear or injury; S83.3 Tear of articular cartilage of knee, current, M93.2 Osteochondritis dissecans.

The corresponding ICD-9 CM codes and conditions, which are used in the USA, associated with knee pain and mobility disorders are: 836.0 Tear of medial cartilage or meniscus of knee, current, 836.1 Tear of lateral cartilage of meniscus of knee, current, 717.0 Old bucket handle tear of medial meniscus, 717.1 Derangement of anterior horn of medial meniscus, 717.2 Derangement of posterior horn of medial meniscus, 717.3 Other and unspecified derangement of medial meniscus, 717.40 Derangement of lateral meniscus unspecified, 717.41 Bucket handle tear of lateral meniscus, 717.42 Derangement of anterior horn of lateral meniscus, 717.43 Derangement of posterior horn of lateral meniscus, 717.49 Other derangement of lateral meniscus; 717.89 Other internal derangement of knee, 732.7 Osteochondritis dissecans, 733.92 Chondromalacia.

The primary ICF body functions codes associated with the above noted ICD-10 conditions are **b28016 Pain in joint, b7100 Mobility of a single joint,** and **b770 Gait pattern functions.**

The primary ICF body structures codes associated with knee pain and mobility disorders are **s75000 Bones of thigh, s75010 Bones of lower leg, s75011 Knee joint,** and **s75018 Structure of lower leg, specified as fibrocartilage or hyaline cartilage of the knee.**

The primary ICF activities and participation codes associated with knee pain and mobility disorders are **d2302 Completing the daily routine** and **d4558 Moving around, specified as quick direction changes while walking or running.**

The ICD-10 and primary and secondary ICF codes associated with knee pain and mobility disorders are provided in Table 3.

ICD-10 and ICF Codes Associated with Knee Pain and Mobility Disorders

INTERNATIONAL STATISTICAL CLASSIFICATION OF DISEASES AND RELATED HEALTH PROBLEMS		
Primary ICD-10	S83.2	Tear of meniscus, current
	S83.3	Tear of articular cartilage of knee, current
Secondary ICD-10	M23.2	Derangement of meniscus due to old tear or injury
	M93.2	Osteochondritis dissecans

INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY, AND HEALTH

PRIMARY ICF CODES		
Body function	b28016	Pain in joint
	b7100	Mobility of a single joint
	b7700	Gait pattern functions
Body structure	s75000	Bones of thigh
	s75010	Bones of lower leg
	s75011	Knee joint
	s75018	Structure of lower leg, specified as fibrocartilage or hyaline cartilage of the knee
Activities and participation	d2302	Completing the daily routine
	d4558	Moving around, specified as quick direction changes while walking or running
SECONDARY ICF CODES		
Body function	b7150	Stability of a single joint
	b7303	Power of muscles in lower half of the body
	b7408	Muscle endurance functions, specified as endurance of muscles of one limb
	b7601	Control of complex voluntary movements
	b770	Gait pattern functions (absence of knee catching or locking with walking and running)
Body structure	s75002	Muscles of thigh
	s75012	Muscles of lower leg
Activities and participation	d4101	Squatting
	d4102	Kneeling
	d4551	Climbing
	d4552	Running
	d4553	Jumping
	d9201	Sports

CLINICAL GUIDELINES

Impairment/Function-based Diagnosis

INCIDENCE

Injuries to the menisci are the second most common injury to the knee with an incidence of 12-14% and a prevalence of 61 cases per 100,000 persons.[1, 83, 123] A high incidence of meniscal tears occurs with an injury to the anterior cruciate ligament (ACL), ranging from 22% to 86%.[99] In the United States, 10% to 20% of all orthopaedic surgeries consist of surgery to the meniscus on an estimated 850,000 patients each year.[1, 107]

Based on all knee arthroscopies, the prevalence of articular cartilage pathologies is reported to be between 60-70%.[2, 30, 52] The incidence of isolated articular cartilage lesions is greater than one-third that of non-isolated cartilage lesions.[134] Thirty-two percent to 58% of articular cartilage lesions are the result of a traumatic, non-contact mechanism of injury.[61, 134] Sixty-four percent of all chondral lesions are less than 1 cm^2.[134] Thirty-three to sixty percent of articular cartilage lesions are greater than grade III lesions based on the International Cartilage Repair Society grading system (ICRS).[126] The ICRS cartilage injury classification consists of 5 grading levels, from grade 0 (normal cartilage without notable defects) to grade 4 (severely abnormal – full thickness osteochondral injury).[14] The most frequent localization of cartilage lesions are to the medial femoral condyle and the patella articular surface.[134] Medial meniscus tears (37%) and ACL ruptures (36%) are the most common concomitant injuries.

PATHOANATOMICAL FEATURES

The medial and lateral menisci cover the superior aspect of the tibia.[13] Each meniscus is comprised of fibrocartilage and is wedge-shaped. The lateral meniscus is more circular, whereas the medial meniscus is more crescent-shaped. The lateral meniscus is more mobile than the medial meniscus. The menisci function to distribute stress across the knee during weight bearing, provide shock absorption, serve as secondary joint stabilizers, facilitate joint gliding, prevent hyperextension, and protect the joint margins.[13] Individuals who sustain a meniscal tear report a similar history as an individual with an ACL tear, such as feeling a “pop” while suddenly changing direction with or without contact.[13] The rate of medial meniscal tears increases over time from the initial ACL injury, whereas the rate of lateral meniscal tears does not.[63, 99, 126] Prolonged delays in ACL reconstruction are related to greater occurrence of meniscus injuries.[99]

The articular cartilage that covers the gliding surfaces of the knee joint is hyaline in nature.[9, 75] Hyaline cartilage decreases the friction between gliding surfaces, withstands compression by acting as a shock absorber, and resists wear during normal situations.[9, 17] Injuries to the articular cartilage can be the result of trauma or repetitive minor trauma.[9, 61, 125, 134] Some individuals who sustain articular surface injury do not seek treatment. Many lesions are nonprogressive and remain asymptomatic, although some experts believe that even small asymptomatic lesions may increase in size and eventually become painful if left untreated.[42] In regards to operative care, 4 methods are most widely used: arthroscopic lavage and debridement, microfracture, autologous chondrocyte implantation (ACI), and osteochondral transplantation (OATS).[20, 25, 75, 136]

CLINICAL COURSE

III

A review of the literature by Meredith et al,[93] which included studies published through June 2003 and abstracts presented at the American Academy of Orthopaedic Surgeons from 1990 to 2004, concluded that short-term functional outcomes in young patients with isolated partial meniscectomy were very good. Mean Lysholm scores ranged from 80/100 to 99/100 at a follow-up of 10 years post surgery. Tegner activity scores ranged from 5/10 to 7/10 preoperatively and at peak improvement, with a slight decrease at follow-up greater than 10 years.

III

Ericsson and colleagues[36] assessed isokinetic strength and functional performance, and administered the Knee Injury and Osteoarthritis Outcome Score (KOOS) at a mean follow-up of 4 years post meniscectomy. They found lower knee extensor strength and diminished 1-leg rising capacity (single limb sit-to-stand) in the surgical limb. The mean scores for the different dimensions on the KOOS ranged from 63/100 to 89/100. Quadriceps weakness was related to all 5 subscales on the KOOS and 1-leg rising ratio.

II

Roos et al[111] conducted a prospective study to assess patient outcomes after meniscectomy. They found 40% of patients who were active in sports prior to injury had reduced their activity 3 months post-surgery. Patients showed significant improvement from pre- to post-surgery based on Lysholm scores (61/100 pre-operatively to 74/100 post-operatively).

III

Matthews and St-Pierre[90] investigated isokinetic knee extension and flexion strength following arthroscopic partial meniscectomy. Twenty-one patients had medial partial meniscectomy and 1 patient had lateral partial meniscectomy. Following surgery, patients were given a home exercise program and reevaluated every 2 weeks until week 12 post-surgery. They found strength was 15% lower in the quadriceps of the involved knee prior to surgery. Quadriceps strength in the surgical knee improved to pre-surgical levels by 4 to 6 weeks but continued to remain 12-14% lower than the uninvolved side. Hamstring strength in the involved side returned to normal levels within 2 weeks of surgery.

II

Morrissey and colleagues[97] studied the factors related to early recovery rate after partial knee meniscectomy. Eighty-three individuals were evaluated 4 days and 6 weeks following partial meniscectomy. Recovery rate was determined by the quotient of the change in the Hughston Clinic knee questionnaire during the time period by the baseline Hughston Clinic score and its relationship with demographic and knee impairment values. They found that gender, combination of gender and injured meniscus, and injury chronicity had a significant relationship with recovery rate.

IV

A recent study published by Logan and colleagues[76] investigated the long-term outcomes of meniscal repairs in elite athletes. Forty-two athletes underwent 45 meniscal repairs, including repairs of bucket-handle, radial, and complex meniscal tears. Thirty-three percent of the meniscal repairs were to the lateral meniscus and 67% to the medial meniscus. All subjects underwent the same surgical procedure and post-operative rehabilitation. The mean time from injury to surgery was 7 months (range, 0-45 months). All patients completed and returned forms that included Lysholm and International Knee Documentation Committee (IKDC) subjective knee forms. The mean follow-up time for the return of the forms was 8.5 years. At the follow-up period, the average Lysholm score was 87.4 (range, 37-100) and IKDC subjective knee score was 82.2 (range, 18-100). A vast majority (81%) of athletes returned to sports with a large number returning to the previous level of competition.

The methodological quality of articular cartilage repair studies remains generally low with the vast majority being Level IV (case series).[60] Despite the patients' improvement on the clinical outcome measures compared with preoperative assessment, the limited number of randomized, controlled trials suggests that no surgical technique has shown consistently superior results compared with others.[82] Microfracture surgery is the preferred treatment for small (less than 2 cm^2) articular cartilage lesions because of its simplicity and cost-effectiveness.[68, 95, 120]

IV

Jakobsen and colleagues[60] performed a review of cartilage repair studies. They found no significant difference in outcomes between microfracture, OATS, autologous periosteal transplantation, or ACI surgeries, possibly due to the heterogeneity of the studies and the large diversity of outcome measurement scales used.[60] They also reported that the studies were generally of low quality based on modified Coleman Methodology Score. The studies reviewed demonstrated the higher success rates were present in investigations of lesser quality. The authors concluded that caution is warranted in recommending any treatment to patients based on the low methodological quality of the reviewed studies.[60]

II

In a prospective follow-up study, Gobbi et al[42] investigated the outcome of microfracture technique for full thickness chondral knee lesions in athletes. At final follow-up (mean: 72 months), knee pain and swelling had improved in 70% of the patients. Also, single limb single hop test for distance was normal in 70% of the patients, but remained abnormal or severely abnormal in the remaining 30%. At the 2 year follow-up, Tegner score was 6/10 and at final follow-up (6 years), it had decreased to 5/10. From pre-operative assessment to final follow-up period, Lysholm scores increased by 53% and subjective reports increased by 75%.

IV

Steadman et al[120] performed a case series with a long term follow-up of 11 years (range: 7-17 years) using microfracture. They reported significant improvements in Lysholm and Tegner scores and good to excellent results based on the modified SF-36 and Western Ontario and McMaster University Osteoarthritis Index (WOMAC).

IV

Hangody et al[49] reported on a large series dating back 14 years for the use of osteochondral grafting. The series of mosaicplasties consisted of 789 implantations on femoral condyles and 31 on the tibial condyles. Clinical scores showed good to excellent results in 92% of patients with femoral condylar mosaicplasties and 87% of tibial implantations.

III

Lahav and colleagues[73] evaluated the clinical outcomes in 15 of 21 patients over a 5-year period following osteochondral autologous transplantation. At final follow-up, KOOS pain scores was 81/100, symptoms 54/100, function of activities of daily living 93/100, function of sports and recreation 65/100, and quality of life 51/100. The mean IKDC score was 68/100.

IV

Chu et al[25] reported on 55 knees which underwent osteochondral allograft transplantation with a mean follow-up of 6 years (range 11 - 147 months). Average age of the patient was 35 years. An 18-point scale was used to evaluate pain, range of motion, and function. Excellent was defined as a knee without pain, full range of motion, and allowing unlimited activity. A good knee permitted full time employment and moderate activity. Good to excellent outcomes were found in 76% (45/55) of the knees.

IV

Bugbee and Convery[20] presented the results following osteochondral allografts in 97 knees with a mean follow-up of 50 months (range 24 to 148 months). Using the same 18-point scale as Chu et al[25], 48 of 61 monopolar grafted knees were rated as good or excellent yielding, an overall success rate of 86%. The average size articular defect was 8 cm^2 (range 1 to 27). Of the bipolar grafted knees, 53% (16 of 30) were rated as good or excellent with an average total surface area of resurfacing being 23 cm^2 (range 6 to 37). 5 knees had resurfacing for multiple cartilage defects with an average total surface area of 20 cm^2. 3 knees were rated as excellent or good.

I

The Cochrane Collaboration Review[133] on ACI for full thickness articular cartilage defects of the knee included 4 randomized controlled trials with a total of 266 participants. They concluded that no significant differences existed in outcomes between ACI and other chondral lesion surgical interventions.

II

Loken and associates[77] evaluated the long-term effect of ACI to repair chondral lesions to the knee. They demonstrated that knee extension total work as tested on an isokinetic dynamometer at 60 degrees/second improved from year 1 to year 2. Isokinetic quadriceps and hamstrings testing at 60 and 240 degrees/second, also demonstrated that the surgically-treated side was significantly weaker than the uninvolved knee at year 1, 2, and 7.

I

In a systematic review, Mithoefer et al[95] evaluated 28 studies involving 3122 patients who had undergone microfracture surgery for articular cartilage damage to the knee. They reported that the average ($\pm$ SD) postoperative Lysholm score was 80.8/100 ($\pm$ 6) and the average Tegner score was 4.8/10 ($\pm$ 0.8) at the last follow-up. Good to excellent clinical improvement was seen in the first 2 years, and good clinical improvement after 2 years. Although, a moderate to high number of patients had a decrease in function between 18 and 36 months, all functional scores were greater than those obtained preoperatively.

C

Knee pain and mobility impairments associated with meniscal and articular cartilage tears can be the result of a contact or noncontact incident, which can result in damage to 1 or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified meniscal or articular cartilage pathology or following meniscal or chondral surgery.

RISK FACTORS

III

In a multi-center retrospective study, Tandogan and associates[126] investigated meniscal and chondral lesions concomitant with ACL tears and the relationship of age, time from initial injury, and level of sports participation with these lesions. Seven hundred sixty-four patients with ACL tears underwent a first-time arthroscopy. Patients' sport participation level were defined based the level of competitive sports played. The initial ACL injury was determined based the patient's history and mechanism of injury. The authors performed logistic regression to adjust for confounding factors. At 2 to 5 years following the initial ACL injury, the odds are 2.2 times higher of having a subsequent meniscal or articular cartilage tear associated with an ACL tear than in the first year. The odds increased to 5.9 after 5 years. Time from initial ACL injury and age were predictive of lateral meniscal tears. The mean time for subsequent injury in individuals who had lateral meniscal tears was 25.5 $\pm$ 41.2 months after the initial ACL injury and those who did not have lateral meniscal tears 16.6 $\pm$ 26.2 months after the initial ACL injury. The mean ages of patients with lateral meniscal tears was 27.8 $\pm$ 7.4 years and without lateral meniscus tears was 26.4 $\pm$ 7.3 years. Only time from initial ACL injury was predictive of medial meniscal tears. The mean time for subsequent injury in patients with a medial meniscus tear was 26.1 $\pm$ 39.3 months after the initial ACL injury, whereas in those who did not tear their medial meniscus was 11.4 $\pm$ 17.8 months after the initial ACL injury. Differences in mechanism of injury, lower extremity alignment, and timing of surgery may account for differences in the frequency of medial and lateral meniscal injuries.

III

Johnson and colleagues[62] reported that meniscal tears could be accurately diagnosed 76% of the time based on 30 predictors in the patient's medical history and 97% of the time based on 142 predicting questions. High-level sports participation prior to injury and the amount of knee joint laxity after injury were predictive of those who underwent late (greater than 90 days after injury) meniscal or ligament surgery but the predictive value was too weak to be of clinical value.[31, 98]

II

In a cohort study based on the Norwegian National Knee Ligament registry, Granan et al[44] reported that the odds of meniscal tears increased for each month that elapsed from the initial ACL injury date to the ACL-reconstruction surgery date. Previous surgery, age, and being a woman decreased the odds for having a meniscal injury in younger patients. In older patients, the presence of a cartilage lesion increased the odds of having a meniscal tear, whereas previous knee surgery and being a woman decreased the odds.

C

Clinicians should consider time from injury and age as predisposing factors for having a meniscal injury. Patients who participated in high-level sports or had increased knee laxity after an ACL injury are more likely to have late meniscal surgery.

III

Tandogan et al[126] performed a retrospective multi-center study to document the location and type of meniscal and chondral lesions that accompany ACL tears. Cases of 764 patients were reviewed. Nineteen percent of the knees had 1 or more chondral lesions, with the majority located in the medial tibio-femoral compartment. High rates of chondral lesions are associated with meniscal tears in the same compartment. Patients' age (greater than 30) and an ACL index injury (greater than 5 years ago) were predisposing factors for an increased number of and more severe chondral lesions.

IV

In a retrospective study, Eskelinen and colleagues[37] reviewed the records of 88 young male patients. A small percentage of chondral lesions were located on the medial femoral condyle. The majority of chondral lesions were of the superficial (grade I-II) type. The authors found that higher body mass index may predispose young male adults to more severe cartilage lesions.

IV

Biswal and colleagues[10] retrospectively reviewed 43 patients who had repeat magnetic resonance imaging (MRI) of the same knee on 2 different occasions, separated by at least 1 year. Fifty percent of the patients had sustained a sports-related injury and 23% had experienced an accidental fall. They noted that meniscal tears and ACL tears were associated with accelerated cartilage loss. Chondral lesions on the central aspect of the medial compartment had more rapid progressive loss than in other regions.

II

Granan et al[44] reported that the odds of cartilage lesions increased for each month that elapsed from the ACL injury date to surgery date for ACL-reconstruction. Previous knee surgery and being a woman decreased the odds for having chondral injury, whereas higher age increased the odds in younger patients (17-40 years). In older patients (greater than 40 years), the presence of a meniscal tear and previous knee surgery increased the odds of having a chondral lesion, whereas being a woman reduced the odds.

C

Clinicians should consider the patients' age and presence of a meniscal tear for the odds of having a chondral lesion. Patients' age and time from initial ACL injury are predictive factors of the severity of chondral lesions and time from initial ACL injury is significantly associated with the number of chondral lesions.

DIAGNOSIS/CLASSIFICATION

I

The ICD diagnosis of a meniscal tear and the associated ICF diagnosis of joint pain and mobility impairments are made with a reasonable level of certainty when the patient presents with the following clinical findings:[3, 6, 51, 78, 94, 113]

- Twisting injury
- Tearing sensation at time of injury
- Delayed effusion (6-24 hours post injury)
- History of “catching” or “locking”
- Pain with forced hyperextension
- Pain with maximum flexion
- Pain or audible click with McMurray’s maneuver
- Joint line tenderness
- Discomfort or a sense of locking or catching in the knee over either the medial or lateral joint line during the Thessaly Test when performed at 5 or 20 degrees of knee flexion

III

The ICD diagnosis of an articular cartilage defect and the associated ICF diagnosis of joint pain and mobility impairments is made with a fair level of certainty when the patient presents with the following clinical findings:[15]

- Acute trauma with hemarthrosis (0-2 hrs) (associated with osteochondral fracture)
- Insidious onset aggravated by repetitive impact
- Intermittent pain and swelling
- History of “catching” or “locking”
- Joint line tenderness

B

Knee pain, mobility impairments, and effusion are useful clinical findings for classifying a patient with knee pain and mobility disorders into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: tear of the meniscus and tear of the articular cartilage; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category knee pain (b28016 Pain in joint) and mobility impairments (b7100 Mobility of a single joint).

DIFFERENTIAL DIAGNOSIS

A primary goal of diagnosis is to match the patient's clinical presentation with the most efficacious treatment approach.[22] A component of diagnosis is to also determine whether physical therapy management is appropriate.[22] In a small percentage of patients, trauma to the thigh and knee may be something more serious than the commonly occurring contusions, muscle strains, cartilage tears or ligament disorders, such as fracture,[5] knee dislocation,[108] or neurovascular compromise.[108] In addition, following surgical intervention, serious conditions may develop, such as arthrofibrosis,[91, 92] postoperative infection and septic arthritis,[131] deep vein thrombosis,[104] anterior knee pain,[41, 54] and patella fractures.[128] Vigilance is warranted for these conditions. Clinicians should recognize the key signs and symptoms associated with serious pathological knee conditions, continually screen for the presence of these conditions throughout treatment, and immediately initiate referral to the appropriate medical practitioner when a potentially serious medical condition is suspected.[22]

V

The following differential diagnosis have been suggested for knee pain based on anatomical site:[21]

- Anterior knee pain
  - Patellar subluxation or dislocation
  - Patellar apophysitis (Singing-Larsen-Johansson lesion)
  - Tibial apophysitis (Osgood-Schlatter lesion)
  - Patellar tendinitis (Jumper's knee)
  - Patellofemoral pain syndrome
- Medial knee pain
  - Tibial (Medial) collateral ligament sprain
  - Medial meniscal tear
  - Pes anserine bursitis
  - Medial plica syndrome
  - Medial articular cartilage lesion
- Lateral knee pain
  - Fibular (Lateral) collateral ligament sprain
  - Lateral meniscal tear
  - Iliotibial band syndrome
  - Lateral articular cartilage lesion
- Posterior knee pain
  - Popliteal cyst (Baker's cyst)
  - Posterior cruciate ligament injury
  - Posterolateral corner injury
  - Distal hamstrings injury
  - Proximal gastrocnemius injury
- Non-specific knee and thigh/leg symptoms[5, 21, 91, 92, 104, 108, 131]
  - Arthrofibrosis

- Deep vein thrombosis
- Dislocation
- Fracture
- Neurovascular compromise
- Osteoarthritis
- Septic arthritis
- Referred pain from hip pathology
- Peripheral nerve entrapment
- Lumbar radiculopathy

III

Psychosocial factors may partially contribute to an inability to return to pre-injury activity levels. Fear of movement/re-injury decreases as a patient is further removed from surgery and is negatively related to knee performance as a function of time.[23] Patients who did not return to their pre-injury activity level had more fear of re-injury, which was correlated with low knee-related quality of life.[72] Elevated pain-related fear of movement/re-injury based on a shortened version of the Tampa Scale for Kinesiophobia (TSK-11) place a patient at risk for chronic disability and reducing this fear can be accomplished through patient education and graded exercise prescription.[23, 74] Thomee et al[130] found that patients' perceived self-efficacy of knee function using the knee self-efficacy scale (K-SES) prior to ACL reconstruction can possibly predict patients' return to acceptable levels of physical activity, symptoms, and muscle function 1 year following ACL reconstruction.

C

Clinicians should consider diagnostic classifications associated with serious pathological conditions or psychosocial factors when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline, or, when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

IMAGING STUDIES

I

Acute knee injury is one of most common orthopaedic conditions. When a patient reports a history of acute knee trauma, the therapist needs to be alert for the presence of fracture. Being able to properly identify when to obtain radiographs of the knee can eliminate needless radiographs and be cost-effective.[5] The Ottawa Knee rule has been developed and validated to assist clinicians in determining when to order radiographs in individuals with acute knee injury.[5, 122] A knee radiograph series are required in patients with any of the following criteria:

- Age 55 or older
- Isolated tenderness of patella (no bone tenderness of knee other than patella)
- Tenderness of head of the fibula
- Inability to flex knee to 90 degrees
- Inability to bear weight both immediately and in the emergency department for 4 steps regardless of limping

III

Clinical examination by well-trained clinicians may be as accurate as MRI in regards to the diagnosis of meniscal lesions.[69, 80] A lower threshold of suspicion of a meniscal tear is warranted in middle aged and elderly patients.[48, 80] However, a recent study found an increased prevalence of meniscal damage with increasing age, although, the majority of individuals were asymptomatic.[33] For articular cartilage pathology, clinical examination is frequently inconclusive as patients present with non-specific symptoms of joint pain or swelling that may not develop until late in the course of the disease when the subchondral bone is exposed.[18, 19] MRI may be reserved for more complicated or confusing cases, such as persistent symptoms of pain and swelling that may indicate occult cartilage or meniscal pathology.[69] In asymptomatic individuals with risk factors such as joint injury, early articular cartilage damage may be present and MRI or arthroscopy may be needed.[86, 138] When compared to arthroscopy as the clinical standard, conventional MRI sequences have an overall sensitivity of 83.2% and a specificity of 94.3% for the detection of chondral lesions.[40] MRI may assist an orthopaedic surgeon in pre-operative planning and predicting the prognosis.[69, 80]

CLINICAL GUIDELINES

Examination

OUTCOME MEASURES

A vast number of knee injury outcome scales have been developed and used over the years to evaluate a patient's disability. Recently, 2 reviews have been completed on knee outcome scales.[79, 137]

I

The Medical Outcomes Study 36-item Short Form (SF-36) is currently the most popular general health outcome measure.[137] The measure was designed to improve on the ability to measure general health outcomes without significantly lengthening the questionnaire and could be completed in less than 10 minutes. The SF-36 consists of 35 questions in 8 subscale domains and 1 general overall health status question. Each subscale score is totaled, weighted, and transformed to fall between 0 (worst possible health, severe disability) and 100 (best possible health, no disability).[100] The SF-36 form has been validated for a variety of ages and languages.[137] It has demonstrated effectiveness in a vast number of conditions pertaining to orthopaedic and sports injuries.

III

Shapiro et al[115] investigated the use of the SF-36 to determine if this assessment tool could identify patients who required ACL reconstruction, could detect changes with treatment over time, and was correlated with the IKDC knee evaluation form, Lysholm scoring scale, and the Tegner activity scale at baseline and at 3 follow-up periods. The 3 SF-36 scales related to musculoskeletal injury were analyzed: physical function, role physical, and bodily pain. One hundred sixty-three patients with ACL injuries were given the questionnaires. Follow-up evaluation occurred at 6 months and at 1 and 2 years. Subject groups consisted of patients recommended for ACL surgery with surgery performed, those recommended for surgery without surgery, those not recommended for surgery and treated non-operatively, and those not recommended for surgery initially but who underwent surgery later due to chronic symptoms. The SF-36 was able to discriminate between acute (< 4 months post-injury) and chronic (> 4 months post-injury) ACL injuries at the baseline evaluation. Although, no correlations were found at any time period in any treatment group, the authors found changes greater than 10 points in many of the physical health-based scales, indicating that this difference may be meaningful and may be significant with a larger sample size. The scores on the SF-36 and Lysholm scale were moderately correlated in the acute and chronic groups, the scores between the SF-36 physical functioning subscale and Tegner scale were minimally correlated in only the chronic ACL group, and the scores between the SF-36 and IKDC score were weakly correlated in both groups. The authors concluded that the SF-36 can discriminate between injury classification stages at baseline and can detect changes with treatment over time.

I

The Knee Outcome Survey - Activities of Daily Living Scale (KOS-ADLS) is a patient-reported measure of functional limitations and impairments of the knee during activities of daily living.[59] The KOS-ADLS contains 7 items related to other symptoms and 10 related to functional disability during activities of daily living. Each item is scored 0-5 and the total score is expressed as a percentage, with lower scores corresponding to greater disability. Irrgang et al[59] identified a higher internal consistency of the KOS-ADLS than that of the Lysholm Knee Scale. They also identified that validity of the scale was demonstrated by a moderate correlation with the Lysholm Knee Scale and the global assessment of function. They found that the KOS-ADLS is responsive for the assessment of functional limitations of the knee. The test-retest intraclass correlation coefficient ($ICC_{2,1}$) was 0.97, standard error of measurement (SEM) was 3.2, and minimum detectable change at 95% confidence level (MDC_{95}) was 8.87.

I

The Knee Injury and Osteoarthritis Outcome Score (KOOS) is designed as a patient-reported assessment for evaluating sports injuries and outcomes in the young and middle-aged athlete.[110, 137] The KOOS consists of items in 5 domains, 9 items related to pain, 7 items related to symptoms, 17 items related to activities of daily living, 5 items related to sport and recreation function, and 4 items related to knee-related quality of life. Each item is graded from 0-4. Each subscale is summed and transformed to a score of 0 (worst) to 100 (best). Roos and colleagues[110, 137] identified a moderate relationship with the physical function domains of the KOOS and the SF-36 physical health domains but weak correlations with the KOOS domains and the SF-36 mental health domains. MDC_{95} for pain, symptoms, activities of daily living, sport and recreational function, and knee-related quality of life domains are 13.85, 9.97, 11.92, 22.96, and 15.45, respectively. The pain, sport and recreation, and quality of life domains have been determined to be the most responsive to change, with the largest effect size for active, young patients.[137] The KOOS has been demonstrated to contain items regarding symptoms and disabilities important to patients with an ACL tear, isolated meniscal tears, or knee osteoarthritis.[127]

I

The International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC) is a joint-specific outcome measure for assessing symptoms, function, and sports activity pertinent to a variety of knee conditions.[137] The form contains 18 questions, in which the total scores are expressed as a percentage. The IKDC has been demonstrated to contain items regarding symptoms and disabilities important to patients with an ACL tear, isolated meniscal tears, or knee osteoarthritis.[127]

Irrgang et al[57] were able to demonstrate the responsiveness of the IKDC 2000 Subjective Knee Form. Two hundred and seven patients with a variety of knee pathologies who had scores at baseline and final follow-up participated in this study.

The authors identified that a change score of 11.5 had a sensitivity of 0.82 and a specificity of 0.64, indicating that a person who scored less than 11.5 perceived himself as not improved, whereas, a change score of 20.5 had a sensitivity of 0.64 and a specificity of 0.84, indicating that a person who scored greater than 20.5 perceived himself/herself as improved. MDC_{95} for the IKDC was a score of 12.8 for knee disorders. Based on the close agreement of the cutoff score and MDC_{95}, a score of 11.5 is necessary to distinguish between those who have improved and those who have not improved.

IV

Crawford et al[29] investigated the reliability, validity, and responsiveness of the IKDC Subjective Knee Form for injuries to the menisci utilizing 4 subsets of patients. The overall IKDC exhibited test-retest reliability with ICC of 0.95. Internal consistency was found to be acceptable (Cronbach $\alpha = 0.773$). A significant correlation ($r=0.60$) was found between the IKDC and SF-12 physical component. Construct validity was found to be significant. The SEM was 3.19 and the MDC_{95} for the IKDC was a score of 8.8 points for meniscus disorders.

II

The Lysholm Knee Scale was originally designed for follow-up evaluation of knee ligament surgery.[137] The scale contains 8 items of symptoms and function. It is scored from 0-100 points. Instability and pain are weighted the most heavily.[137] The Lysholm scale is arbitrarily graded with 95-100 as excellent, 84-94 as good, 65-83 as fair, and less than 65 as poor. Research to date on validity, sensitivity, and reliability of the Lysholm scale is inconclusive.[137] The Lysholm scale may prove to be more meaningful when combined with an activity rating scale.[114] Two studies have examined the test-retest reliability of the Lysholm Knee Scale and have demonstrated the overall ICC for test-retest reliability of 0.70 to 0.93.[12, 70]

II

The Cincinnati Knee Rating Scale is a clinician-based and patient-reported outcome measure. It was developed to assess subjective symptoms and functional activities.[137] It has been modified over the years. It has been designed as a 6 dimension scale based on a total of 100 points: symptoms (20 points), daily and sports activities (15 points), physical examination (25 points), knee stability testing (20 points), radiographic findings (10 points), and functional testing (10 points).[7] Portions of the rating scale have been validated.[137] The ICC value for test-retest reliability in patients with ACL reconstruction was greater than 0.75.[7] The MDC_{95} for pain, swelling, partial giving way, and full giving way factors was 2.45, 2.86, 2.82, and 2.30, respectively. The effect size for responsiveness for change for pain, swelling, partial giving way, full giving way, symptoms average, ACL function average, sports function average, and overall rating score was 1.4, 1.18, 1.87, 1.49, 1.74, 0.69, 1.91, and 3.49, respectively (effect size greater than 0.80 is considered large effect).

V

The Tegner Activity Level Scale was developed as a score of activity level from 0 to 10 points. The scale grades a person's activity level where 0 is 'on sick leave/disability' and 10 is 'participation in competitive sports at the national elite level.' It is commonly used in combination with the Lysholm score.[137]

III

Briggs et al[12] examined the reliability, validity, and responsiveness of the Tegner Activity Scale in patients with meniscal injuries. The Tegner Activity Scale exhibited test-retest reliability with ICC of 0.817 (95% CI: 0.75-0.87). The SEM was 0.4 and MDC_{95} was 1 point for isolated meniscal lesions.

II

The Marx Activity Level Scale is a patient-reported activity assessment. It contains 4 questions evaluating high-level functional activities. Each question is scored 0-4, based on the frequency each item is performed per week. It is designed to assess the patient's highest peak activity over the past year.[137] The scale has been validated[87] but responsiveness has not been determined.[137]

B

Clinicians should use a validated patient-reported outcome measure, a general health questionnaire, and a validated activity scale for patients with knee pain and mobility impairments. These tools are useful for identifying a patient's baseline status relative to pain, function, and disability and for monitoring changes in the patient's status throughout the course of treatment.

ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES

A variety of activity limitation and participation restriction measures have been described in the literature. The most common method to quantify lower extremity function is through functional performance tests.

Hop testing has frequently been proposed as a practical, performance-based outcome measure that reflects the integrated effect of neuromuscular control, strength, and confidence in the limb.[105]

The single limb hop tests are the most common hop tests utilized to capture limb asymmetries in patients with lower extremity dysfunction. The following 4 hop tests are primarily used in patients with knee lesions: single limb single hop for distance, single limb triple crossover hop for distance, single limb triple hop for distance, and single limb 6-m timed hop. These hop tests have demonstrated high test-retest reliability in normal, young adults.[11, 112] ICCs for single limb single hop for distance ranged from 0.92-0.96, single limb triple crossover hop for distance ranged from 0.93-0.96, single limb triple hop for distance ranged from 0.95-0.97, and single limb 6-m timed hop ranged from 0.66-0.92.

III

Low to moderate correlations were found between hop test performance and lower extremity muscular strength, as well as, between hop test performance and self-report outcome measures.[38]

Other activity limitation and participation restriction measures (6-minute walk test, stair measure, and timed up and go test) may be a part of the patient-reported outcome measure noted in this guideline's section on Outcome Measures.

C

Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, 6-minute walk test, or timed up and go test, to assess activity limitation and participation restrictions associated with their patient's knee pain or mobility impairments and to assess the changes in the patient's level of function over the episode of care.

ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES

SINGLE LIMB SINGLE HOP TEST FOR DISTANCE	
ICF category	Measurement of activity limitation, jumping
Description	The distance a patient travels when a single hop on 1 limb is performed.
Measurement method	The patient stands on the uninvolved limb, with toes on the starting line. The patient hops as far as possible forward and lands on the same limb. The distance hopped is measured from the starting line to the point where the patient's heel landed. The patient is given 2 practice trials and 2 recorded trials. Testing is repeated on the involved limb.
Nature of variable	Continuous
Units of measurement	Centimeters
Measurement properties	Test-retest reliability • Healthy individuals: $ICC_{2,3}$=0.92, SEM=4.61 cm, MDC_{95} =12.78 cm[112] • Mean distance: 208.08-208.24 cm LSI reliability in patients with ACL reconstruction[105] • $ICC_{2,1}$ = 0.92 • MDC_{90} = 8.09% • Range of mean LSI at 16 weeks post-ACL reconstruction = 81.0-82.9% • Mean LSI at 22 weeks post-ACL reconstruction = 88.2%

SINGLE LIMB TRIPLE HOP TEST FOR DISTANCE	
ICF category	Measurement of activity limitation, jumping
Description	The distance a patient travels when 3 maximal forward hops are performed in succession.
Measurement method	The patient stands on the uninvolved limb, with the toes on the starting line. The patient performs 3 consecutive maximal hops as far as possible forward and lands on the same limb. The distance hopped is measured from the starting line to the point where the patient's heel landed after the third hop. The patient is given 2 practice trials and 2 recorded trials. The test is repeated on the involved limb.
Nature of variable	Continuous
Units of measurement	Centimeters
Measurement properties	Test-retest reliability • Healthy individuals: $ICC_{2,3}$=0.97, SEM=11.17 cm, MDC_{95} = 30.96 cm[112] • Mean distance: 670.12-673.35 cm LSI reliability in patients with ACL reconstruction[105] • $ICC_{2,1}$ = 0.88 • MDC_{90} = 10.02% • Range of mean LSI at 16 weeks post-ACL reconstruction = 82.1-82.6% • Mean LSI at 22 weeks post-ACL reconstruction = 87.7%

SINGLE LIMB CROSSOVER HOP TEST FOR DISTANCE	
ICF category	Measurement of activity limitation, jumping
Description	The distance a patient travels when 3 maximal crossover forward hops are performed.
Measurement method	The patient stands on the uninvolved limb, with the toes on the starting line. The patient performs 3 consecutive maximal hops as far as possible forward and lands on the same limb while alternately crossing over a 15-cm strip on the floor. The distance hopped is measured from the starting line to the point where the patient's heel landed after the third hop. The patient is given 2 practice trials and 2 recorded trials. The test is repeated on the involved limb.
Nature of variable	Continuous
Units of measurement	Centimeters
Measurement properties	Test-retest reliability • Healthy individuals: $ICC_{2,3}$=0.93, SEM=17.74 cm, MDC_{95} = 49.17 cm[112] • Mean distance: 637.40-649.19 cm LSI reliability in patients with ACL reconstruction[105] • $ICC_{2,1}$ = 0.84 • MDC_{90} = 12.25% • Range of mean LSI at 16 weeks post-ACL reconstruction = 82.2-84.4% • Mean LSI at 22 weeks post-ACL reconstruction = 88.3%

SINGLE LIMB 6 METER HOP TEST FOR TIME	
ICF category	Measurement of activity limitation, jumping
Description	The amount of time a patient needs to hop on 1 limb a distance of 6-m as quickly as possible.
Measurement method	The patient stands on the uninvolved limb, with the toes on the starting line. After the examiner's command of "Ready, set, go", timing begins with a stopwatch accurate to 0.01 seconds. The patient hops the 6-m distance as quickly as possible with the test limb. The testing stops when the subject crosses the 6-m finish line. The patient performs 2 practice hops and performs 2 recordable hops. Testing is repeated on the involved limb.
Nature of variable	Continuous
Units of measurement	Seconds
Measurement properties	Test-retest reliability • Healthy individuals: $ICC_{2,3}$=0.93, SEM=0.06 s, MDC_{95} = 0.17 s[112] • Mean time: 1.82-1.86 s LSI reliability in patients with ACL reconstruction[105] • $ICC_{2,1}$ = 0.82 • MDC_{90} = 12.96% • Range of mean LSI at 16 weeks post-ACL reconstruction = 81.7-83.2% • Mean LSI at 22 weeks post-ACL reconstruction = 89.6%

6-MINUTE WALK TEST[27]	
ICF category	Measurement of activity limitation, walking long distances
Description	A physical performance measure which assesses how far a person can walk in 6 minutes.[34]
Measurement Method	The patient is instructed to walk as far as possible during the 6-minute time frame with the opportunity to stop and rest if required. The test is conducted on an unobstructed level surface. The distance traveled by the patient is measured to the nearest meter. Standardized verbal encouragement, "You are doing well, keep up the good work" is provided at 60-second intervals. The patient is permitted to use his regular walking aids if needed.[67]
Nature of variable	Continuous
Units of measurement	Meters
Measurement properties	Test-retest reliability • $ICC_{2,1}$: 0.95-0.97[121] • $ICC_{2,1}$: 0.94 (95% CI: 0.88-0.98)[67] • MDC_{90}: 61.34 meters in patients with total knee and hip arthroplasty[67]

TIMED UP AND GO TEST (TUG)[27]	
ICF category	Measurement of activity limitations, getting in and out of a seated position, walking short distances
Description	A physical performance measure which assesses how well a person can get up from a chair with arm rests, walk a short distance (3 meters), turn around, return, and then sit down again.[88]
Measurement Method	The patient sits in a chair with arm rests and is asked to stand up from the chair and walk as quickly and safely as possible to a point 3 meters away, turn, walk back to the chair, and sit down again. The performance of this test is timed.
Nature of variable	Continuous
Units of measurement	Seconds
Measurement properties	Intertester and intratester reliability • ICC: 0.99[103] • $ICC_{2,1}$: 0.95-0.97[121] • MDC_{90}: 2.49 seconds in patients with total knee and hip arthroplasty[67] Criterion-related validity • Good agreement among observers on the subjective scoring of the TUG[103] • Good correlation with the Berg Balance Scale (r = -0.81), gait speed (r = -0.61), Barthel's Index of activities of daily living (r = -0.78), and predicted patient's ability to walk outside safely[103]

STAIR MEASURE TEST[27]	
ICF category	Measurement of activity limitation, climbing
Description	A physical performance measure, which assesses how well a person, can ascend and descend a flight of stairs
Measurement Method	The patient is instructed to ascend and descend 9 steps (step height, 20 cm) in his usual manner, and at a safe and comfortable pace.[67]
Nature of variable	Continuous
Units of measurement	Seconds
Measurement properties	Test-retest reliability in patients with total knee and hip arthroplasty[67] • $ICC_{2,1}$: 0.90 (95% CI: 0.79-0.96) • SEM: 2.35 s (95% CI: 1.89-3.10) • MDC_{90}: 5.49 s

PHYSICAL IMPAIRMENT MEASURES

MODIFIED STROKE TEST	
ICF category	Measurement of impairment of body structure, knee joint
Description	The amount of fluid in the knee joint measured by visual inspection by clinician
Measurement method	A stroke test is performed with the patient in supine and with the knee relaxed in full extension. Starting at the medial joint line the examiner strokes upward 2 or 3 times toward the suprapatellar pouch in an attempt to move effusion from the knee. The examiner then strokes downward on the distal lateral thigh just superior to the suprapatellar pouch toward the lateral joint line. A wave of fluid may be observed within seconds on the medial side of the knee.[4, 81, 124]
Nature of variable	Ordinal
Units of measurement	Grading Zero = No wave produced with downward stroke Trace = Small wave of fluid on the medial side of the knee 1+ = Larger bulge of fluid on the medial side of the knee 2+ = Effusion completely fills the medial knee sulcus with downward stroke or returns to the medial side of the knee without downward stroke 3+ = Inability to move the effusion out of the medial aspect of the knee
Measurement properties	The modified stroke test has a Kappa value of 0.61.[124] 72% of testing pairs had perfect agreement. 8% had a disagreement of 2 grades.
Instrument variations	Other effusion tests can be used to assess knee effusion.[26, 65] In addition to visual inspection, knee effusion can be measured using a tape measure or perometer (an optoelectric device designed to measure limb volume) for knee circumference.[84, 129]

BULGE SIGN	
ICF category	Measurement of impairment of body structure, knee joint
Description	The amount of fluid in the knee joint measured by visual inspection by clinician
Measurement method	The examiner, with 1 hand located superior to the patella, pushes the tissues (and possible fluid) inferiorly towards the patella. Keeping this hand in this position while holding pressure on these tissues, the examiner uses the other hand to press the medial aspect of the knee just posterior to the patellar edge to force any fluid within the joint laterally. While watching the medial joint area, the hand over this area is taken and used to press quickly along the lateral (ie, opposite) aspect of the knee, looking for a fluid wave to present medially.
Nature of variable	Nominal
Units of measurement	• Absent • Present
Measurement properties	Reliability coefficient of 0.97[26] in patients with knee osteoarthritis.
Instrument variations	Other effusion tests can be used to assess knee effusion.[26, 65] In addition to visual inspection, knee effusion can be measured using a tape measure or perometer for knee circumference.[84, 129]

KNEE PASSIVE RANGE OF MOTION	
ICF category	Measure of impairment of body function, mobility of a single joint
Description	The amount of passive knee extension and flexion measured using a goniometer
Measurement method	For measurement using the goniometer, 1 arm of the goniometer is placed parallel to the shaft of the femur lining up with the greater trochanter, and the other arm is placed parallel to the shaft of the lower leg lining up with the lateral malleolus of the fibula. The axis of the goniometer is placed over the lateral femoral epicondyle. Knee extension: The patient is supine. The heel of the limb of interest is propped on a bolster, assuring the back of the knee and calf are not touching the support surface. The amount of knee extension is recorded with the goniometer. Knee flexion: The patient is supine. The patient flexes the knee as far as possible. The therapist then passively flexes the knee to the point of tissue resistance. The amount of knee flexion is recorded with the goniometer.
Nature of variable	Continuous
Units of measurement	Degrees
Measurement properties[102]	• Validity: ICC=0.98-0.99 • Intraexaminer reliability coefficients ranging from ICC=0.85-0.99. • Interexaminer reliability coefficients ranging from ICC=0.62 to 0.99. • SEM = 2.37^{o} , MDC_{95} = 6.57^{o}

KNEE ACTIVE RANGE OF MOTION	
ICF category	Measure of impairment of body function, mobility of a single joint
Description	The amount of active knee extension and flexion measured using a goniometer
Measurement method	For measurement using the goniometer, 1 arm of the goniometer is placed parallel to the shaft of the femur lining up with the greater trochanter, and the other arm is placed parallel to the shaft of the lower leg lining up with the lateral malleolus of the fibula. The axis of the goniometer is placed over the lateral femoral epicondyle. Knee extension: The patient is supine. The heel of the limb of interest is propped on a bolster, assuring the back of the knee and calf are not touching the support surface. The patient is asked to actively contract the quadriceps. The amount of knee extension is recorded with the goniometer. Knee flexion: The patient is supine. The patient flexes the knee as far as possible. The amount of knee flexion is recorded with the goniometer.
Nature of variable	Continuous
Units of measurement	Degrees
Measurement properties	Intraexaminer $ICC_{2,1}$ for active extension and flexion was 0.85 and 0.95, respectively.[28]

MAXIMUM VOLUNTARY ISOMETRIC QUADRICEPS STRENGTH	
ICF category	Measure of impairment of body function, power of isolated muscles and muscle groups
Description	The amount of quadriceps strength and activation of the involved limb relative to the noninvolved limb
Measurement method[24, 53]	The patient is seated on a dynamometer with hips and knees in 90 degrees of flexion. The distal tibia is secured to the dynamometer force arm just proximal to the lateral malleolus, and Velcro straps are used to stabilize the thigh and pelvis. The axis of rotation is adjusted so as to align with the lateral epicondyle of the femur. After cleansing the area with alcohol, 7.6 cm by 12.7 cm self-adhesive electrodes, used to deliver the electrical stimulus during testing, are placed over the proximal vastus lateralis and the distal vastus medialis muscle bellies. To ensure that the patient is exerting a maximal effort, the patient is familiarized with the procedure, and receives verbal encouragement from the tester and visual feedback from the dynamometer's real time force display. The patient performs 3 practice trials, and testing is initiated after 5 minutes of rest. For the test, the patient is instructed to maximally contract their quadriceps for 5 seconds during which a supramaximal burst of electrical stimulation (amplitude, 135 volts; pulse duration, 600 microseconds; pulse interval, 10 milliseconds; train duration, 100 milliseconds) is applied to the quadriceps to ensure complete muscle activation. If the force produced by the patient is less than 95% of the electrically elicited force, the test is repeated, with a maximum of 3 trials per limb. To avoid the influence of fatigue, the patient is given 2-3 minutes of rest between trials. If full activation is not achieved (voluntary torque less than 95% of the electrically elicited force) during any of the trials, the highest voluntary force output from the 3 trials is used for analysis. Custom software is used to identify the maximum voluntary force produced by both the uninvolved and involved limbs during testing. A quadriceps index is calculated as a strength test score after testing is completed by calculating (involved side maximum force/uninvolved side maximum force) x 100%.
Nature of variable	Continuous
Units of measurement	Force: Newtons Torque: Newton-meter Quadriceps index: Percentage
Measurement properties[24]	Interrater reliability $ICC_{2,1}$: 0.97-0.98

ISOKINETIC MUSCLE STRENGTH	
ICF category	Measure of impairment of body function, power of isolated muscles and muscle groups
Description	The amount of quadriceps strength of the involved limb relative to the noninvolved limb
Measurement method[89]	The patient is seated on a dynamometer with hips positioned in 90 degrees of flexion. The distal tibia is secured to the dynamometer force arm just proximal to the lateral malleolus, and Velcro straps are used to stabilize the thigh and pelvis. The axis of rotation is adjusted so as to align with the lateral epicondyle of the femur. To ensure that the patient is exerting a maximal effort, he is familiarized with the procedure and receives verbal encouragement from the tester and visual feedback from the dynamometer's real time force display. The patient performs 3 practice trials, and testing is initiated after 5 minutes of rest. For the test, the patient is instructed to perform 3 to 5 repetitions of maximal concentric and eccentric contractions for extension and flexion of each knee at 60 or 120 degrees/second and 25 to 30 repetitions of maximal concentric and eccentric contractions for extension and flexion of each knee at 180 or 240 degrees/second. Custom software is used to identify the maximum voluntary force produced by both the uninvolved and involved limbs during testing. Peak torque and total work can be determined. A quadriceps index can be calculated as a strength test score after testing is completed by calculating (involved side maximum force/uninvolved side maximum force) x 100.
Nature of variable	Continuous
Units of measurement	Torque: Newton-meter Work: Joules Quadriceps index: Percentage
Measurement properties[118]	Test-retest reliability ICCs (95%CI): Peak Torque / Work Concentric extension: 0.93(0.81-0.97) / 0.94(0.83-0.98) Concentric flexion: 0.93(0.80-0.97) / 0.88(0.69-0.96) Eccentric extension: 0.93(0.81-0.97) / 0.95(0.87-0.98) Eccentric flexion: 0.94(0.85-0.98) / 0.94(0.84-0.98) MDC_{95}: Peak Torque / Work

	Concentric extension	22.76	18.02
	Concentric flexion	15.44	22.73
	Eccentric extension	33.93	21.81
	Eccentric flexion	17.96	20.68

KNEE JOINT LINE TENDERNESS			
ICF category	Measure of impairment of body function, pain in joint		
Description	The amount of tenderness present along the medial and lateral joint lines of the knee joint		
Measurement method	The examiner palpates the medial and lateral joint lines of the knee joint. The presence of tenderness is recorded.		
Nature of variable	Nominal		
Units of measurement	• Absent • Present		
Measurement properties	Diagnostic Accuracy[71, 94]		
			95% Confidence interval (CI)
	Sensitivity	76%	73 - 80%
	Medial meniscus	83%	71 - 90%
	Lateral meniscus	68%	46 - 85%
	Specificity	77%	64 - 87%
	Medial meniscus	76%	55 - 89%
	Lateral meniscus	97%	89 - 99%
	Positive predictive value		
	Medial meniscus	91%	81 - 96%
	Lateral meniscus	87%	62 - 96%
	Negative predictive value		
	Medial meniscus	59%	41 - 75%
	Lateral meniscus	91%	82 - 96%
	Diagnostic accuracy		
	Medial meniscus	81%	71- 88%
	Lateral meniscus	90%	82 - 95%
	Negative likelihood ratio		
	Medial meniscus	0.2	0.2 - 0.3
	Lateral meniscus	0.3	0.2 - 0.4
	Positive likelihood ratio		
	Medial meniscus	3	2 - 5
	Lateral meniscus	22	8 - 64
	Diagnostic odds ratio	10.98	3.02 - 39.95
	Medial meniscus	15	5 - 50
	Lateral meniscus	68	12 - 376
Testing variation	No data exists on joint line tenderness for the diagnosis of chondral defects.		

McMURRAY'S TEST			
ICF category	Measure of impairment of body function, mobility in a joint		
Description	A palpable or audible thud or click during McMurray's test		
Measurement method[113]	The patient is supine. The examiner grasps the ankle of the tested limb with 1 hand. The opposite hand is placed on the tested knee with the thumb over the lateral joint line and the middle finger over the medial joint line. The knee is maximally flexed, externally rotated, and then slowly extended to assess the medial meniscus. The knee is maximally flexed, internally rotated, and then slowly extended to evaluate the lateral meniscus.		
Nature of variable	Nominal		
Units of measurement	• Absent • Present		
Measurement properties	Diagnostic Accuracy[71, 94]		
			95% CI
	Sensitivity	55%	50 - 60%
	Medial meniscus	50%	38 - 62%
	Lateral meniscus	21%	9 - 43%
	Specificity	77%	62 - 87%
	Medial meniscus	77%	57 - 90%
	Lateral meniscus	94%	85 - 98%
	Positive predictive value		
	Medial meniscus	86%	71 - 94%
	Lateral meniscus	50%	22 - 78%
	Negative predictive value		
	Medial meniscus	35%	23 - 50%
	Lateral meniscus	80%	70 - 88%
	Diagnostic accuracy		
	Medial meniscus	57%	46 - 67%
	Lateral meniscus	77%	67 - 85%
	Negative likelihood ratio		
	Medial meniscus	0.6	0.6 - 0.7
	Lateral meniscus	0.8	0.8 - 1.0
	Positive likelihood ratio		
	Medial meniscus	2	1 - 3
	Lateral meniscus	3	0.3 - 35
	Diagnostic odds ratio	3.99	1.04 - 15.31
	Medial meniscus	3	1 - 10
	Lateral meniscus	4	0.9 - 18
Testing variation	A varus or valgus stress may be applied during the McMurray's test to reproduce thud or click. Isolated re-creation of pain constitutes a positive test.		

THESSALY TEST	
ICF category	Measure of impairment of body function, pain in joint and mobility of a joint
Description	Discomfort or a sense of locking or catching in the knee over either the medial or lateral joint line
Measurement method[113]	The patient is standing. The patient is instructed to stand on the tested limb. The patient can use upper extremity support by holding the clinician's hands during the test. The patient rotates his knee and body internally and externally 3 times with the knee in 5° and 20° of flexion.
Nature of variable	Nominal
Units of measurement	• Absent • Present
Measurement properties	Diagnostic Accuracy[71, 113]

<u>5° knee flexion</u>		<u>95% CI</u>
Sensitivity		
Medial meniscus	41 - 66%	
Lateral meniscus	16 - 81%	
Specificity		
Medial meniscus	68 - 86%	
Lateral meniscus	89 - 91%	
Positive predictive value		
Medial meniscus	77%	60 - 89%
Lateral meniscus	30%	11 - 60%
Negative predictive value		
Medial meniscus	31%	20 - 45%
Lateral meniscus	77%	66 - 85%
Diagnostic accuracy		
Medial meniscus	49 - 86%	
Lateral meniscus	71 - 90%	
Negative likelihood ratio		
Medial meniscus	0.9	0.8 - 1.0
Lateral meniscus	1.0	0.8 - 1.0
Positive likelihood ratio		
Medial meniscus	1.0	1 - 2
Lateral meniscus	1.0	0 - 59
Diagnostic odds ratio		
Medial meniscus	2	1 - 4
Lateral meniscus	1	0.3 - 6
<u>20° knee flexion</u>		<u>95% CI</u>
Sensitivity		
Medial meniscus	59 - 89%	
Lateral meniscus	67 - 92%	
Specificity		

	Medial meniscus	83 - 97%	
	Lateral meniscus	95 - 96%	
	Positive predictive value		
	Medial meniscus	83%	69 - 92%
	Lateral meniscus	66%	35 - 88%
	Negative predictive value		
	Medial meniscus	37%	23 - 53%
	Lateral meniscus	81%	71 - 89%
	Diagnostic accuracy		
	Medial meniscus	61 - 94%	
	Lateral meniscus	80 - 96%	
	Negative likelihood ratio		
	Medial meniscus	0.6	0.5 - 1.0
	Lateral meniscus	0.7	0.6 - 1.0
	Positive likelihood ratio		
	Medial meniscus	2	1 - 2
	Lateral meniscus	6	2 - 25
	Diagnostic odds ratio		
	Medial meniscus	3	1 - 8
	Lateral meniscus	9	2 - 40

Meniscal pathology composite score[78]	
ICF category	Measure of impairment of body function, mobility in a joint
Description	The combination of 5 common diagnostic tests normally used to assess for the presence of a meniscal tear
Measurement method	1. History of mechanical catching or locking reported by the patient 2. Joint line tenderness 3. Pain with forced knee hyperextension 4. Pain with maximum passive knee flexion 5. Pain or audible click with McMurray's maneuver
Nature of variable	Nominal
Units of measurement	• Absent • Present
Measurement properties[78]	Diagnostic Accuracy 5 positive findings Sensitivity 11.2% Specificity 99.0% Positive predictive value 92.3% Negative predictive value 51.5% Diagnostic accuracy 54.1% Negative likelihood ratio 0.90 Positive likelihood ratio 11.20 Diagnostic odds ratio 12.44 ≥ 4 positive findings Sensitivity 16.7% Specificity 96.1% Positive predictive value 81.8% Negative predictive value 49.7% Diagnostic accuracy 55.5% Negative likelihood ratio 0.87 Positive likelihood ratio 4.28 Diagnostic odds ratio 4.92 ≥ 3 positive findings Sensitivity 30.8% Specificity 90.2% Positive predictive value 76.7% Negative predictive value 55.4% Diagnostic accuracy 59.8% Negative likelihood ratio 0.77 Positive likelihood ratio 3.14 Diagnostic odds ratio 4.08 ≥ 2 positive findings Sensitivity 51.4%

	Specificity	71.6%
	Positive predictive value	65.5%
	Negative predictive value	58.4%
	Diagnostic accuracy	61.2%
	Negative likelihood ratio	0.68
	Positive likelihood ratio	1.81
	Diagnostic odds ratio	2.66
		≥ 1 positive findings
	Sensitivity	76.6%
	Specificity	43.1%
	Positive predictive value	58.6%
	Negative predictive value	63.8%
	Diagnostic accuracy	60.3%
	Negative likelihood ratio	0.54
	Positive likelihood ratio	1.35
	Diagnostic odds ratio	2.50
		0 positive findings
	Sensitivity	23.4%
	Specificity	56.9%
	Positive predictive value	36.2%
	Negative predictive value	41.4%
	Diagnostic accuracy	39.7%
	Negative likelihood ratio	1.35
	Positive likelihood ratio	0.54
	Diagnostic odds ratio	0.40

CLINICAL GUIDELINES

Interventions

A variety of interventions have been described for the treatment of knee pain and mobility impairments associated with meniscal or cartilage tears. A limited amount of evidence for high-quality randomized, controlled trials and systematic reviews exists to support the benefits of physical therapy interventions in these patients.

PROGRESSIVE KNEE MOTION

IV

Haapala et al[46, 47] studied the effects of immobilization and subsequent remobilization on dogs. The right hind limbs were immobilized for 11 weeks and subsequently remobilized for 50 weeks. After immobilization the mean thickness of uncalcified cartilage at the medial femur was 19-20% but no changes of total cartilage, calcified, and uncalcified cartilage thickness were observed on the lateral femur or medial tibia. Cartilage proteoglycan content was decreased by 29-44% in the medial compartment with no changes in the lateral compartment compared to controls. Equilibrium shear modulus was decreased on the summit of the lateral femur and tibia after 11 weeks of immobilization. After remobilization, equilibrium shear modulus returned to control levels in the tibia but was still only 85% of control levels in the femur.

IV

Jurvelin and colleagues[64] studied the biomechanical properties of articular cartilage after 11 weeks of immobilization and 15 weeks of remobilization in dogs. After immobilization, cartilage thickness over the femur was reduced by 13%, over the medial tibia by 6% , and over the lateral tibia by 4%. Elastic modulus was decreased by 17-25%. Equilibrium shear modulus was still reduced as compared to controls after remobilization.

III

In a retrospective study, Rodrigo et al[109] investigated the use of continuous passive motion (CPM) devices in patients following debridement with microfracture. Patients (n=295) were assigned to 2 groups: CPM use or non-CPM use. Patients were not randomized into groups, but usually placed into groups based on insurance coverage for the use of CPM. Patients in the CPM group utilized a CPM machine 6 to 8 hours per day for 8 weeks. Patients in the non-CPM group were advised to perform several hundred repetitions of active extension and flexion of the operated knee 3 times per day. Seventy-seven patients underwent second-look arthroscopy. Upon second-look arthroscopy, 85% of patients who used a CPM machine had a satisfactory outcome in lesion grade, whereas, only 15% of those patients who did not use a CPM machine had a satisfactory outcome in lesion grade.

II

In a randomized controlled clinical trial, Kelln and associates[66] investigated the use of cycle ergometry to determine if early, active range of motion was beneficial to patients after partial knee meniscectomy. Thirty-one subjects (11 men, 20 women) were divided into a control and interventional group (using a cycle ergometer). They evaluated 3 different knee girth circumferences, knee range of motion, gait, quality of quadriceps contraction, and 3 IKDC questionnaires pre-operatively, and at day 1, weeks 1 and 2, and months 1 and 3 post-operatively. For knee girth measurements, pre-operative values were less than post-operative values. Pre-operative knee flexion values were significantly less than post-operative values, whereas pre-operative knee extension was only significantly less than post-operative day 1. The intervention group exhibited better gait patterns than the control group. For IKDC scores, pre-operative values were significantly less for all but 1 post-operative measures. Randomization was not clearly described.

V

Heckmann and colleagues[50] recommend the use of a hinged, long-leg brace for the first 6 weeks to be used by patients following complex meniscal repairs and transplants. These authors recommend that the brace be opened from 0 to 90^{o} immediately after surgery but locked at 0^{o} extension at night for the first 2 weeks. This is used to prevent range of motion limitations after complex meniscal repairs and transplants.

III

In a study assessing the effect of accelerated rehabilitation including no bracing in individuals following meniscus repair, Barber[8] found no significant differences between the healing rates of meniscal repairs in the standard and accelerated rehabilitation groups.

IV

Shelbourne and associates[116] reported on clinical results of accelerated rehabilitation including no bracing after isolated meniscal repair. Sixty-nine patients with isolated meniscal repairs were included in this study. Rehabilitation in the standard group consisted of limited range of motion and weight bearing until 6 weeks after repair. Patients were restricted from returning to sporting activity until after 4 months. The accelerated rehabilitation group consisted of immediate weight bearing as tolerated, early mobilization with emphasis on prevention of knee effusion and patients could return to sports when full range of motion was achieved along with demonstration of a 75% strength index and completion of a functional running program. Meniscal repair was successful in managing symptoms in 88% of the standard group and in 90% of the accelerated group. The accelerated group showed a shorter time period to full range of motion, higher quadriceps strength at 2 months, and a more rapid return to full activity. However, randomization and statistical analysis was not reported in the clinical results.

C

Clinicians may utilize early progressive knee motion following knee meniscal and articular cartilage surgery.

PROGRESSIVE WEIGHT BEARING

III

Barber[8] investigated the effects of accelerated rehabilitation in individuals who underwent meniscal repair using a minimum of a12-month follow-up. Ninety-five patients were included in the study. The standard rehabilitation group (n=58 meniscal repairs) consisted of immobilization with a brace in a flexed position for 6 weeks, and non-weight bearing up to 12 weeks. When the brace use was terminated, an exercise program was initiated and pivoting sports were restricted for 6 months post-surgery. The accelerated rehabilitation group (n=40 meniscal repairs) consisted of no bracing, no limits in range of motion, and full weight bearing as tolerated. Return to all activities including pivoting sports was permitted as soon as desired. Failure of a meniscal repair was defined as incomplete healing noted at second-look arthroscopy or objective signs of meniscal tear. In the standard group, an 84% success rate was noted in acute tears that were repaired (n=43), 73% in chronic tears that were repaired (n=15), 67% success rate in meniscal repairs in unstable knees (n=15), 77% in knees with intact ACLs (n=13), and 90% success rate in knees that were stabilized after ACL reconstruction (n=30). In the accelerated group, an 83% success rate in acute tears that were repaired (n=23), 100% in chronic tears (n=16), 50% success in unstable knees (n=2), 75% in knees with intact ACLs (n=4), and 94% success rate in knees that were stabilized after ACL reconstruction (n=34). No significant differences were seen between the healing rates of meniscal repairs in the standard and accelerated rehabilitation groups.

IV

Shelbourne et al[116] reported on clinical results of accelerated rehabilitation after isolated meniscal repair. Sixty-nine patients with isolated meniscal repairs were included in this study. Rehabilitation in the standard group consisted of limited range of motion and weight bearing until 6 weeks after repair. Patients were restricted from returning to sporting activity until after 4 months. The accelerated rehabilitation group consisted of immediate weight bearing as tolerated, early mobilization with emphasis on prevention of knee effusion, and patients could return to sports when full range of motion was achieved as well as demonstrating a 75% strength index and completing of functional running program. Meniscal repair was successful in managing symptoms in 88% of the standard group and in 90% of the accelerated group. The accelerated group showed a more rapid return in full range of motion (6 weeks in the accelerated group versus 10 weeks in the standard group), a higher quadriceps strength at 2 months (82% in the accelerated group versus 71% in the standard group), and an accelerated return to full activity (10 weeks in the accelerated group versus 20 weeks in the standard group). However, randomization and statistical analysis was not reported in the clinical results.

V

In a clinical commentary, Heckmann et al[50] recommends that patients who undergo peripheral meniscal repairs to be partial weight bearing for the first 2 weeks and progress to full weight bearing at 3-4 weeks post surgery. They recommend that patients who undergo complex meniscal repairs or transplantations restrict their weight bearing for the first 6-8 weeks. This limitation is designed to control high compressive and shear forces that could disrupt the healing meniscus repair or transplant.[50]

V

In clinical commentaries by Irrgang and Pezzullo[58] and Buckwalter,[16] the authors suggest that articular cartilage healing may benefit from compression of the articular cartilage lesions without concomitant shear stress, whereas premature, or excessive loading, especially with shear forces during compression, may impede or inhibit healing.

D

There are conflicting opinions regarding the best use of progressive weight bearing in patients with meniscal repairs or chondral lesions.

PROGRESSIVE RETURN TO ACTIVITY

III

Barber[8] studied the effects of accelerated rehabilitation in individuals who underwent meniscal repair at a minimum of 12-month follow-up. Fifty-six patients were placed in the standard rehabilitation group consisting of immobilization with a brace in a flexed position for 6 weeks. When the brace use was terminated, an exercise program was initiated and pivoting sports were restricted for 6 months post-surgery. Thirty-nine patients were placed in the accelerated rehabilitation group which consisted of no bracing, no limits in range of motion, and full weight bearing as tolerated. Return to all activities including pivoting sports was permitted as soon as desired. Failure of a meniscal repair was defined as incomplete healing noted at second-look arthroscopy or objective signs of meniscal tear. In the standard group, 7 of 43 repairs failed for the acute tears that were repaired, 4 of the 15 chronic tears that were repaired failed, 5 of 15 repairs in unstable knees failed, 3 of 13 repairs in knees with intact ACLs failed, and 27 of 30 repairs in knees that were stabilized after ACL reconstruction were considered successful. In the accelerated group, 4 of 23 repairs failed for the acute tears that were repaired, 0 of 16 chronic tears that were repaired failed, 1 of 2 repairs failed in unstable knees, 1 of 4 repairs failed in knees with intact ACLs, and 2 of 34 repairs failed in knees that were stabilized after ACL reconstruction. No significant differences were seen between the healing rates of meniscal repairs in the standard and accelerated rehabilitation groups.

IV

Shelbourne et al[116] described the results of clinical outcomes of accelerated rehabilitation after isolated meniscal repair. Sixty-nine patients with isolated meniscal repairs were included in this study. Rehabilitation in the standard group consisted of limited range of motion and weight bearing until 6 weeks after repair and patients were allowed to return to sporting activity after 4 to 6 months. The accelerated rehabilitation group consisted of immediate weight bearing as tolerated, early mobilization with emphasis on prevention of knee effusion and patients could return to sports when full range of motion was achieved as well as demonstrating a 75% strength index and the completion of a functional running program. Meniscal repair was unsuccessful in managing symptoms in 12% in the standard group and 10% in the accelerated group. The standard group showed a delayed return in full range of motion, a lower quadriceps index at 2 months, and a slower return to full activity.

IV

Mariani et al[85] investigated the use of accelerated rehabilitation, which included early mobilization and weight-bearing, in 22 patients with bone-patella tendon-bone autograft ACL reconstruction and concomitant outside-in meniscal repair. Patients were reviewed by clinical assessment and MRI at a mean follow-up of 28 months. Good results were reported in 77.3% of patients, normal knee extension was exhibited in 88.9% of patients, and clinical signs of meniscal retear were noted in 13.6% of patients. Based on these results, the authors concluded that accelerated rehabilitation in these patients had no deleterious effects.

IV

Reinold et al[106] suggest in a recent clinical commentary that the return to competitive athletics should be delayed to allow for full maturation of the repaired articular cartilage, which may take up to 15 to 18 months post surgery. Surgical procedures such as OATS and ACI are designed to return individuals to normal activities of daily living function, although, some may return to high level activities.

C

Clinicians may utilize early progressive return to activity following knee meniscal repair surgery.

E

Clinicians may need to delay return to activity depending on the type of articular cartilage surgery.

SUPERVISED REHABILITATION

II

Moffet et al[96] conducted a randomized controlled trial on the efficacy of an early, intensive, supervised rehabilitation program on knee strength recovery in the first 3 weeks post-meniscectomy. Strength measurements were performed pre-operatively and 3 weeks post surgery at 30 and 180 degrees/second on an isokinetic dynamometer. They demonstrated that patients who received 9 supervised physical therapy visits had better knee extensor strength recovery than patients who only received a home-based program ($p < 0.001$). In a subgroup analysis matched on pre-operative knee extension work deficits and type of meniscal lesion, the home-based group strength differences was as much as 26% lower compared to the supervised group at 3 weeks post meniscectomy. Preoperatively, the matched groups had similar knee extension work deficits (as compared to the uninvolved limb) of 18% at 30 degrees/second and 12% at 180 degrees/second. Post-operatively, the home-based group had 40% deficit at 30 degrees/second and 42% deficit at 180 degrees/second, whereas, the supervised group had 15% deficit at 30 degrees/second and 16% deficit at 180 degrees/second.

II

Vervest et al[132] randomized 20 patients into 2 groups: home-based group and supervised exercise group. Distance and height of single limb hops, pain, Tegner and Lysholm scores, and sports and occupational rating scales were measured at 7, 14, 21, and 28 days post meniscectomy. At 28 days post surgery, the supervised exercise group was significantly better than the home-based group regarding Sports Activity Rating scale and hop tests. However, no differences were noted in functional outcomes, pain, or patient satisfaction.

II

In a randomized controlled trial, Goodwin et al[43] randomly assigned 84 patients to either a supervised program with a home program or a home program alone. Blinded sessions were conducted at 5 and 50 days post surgery. The examined patients' self-reported outcomes with the Hughston Clinic, Medical Outcomes Study SF-36, the EuroQol EQ-5D questionnaires, and the number of days to return to work after surgery divided by the Factor Occupational Rating System score. Functional performance was measured with vertical and horizontal hops. The authors demonstrated no differences in outcome measures or return to work between patients who received a home-based program and patients who received supervised physical therapy along with a home program. This study only consisted of immediate follow-up.

B

Clinicians should consider a clinic-based program for patients following meniscectomy to increase quadriceps strength and functional performance.

NEUROMUSCULAR REEDUCATION (FUNCTIONAL EXERCISE)

II

Ericsson et al[35] studied the effects of multimodal functional exercise program on performance and muscle strength in patients who had undergone meniscectomy between 1 and 6 years previously. Forty-five patients (22 in exercise group, 23 in control group) were initially evaluated. Patients were evaluated on the functional performance of a single limb single hop test and single limb raise (single limb sit-to-stand) to failure, and isokinetic muscle strength (peak torque of 5 trials at 60 degrees/second) and muscle endurance (total work of 25 repetitions at 180 degrees/second) testing of the quadriceps and hamstrings on an isokinetic dynamometry. The exercise group demonstrated greater improvement in single limb single hop test, hamstrings strength at 60 degrees/second, and quadriceps endurance at 180 degrees/second. All functional tests, hamstring strength, and quadriceps endurance improved from baseline to follow-up in the exercise group, with no changes noted in the control group. Moderate correlations were seen between the number of supervised sessions and performance on the single limb single hop test, and quadriceps and hamstring endurance.

C

Clinicians can consider neuromuscular reeducation (functional exercise) for patients following meniscectomy to increase quadriceps endurance, hamstring strength, and functional performance.

NEUROMUSCULAR ELECTRICAL STIMULATION

II

Williams et al[135] investigated the effects of electrical stimulation on quadriceps strength in patients following meniscectomy. Eighteen men and 3 women were recruited for this study. The mean age of the patients was 33 years old (range 18-45 years). Thirteen subjects were randomly assigned to the experimental group and 8 subjects were assigned to the control group. All subjects were painfree during activities of daily living, and had minimal to no effusion. The average time from surgery to the initial testing was 44 days (range 16-88 days). All subjects were tested on an isokinetic dynamometer for isokinetic knee extension and flexion torque at 120, 180, 240, and 300 degrees/seconds before and after the training period. All subjects underwent a 3 week training period. The control group received quadriceps and hamstrings isometrics and a progressive isotonic resistance training program 3 times/week. The experimental group received the same isometric and isotonic training program. Their training program was augmented with electrical stimulation to the involved quadriceps muscles. The testing position was performed with the knee flexed at 35 degrees and the ankle was stabilized to create an isometric contraction to the quadriceps. The electrical stimulation was delivered at a 2500 Hz sinusoidal current at 50 pulses per second 5 times per week for 3 weeks, for 15 seconds on with 3.5 second ramp and 50-second rest period for 10 minutes each session. In the control group, quadriceps torque significantly increased at 120 and 180 degrees/second, and average speed. In the experiment group, quadriceps torque significantly increased at all speeds and average speed. However, the study did not describe the randomization process. No comparisons in quadriceps torque were made between the control and experimental groups.

IV

Limited research has explored the use of electrical stimulation to increase thigh muscle strength following meniscal or chondral injuries. However, a larger number of studies have shown positive effects of electrical stimulation in patients with reduced quadriceps strength in patients with ACL injuries. Fourteen randomized controlled trials have evaluated the use of electrical stimulation during ACL rehabilitation.[139] A variety of parameters for the electrical stimulation were used, making generalized conclusions difficult. Improved isokinetic strength was noted in some studies with no correlation with patient outcomes or functional performance. However, neuromuscular stimulation may improve quadriceps strength if applied in a high-intensity setting (2500-Hz alternating current at 75 burst per second 2-3 times per week for 3-12 weeks, for 10-15 seconds on with 50-second rest period[32, 39, 117]) early in the rehabilitation process.

C

Neuromuscular electrical stimulation can be used with patients following meniscal or chondral injuries to increase quadriceps muscle strength.

THERAPEUTIC EXERCISES

II

St-Pierre and associates[119] investigated the effects of isokinetic muscle strengthening in patients following meniscectomy. Sixteen subjects were randomly assigned to either an early (2 weeks) or delayed (6 weeks) isokinetic strengthening program. Quadriceps and hamstrings peak torque was measured isometrically at 60 degrees of knee flexion and isokinetically at four different velocities (60, 120, 180, and 240 degrees/second) pre-operatively, and at 2, 6, and 10 weeks post-operatively. Isokinetic muscle training was performed 3 times per week for 1 to 2 months. The authors found no differences between groups but found a time effect. Knee extensors and flexors torques were lower at 2 weeks post-operatively than pre-operatively at all testing velocities. By 6 weeks, quadriceps and hamstrings torque had been restored to pre-operative levels. From 6 to 10 weeks, quadriceps and hamstring strength continued to increase. This study contained no control group and had a small sample size.

C

Clinicians can use isokinetic strength training to increase quadriceps and hamstrings strength following meniscectomy.

CLINICAL GUIDELINES

SUMMARY OF RECOMMENDATIONS

C

CLINICAL COURSE

Knee pain and mobility impairments associated with meniscal and articular cartilage tears can be the result of a contact or noncontact incident, which can result in damage to 1 or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified meniscal or articular cartilage pathology or following meniscal or chondral surgery.

C

RISK FACTORS – meniscus

Clinicians should consider time from injury and age as predisposing factors for having a meniscal injury. Patients who participated in high-level sports or had increased knee laxity after an ACL injury are more likely to have late meniscal surgery.

C

RISK FACTORS – articular cartilage

Clinicians should consider the patients' age and presence of a meniscal tear for the odds of having a chondral lesion. Patients' age and time from initial ACL injury are predictive factors of the severity of chondral lesions and time from initial ACL injury is significantly associated with the number of chondral lesions.

A

DIAGNOSIS/CLASSIFICATION

Knee pain, mobility impairments, and effusion are useful clinical findings for classifying a patient with knee pain and mobility disorders into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: tear of the meniscus and tear of the articular cartilage; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category knee pain (b28016 Pain in joint) and mobility impairments (b7100 Mobility of a single joint).

C

DIFFERENTIAL DIAGNOSIS

Clinicians should consider diagnostic classifications associated with serious pathological conditions or psychosocial factors when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline, or, when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

C

EXAMINATION – OUTCOME MEASURES

Clinicians should use a validated patient-reported outcome measure, a general health questionnaire, and a validated activity scale for patients with knee pain and mobility impairments. These tools are useful for identifying a patient's baseline status relative to pain, function, and disability and for monitoring changes in the patient's status throughout the course of treatment.

C

EXAMINATION – ACTIVITY LIMITATION MEASURES

Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, 6-minute walk test, or timed up and go test, to assess activity limitation and participation restrictions associated with their patient's knee pain or mobility impairments and to assess the changes in the patient's level of function over the episode of care.

C

INTERVENTIONS – PROGRESSIVE KNEE MOTION

Clinicians may utilize early progressive knee motion following knee meniscal and articular cartilage surgery.

D

INTERVENTIONS – PROGRESSIVE WEIGHT BEARING

There are conflicting opinions regarding the best use of progressive weight bearing for patients with meniscal repairs or chondral lesions.

C

INTERVENTIONS – PROGRESSIVE RETURN TO ACTIVITY – meniscus

Clinicians may utilize early progressive return to activity following knee meniscal repair surgery.

E

INTERVENTIONS – PROGRESSIVE RETURN TO ACTIVITY – articular cartilage

Clinicians may need to delay return to activity depending on the type of articular cartilage surgery.

B

INTERVENTIONS – SUPERVISED REHABILITATION

Clinicians should consider a clinic-based program for patients following arthroscopic meniscectomy to increase quadriceps strength and functional performance.

C

INTERVENTIONS – NEUROMUSCULAR REEDUCATION (FUNCTIONAL EXERCISE)

Clinicians can consider neuromuscular reeducation (functional exercise) for patients following meniscectomy to increase quadriceps endurance, hamstring strength, and functional performance.

C

INTERVENTIONS – NEUROMUSCULAR ELECTRICAL STIMULATION

Neuromuscular electrical stimulation can be used with patients following meniscal or chondral injuries to increase quadriceps muscle strength.

INTERVENTIONS – THERAPEUTIC EXERCISES

C

Clinicians can use isokinetic strength training to increase quadriceps and hamstrings strength following meniscectomy.

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