DAVID S. LOGERSTEDT, PT, MA • LYNN SNYDER-MACKLER, PT, ScD • RICHARD C. RITTER, DPT • MICHAEL J. AXE, MD

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

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REVIEWERS: Roy D. Altman, MD • Matthew Briggs, DPT • Constance Chu, MD • Anthony Delitto, PT, PhD • Amanda Ferland, DPT Helene Fearon, PT • G. Kelley Fitzgerald, PT, PhD • Joy MacDermid, PT, PhD • James W. Matheson, DPT • Philip McClure, PT, PhD Paul Shekelle, MD, PhD • A. Russell Smith, Jr., PT, EdD • Leslie Torburn, DPT

For author, coordinator, and reviewer affiliations, see end of text. ©2010 Orthopaedic Section American Physical Therapy Association (APTA), Inc, and the *Journal of Orthopaedic & Sports Physical Therapy.* The Orthopaedic Section, APTA, Inc, and the *Journal of Orthopaedic & Sports Physical Therapy* consent to reproducing and distributing this guideline for educational purposes. Address correspondence to Joseph Godges, DPT, ICF Practice Guidelines Coordinator, Orthopaedic Section, APTA Inc, 2920 East Avenue South, Suite 200; La Crosse, WI 54601. E-mail: icf@orthopt.org

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 age and greater time from injury 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 subsequent to having an ACL injury. The greater a patient's age and longer 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 weak 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: There are conflicting opinions regarding the best use of clinic-based programs for patients following arthroscopic meniscectomy to increase quadriceps strength and functional performance. (Recommendation based on conflicting evidence.)

INTERVENTIONS – THERAPEUTIC EXERCISES: Clinicians should consider strength training and functional exercise to increase quadriceps and hamstrings strength, quadriceps endurance, and functional performance following meniscectomy. (Recommendation based on moderate evidence.)

INTERVENTIONS – NEUROMUSCULAR ELECTRICAL STIMULATION: Neuromuscular electrical stimulation can be used with patients following meniscal or chondral injuries to increase quadriceps muscle strength. (Recommendation based on moderate 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).[141]

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 clinical 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 Related Health Problems (ICD)[140] 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 muscu-

Methods *(continued)*

loskeletal 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.[103] 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 BASED ON		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*.

Methods *(continued)*

CLASSIFICATION

The ICD-10 codes 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, and 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 or 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, and 733.92 Chondromalacia.

The primary ICF body functions codes associated with the above noted ICD-10 conditions are **b28016 Pain in joints, 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		
ICD-10	S83.2	Tear of meniscus, current
	S83.3	Tear of articular cartilage of knee, current
	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 functions	b28016	Pain in joints
	b7100	Mobility of a single joint
	b770	Gait pattern functions (presence of knee catching or locking with walking and running)
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 1 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% to 14% and a prevalence of 61 cases per 100 000 persons.[1,83,124] A high incidence of meniscal tears occurs with an injury to the anterior cruciate ligament (ACL), ranging from 22% to 86%.[100] 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.[1,109]

Based on studies of knee arthroscopies, the prevalence of articular cartilage pathologies is reported to be between 60% and 70%.[2,31,52] The incidence of isolated articular cartilage lesions (30%) is lower that of nonisolated cartilage lesions (70%).[137] Thirty-two percent to 58% of articular cartilage lesions are the result of a traumatic, noncontact mechanism of injury.[61,137] Sixty-four percent of all chondral lesions are less than 1 cm.[2,137] Thirty-three to sixty percent of articular cartilage lesions are greater than grade 3 lesions based on the International Cartilage Repair Society grading system (ICRS).[128] 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).[15] The most common localization of cartilage lesions is to the medial femoral condyle and the patella articular surface.[137] Medial meniscus tears (37%) and ACL ruptures (36%) are the most common injuries concomitant with articular cartilage injuries.

PATHOANATOMICAL FEATURES

The medial and lateral menisci cover the superior aspect of the tibia.[14] 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.[14] 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.[14] The rate of medial meniscal tears increases over time from an initial ACL injury, whereas the rate of lateral meniscal tears does not.[63,100,128] Prolonged delays in ACL reconstruction are related to greater occurrence of meniscus injuries.[100]

The articular cartilage that covers the gliding surfaces of the knee joint is hyaline in nature.[10,75] Hyaline cartilage decreases the friction between gliding surfaces, withstands compression by acting as a shock absorber, and resists wear during normal situations.[10,18] Injuries to the articular cartilage can be the result of major trauma or repetitive minor trauma.[10,61,127,137] 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] Four methods of operative care that are most widely used are arthroscopic lavage and debridement, microfracture, autologous chondrocyte implantation (ACI), and osteochondral transplantation (OATS).[21,26,75,139]

CLINICAL COURSE

III A review of the literature by Meredith et al,[94] 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. Long-term outcomes are also very good: mean Lysholm scores ranged from 80/100 to 99/100 at a follow-up of 10 years postsurgery. Median Tegner activity scores were 7 (range, 5/10 to 7/10) preinjury and at peak improvement, with a slight decrease to a median of 6 (range, 5/10 to 7/10) at follow-up greater than 10 years.

III Ericsson and colleagues[37] assessed isokinetic strength and functional performance, and administered the Knee Injury and Osteoarthritis Outcome Score (KOOS) at a mean follow-up of 4 years postmeniscectomy. They found lower knee extensor strength and diminished 1-limb 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-limb rising ratio.

II Roos et al[113] 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 postsurgery. Patients showed significant improvement from presurgery to postsurgery based on Lysholm scores (61/100 preoperatively to 74/100 postoperatively).

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 postsurgery. They found strength was 15% lower in the quadriceps of the involved knee prior to surgery. Quadriceps strength in the surgical knee improved to presurgical levels by 4 to 6 weeks but continued to remain 12% to 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[98] 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 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 postoperative 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 4 (case series).[59] 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.[68,96,121]

IV Jakobsen and colleagues[59] 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.[59] 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.[59]

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 preoperative assessment to final follow-up period, Lysholm scores increased by 53% and subjective reports improved by 75%.

IV Steadman et al[121] 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[26] reported on 55 knees that 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[21] presented the results following osteochondral allografts in 97 knees with a mean follow-up of 50 months (range, 24-148 months). Using the same 18-point scale as Chu et al,[26] 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, 1-27 cm^2). Of the bipolar grafted knees, 53% (16 of 30) were rated as good or excellent with an average total surface area of resurfacing of 23 cm^2 (range, 6-37 cm^2). Five knees had resurfacing for multiple cartilage defects with an average total surface area of 20 cm^2. Three knees were rated as excellent or good.

I The Cochrane Collaboration Review[136] 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°/s improved from year 1 to year 2. Isokinetic quadriceps and hamstrings testing at 60°/s and 240°/s, 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[96] evaluated 28 studies involving 3122 patients who had undergone microfracture surgery for articular cartilage damage to the knee. They reported that the average (±SD) postoperative Lysholm score was 80.8/100 (±6) and the average Tegner score was 4.8/10 (±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 multicenter retrospective study, Tandogan and associates[128] investigated meniscal and chondral lesions that may accompany 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. The initial ACL injury was determined based on the patient's history and mechanism of injury and verified via medical records. The time from the initial ACL injury to the first-time arthroscopy was used to indicate time from initial injury. Patients' sport participation level was defined based on the level of competitive sports played. The authors performed logistic regression to adjust for confounding factors. Only time from initial ACL injury was predictive of medial meniscal tears. The mean ± SD time for subsequent injury in patients with a medial meniscus tear was 26.1 ± 39.3 months after the initial ACL injury, whereas the time for those who did not tear their medial meniscus was 11.4 ± 17.8 months after the initial ACL injury. At 2 to 5 years following the initial ACL injury, the odds were 2.2 times higher of having a subsequent meniscal or articular cartilage injury 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 ± SD time for subsequent injury in individuals who had lateral meniscal tears was 25.5 ± 41.2 months after the initial ACL injury and the time for those who did not have lateral meniscal tears was 16.6 ± 26.2 months after the initial ACL injury. The mean age of patients with lateral meniscal tears was 27.8 ± 7.4 years, and without lateral meniscus tears was 26.4 ± 7.3 years. 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[60] reported that meniscal tears could be accurately diagnosed 76% of the time based on 30 predictors found 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.[32,99]

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, increasing age, and being a woman decreased the odds for having a meniscal injury in younger patients (17-40 years). In older patients (greater than 40 years), 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 age and greater time from injury 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[128] performed a retrospective multicenter 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 tibiofemoral compartment. High rates of chondral lesions are associated with meniscal tears in the same compartment. Patients' age (greater than 30 years) 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[38] reviewed the records of 88 young male patients. The majority of cartilage lesions were patellar (73.5%), a small percentage of chondral lesions were located on the medial femoral condyle (12.0%) and the remaining lesions (14.5%) were on the femoral groove (8.5%), lateral femoral condyle (3.4%), and lateral tibial condyle (2.6%). 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[11] 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 subsequent to having an ACL injury. The greater a patient's age and longer 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

II The ICD diagnosis of a meniscal tear and the associated ICF diagnosis of joint pain and mobility impairments are made with a fair level of certainty when the patient presents with the following clinical findings[3,6,51,78,95,115]:

- Twisting injury
- Tearing sensation at time of injury
- Delayed effusion (6-24 hours postinjury)
- 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° of knee flexion

V The ICD diagnosis of an articular cartilage defect and the associated ICF diagnosis of joint pain and mobility impairments is made with a low level of certainty when the patient presents with the following clinical findings[16]:

- Acute trauma with hemarthrosis (0-2 hours) (associated with osteochondral fracture)

- Insidious onset aggravated by repetitive impact
- Intermittent pain and swelling
- History of "catching" or "locking"
- Joint line tenderness

C 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.[23] A component of diagnosis is to also determine whether physical therapy management is appropriate.[23] 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,[110] or neurovascular compromise.[110] In addition, following surgical intervention, serious conditions may develop, such as arthrofibrosis,[91,92] postoperative infection and septic arthritis,[134] deep vein thrombosis,[106] and patella fractures.[130] 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.[23]

V The following differential diagnosis has been suggested for knee pain based on anatomical site[22]:

- 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
- Nonspecific knee and thigh/leg symptoms[5,22,91,92,106,110,134]
  - 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 preinjury activity levels. Fear of movement/reinjury decreases as a patient is further removed from surgery and is negatively related to knee performance as a function of time.[24] Patients who did not return to their preinjury activity level had more fear of reinjury, which was correlated with low knee-related quality of life.[72] Elevated pain-related fear of movement/reinjury based on a shortened version of the Tampa Scale for Kinesiophobia (TSK-11) places a patient at risk for chronic disability and reducing this fear can be accomplished through patient education and graded exercise prescription.[24,74] Thomee et al[132] found that patients' perceived self-efficacy of knee function using the knee self-efficacy scale (K-SES) prior to ACL reconstruction can predict patients' return to acceptable levels of physical activity (odds ratio, 2.1), symptoms (odds ratio, 1.4-1.6), and muscle function (odds ratio, 2.2) 1 year following ACL reconstruction when adjusted for age, gender, and preinjury Tegner score.

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

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.[5,123] A knee radiograph series is 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°
- Inability to bear weight both immediately and in the emergency department for 4 steps regardless of limping

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.[34] For articular cartilage pathology, clinical examination is frequently inconclusive as patients present with nonspecific symptoms of joint pain or swelling that may not develop until late in the course of the disease when the subchondral bone is exposed.[19,20] 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.[86,143] When compared to arthroscopy as the reference standard, conventional MRI sequences have an overall sensitivity of 83.2% and a specificity of 94.3% for the detection of chondral lesions.[41] MRI may assist an orthopaedic surgeon in preoperative 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.[79,142]

I The Medical Outcomes Study 36-item Short Form (SF-36) is currently the most popular general health outcome measure.[142] 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).[102] The SF-36 form has been validated for a variety of ages and languages.[142] It has demonstrated effectiveness in a vast number of conditions pertaining to orthopaedic and sports injuries.

III Shapiro et al[117] 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 nonoperatively, 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 postinjury) and chronic (>4 months postinjury) ACL injuries at the baseline evaluation. Although no correlations were found between SF-36 and physician's recommendation for surgical treatment with either acute or chronic ACL injuries, 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.[58] 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[58] 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.[112,142] 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 to 4. Each subscale is summed and transformed to a score of 0 (worst) to 100 (best). Roos and colleagues[112,142] 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.[142] The KOOS has been demonstrated to con-

tain items regarding symptoms and disabilities important to patients with an ACL tear, isolated meniscal tears, or knee osteoarthritis.[129]

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.[142] 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.[129]

Irrgang et al[56] 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[30] 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 α = 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.[142] The scale contains 8 items of symptoms and function. It is scored from 0 to 100 points. Instability and pain are weighted the most heavily.[142] The Lysholm scale is arbitrarily graded with 95 to 100 as excellent, 84 to 94 as good, 65 to 83 as fair, and less than 65 as poor. Research to date on validity, sensitivity, and reliability of the Lysholm scale is inconclusive.[142] The Lysholm scale may prove to be more meaningful when combined with an activity rating scale.[116] 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.[13,70]

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.[142] It has been modified over the years. It was 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).[8] Portions of the rating scale have been validated.[142] The ICC value for test-retest reliability in patients with ACL reconstruction was greater than 0.75.[8] 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 a 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.[142]

III Briggs et al[13] 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 to 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.[142] The scale has been validated[87] but responsiveness has not been determined.[142]

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.[107]

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-meter timed hop. These hop tests have demonstrated high test-retest reliability in normal, young adults.[12,114] ICCs for single-limb single hop for distance ranged from 0.92 to 0.96, single-limb triple crossover hop for distance ranged from 0.93 to 0.96, single-limb triple hop for distance ranged from 0.95 to 0.97, and single-limb 6-meter timed hop ranged from 0.66 to 0.92.

III Low to moderate correlations were found between hop test performance and lower extremity muscular strength, and between hop test performance and self-report outcome measures.[39]

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[114] • Mean distance: 208.08-208.24 cm LSI reliability in patients with ACL reconstruction[107] • $ICC_{2,1}$ = 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.

Single-Limb Triple-Hop Test for Distance (continued)

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[114] • Mean distance: 670.12-673.35 cm LSI reliability in patients with ACL reconstruction[107] • $ICC_{2,1}$ = 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[136] • Mean distance: 637.40-649.19 cm LSI reliability in patients with ACL reconstruction[129] • $ICC_{2,1}$ = 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 s. 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[114] • Mean time: 1.82-1.86 s LSI reliability in patients with ACL reconstruction[107] • $ICC_{2,1}$ = 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[28]

ICF category	Measurement of activity limitation, walking long distances
Description	A physical performance measure which assesses how far a person can walk in 6 min.[35]
Measurement method	The patient is instructed to walk as far as possible during the 6-min 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-s 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[122] • $ICC_{2,1}$: 0.94 (95% CI: 0.88, 0.98)[67] • MDC_{90}: 61.34 m in patients with total knee and hip arthroplasty[67]

Timed Up-and-Go Test (TUG)[28]

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 m), 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 m 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[105] • $ICC_{2,1}$: 0.95-0.97[122] • MDC_{90}: 2.49 s in patients with total knee and hip arthroplasty[67] Criterion-related validity • Good agreement among observers on the subjective scoring of the TUG[105] • 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[105]

Stair Measure Test[28]

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.[4,81,126]
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.[126] 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.[27,65] 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.[84,131]

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[12]	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[27] in patients with knee osteoarthritis.
Instrument variations	Other effusion tests can be used to assess knee effusion.[27,65] In addition to visual inspection, knee effusion can be measured using a tape measure or perometer for knee circumference.[84,131]

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. *(continued)*

Knee Passive Range of Motion (continued)

Measurement method *(continued)*	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[104]	• Validity: ICC = 0.98-0.99 • Intraexaminer reliability coefficients ranging from ICC = 0.85-0.99 • Interexaminer reliability coefficients ranging from ICC = 0.62-0.99 • SEM = 2.37°, MDC_{95} = 6.57°

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[12]	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.[29]

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[25,54]	The patient is seated on a dynamometer with hips and knees in 90° 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 min of rest. For the test, the patient is instructed to maximally contract their quadriceps for 5 s during which a supramaximal burst of electrical stimulation (amplitude, 135 volts; pulse duration, 600 μs; pulse interval, 10 ms; train duration, 100 ms) 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 min of *(continued)*

Maximum Voluntary Isometric Quadriceps Strength (continued)

Measurement method[25,54] ***(continued)***	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) × 100%.
Nature of variable	Continuous
Units of measurement	Force: Newtons Torque: Newton-meter Quadriceps index: Percentage
Measurement properties[25]	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[102]	The patient is seated on a dynamometer with hips positioned in 90° 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 min 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°/s or 120°/s and 25 to 30 repetitions of maximal concentric and eccentric contractions for extension and flexion of each knee at 180°/s or 240°/s. 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) × 100.
Nature of variable	Continuous
Units of measurement	Torque: Newton-meter Work: Joules Quadriceps index: Percentage
Measurement properties[151]	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

Knee Joint Line Tenderness (continued)

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[71,95]:

		95% 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 exist on joint line tenderness for the diagnosis of chondral defects.

McMurray Test

ICF category	Measure of impairment of body function, mobility in a joint
Description	A palpable or audible thud or click during McMurray test
Measurement method[115]	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[71,95]:

		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%

(continued)

McMurray Test (continued)

Measurement properties *(continued)*	Diagnostic Accuracy[71,95]:

		95% CI
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 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[115]	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 at 5° Knee Flexion[71,115]:

		95% CI
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

(continued)

Thessaly Test (continued)

Measurement properties *(continued)*	Diagnostic Accuracy 20° knee flexion[71,115]:		
			95% CI
	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	• History of mechanical catching or locking reported by the patient • Joint line tenderness • Pain with forced knee hyperextension • Pain with maximum passive knee flexion • Pain or audible click with McMurray 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	*(continued)*

Meniscal Pathology Composite Score[78] (continued)

Measurement properties[78] (*continued*)	Diagnostic Accuracy:	
		≥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 from 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% to 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% to 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% to 25%. Equilibrium shear modulus was still reduced as compared to controls after remobilization.

III In a retrospective study, Rodrigo et al[111] 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 preoperatively, and at day 1, weeks 1 and 2, and months 1 and 3 postoperatively. For knee girth measurements, preoperative values were less than postoperative values. Preoperative knee flexion values were significantly less than postoperative values, whereas preoperative knee extension was only significantly less than postoperative day 1. The intervention group exhibited better gait patterns than the control group. For IKDC scores, preoperative values were significantly less for all but 1 postoperative measure. 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° immediately after surgery but locked at 0° extension at night for the first 2 weeks. This is used to adhere to 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[7] found no significant differences between the healing rates of meniscal repairs in the standard and accelerated rehabilitation groups.

IV Shelbourne and associates[118] 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 to full range of motion, higher quadriceps strength at 2 months, and a more rapid return to full activity. However, randomization and statistical analysis were 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[7] investigated the effects of accelerated rehabilitation in individuals who underwent meniscal repair using a minimum of a 12-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 postsurgery. 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[118] 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 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 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 were not reported in the clinical results.

V In a clinical commentary, Heckmann et al[50] recommends that patients who undergo peripheral meniscal repairs be partial weight bearing for the first 2 weeks and progress to full weight bearing at 3 to 4 weeks postsurgery. They recommend that patients who undergo complex meniscal repairs or transplantations restrict their weight bearing for the first 6 to 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[57] and Buckwalter,[17] 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[7] 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 postsurgery. 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[118] 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[108] 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 postsurgery. 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[97] conducted a randomized controlled trial on the efficacy of an early, intensive, supervised rehabilitation program on knee strength recovery in the first 3 weeks postmeniscectomy. Strength measurements were performed preoperatively and 3 weeks postsurgery at 30°/s and 180°/s 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 ($P<.001$). In a subgroup analysis matched on preoperative knee extension work deficits and type of meniscal lesion, the home-based group strength differences were as much as 26% lower compared to the supervised group at 3 weeks postmeniscectomy. Preoperatively, the matched groups had similar knee extension work deficits (as compared to the uninvolved limb) of 18% at 30°/s and 12% at 180°/s. Postoperatively, the home-based group had 40% deficit at 30°/s and 42% deficit at 180°/s, whereas, the supervised group had 15% deficit at 30°/s and 16% deficit at 180°/s.

II Vervest et al[135] randomized, with the aid of a computer program, 20 patients into 2 groups: home-based group and supervised exercise group. Distance and height of single-limb hops, pain measured from a visual analog scale, Tegner and Lysholm scores, and sports and occupational rating scales were measured at 7, 14, 21, and 28 days postmeniscectomy. The effects of the rehabilitation programs were evaluated by a blinded observer. At 28 days postsurgery, the supervised exercise group was significantly better than the home-based group regarding Sports Activity Rating scale ($P = .04$). From day 7 to day 28, significant improvement was seen in the supervised exercise in jump height ($P = .04$) and jump distance ($P = .02$). However, no significant differences were seen between the 2 groups at day 28 for either jump height ($P = .47$) or jump distance ($P = .22$). The 2 groups were not different at day 7 or day 28 in Tegner or Lysholm scores, the factor occupational rating system score, pain, satisfaction with treatment, and satisfaction with function.

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 postsurgery. The authors 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.

II In a prospective randomized control trial, Jokl and associates[62] compared the outcomes of home-based exercise program to that of a supervised outpatient physical therapy program following partial medial meniscectomy. Thirty patients were randomly assigned to either a home-based exercise program or a supervised physical therapy program. Isokinetic peak torque and total work and subjective questionnaire scores were assessed at 2, 4, and 8 weeks postoperatively. At week 4, the mean peak torque of the involved limb compared to the uninvolved limb was 77.9% for the supervised group and 78% for the home exercise group. The total work of the involved limb compared to the uninvolved limb was 92.3% for the supervised group and 96.4% for the home exercise group. Patients' subjective scores were not different between groups in regards to the ability to resume work or return to recreational activities. This study did not describe the randomization process, had a small number of patients, and a short follow-up period.

D There are conflicting opinions regarding the best use of clinic-based programs for patients following meniscectomy to increase quadriceps strength and functional performance.

THERAPEUTIC EXERCISES

Studies have shown that quadriceps strength deficits are present after intra-articular knee injuries and surgeries and can persist for months.[25,36,37,40,53-55,90,97,101,125,133,138] One method employed for facilitating quadriceps strength is resistive volitional exercises. Progressive resistive exercises can safely load the muscles in a graduated manner to allow for muscle strength adaptation while minimizing stress on the damaged tissue.[28,93,108,144]

II St-Pierre and associates[125] 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° of knee flexion and isokinetically at 4 different velocities (60°/s, 120°/s, 180°/s, and 240°/s) preoperatively, and at 2, 6, and 10 weeks postoperatively. 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 postoperatively than preoperatively at all testing velocities. By 6 weeks, quadriceps and hamstrings torque had been restored to preoperative 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.

II Moffet et al[97] conducted a randomized controlled trial on the efficacy of an early, intensive, supervised rehabilitation program on knee strength recovery in the first 3 weeks postmeniscectomy. Strength measurements were performed preoperatively and 3 weeks postsurgery at 30°/s and 180°/s 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 ($P<.001$). Preoperatively, the matched groups had similar knee extension work in the involved limb as compared to the uninvolved limb of 82% at 30°/s and 88% at 180°/s. Postoperatively, at 30°/s, the home-based group (40% deficit) was significantly weaker than the supervised group (15% deficit) ($P = .005$). At 180°/s, the home-based group was significantly weaker than the supervised group (42% deficit in the home group versus 16% deficit in the supervised group) ($P = .006$).

III Matthews and St-Pierre[90] investigated the effect of home exercise program on 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 postsurgery. Home exercise program consisted of edema management, quadriceps setting, straight leg raises, and knee flexion range of motion exercises. Resisted strengthening exercises were not included. They found strength was 15% lower in the quadriceps of the involved knee prior to surgery. Quadriceps strength in the surgical knee improved to presurgical levels by 4 to 6 weeks but continued to remain 12% to 14% lower than the uninvolved side. Hamstring strength in the involved side returned to normal levels within 2 weeks of surgery. Additional gains in quadriceps strength may not be attainable without focused quadriceps strength training.

II Ericsson et al[36] 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. The multimodal functional exercise program was used to improve knee range of motion and lower extremity coordination, improve lower extremity and core strength, promote dynamic stability and improve body posture, and enhance motor skills. Forty-five patients (22 in the exercise group, 23 in the

control group) were initially evaluated. In the exercise group, 16 patients who completed the study attended a mean of 31 ± 16 supervised exercise sessions. No intervention was provided to the control group. Fourteen control subjects were available for the follow-up testing. Patients were evaluated prior to the intervention and at mean of 16 weeks later 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°/s) and muscle endurance (total work of 25 repetitions at 180°/s) testing of the quadriceps and hamstrings. The exercise group demonstrated greater improvement in single-limb single-hop test, hamstrings strength at 60°/s, and quadriceps endurance at 180°/s. 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.

II Williams et al[138] 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 pain-free 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°/s, 180°/s, 240°/s, and 300°/s 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 muscle. The testing position was performed with the knee flexed at 35° 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°/s and 180°/s, and average speed. In the experimental 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.

B Clinicians should consider strength training and functional exercise to increase quadriceps and hamstrings strength, quadriceps endurance, and functional performance following meniscectomy.

NEUROMUSCULAR ELECTRICAL STIMULATION

As previously noted, quadriceps strength deficits are present after intra-articular knee injuries and surgeries and can persist for months.[25,36,37,40,53-55,90,97,101,125,133,138] NMES can safely load the muscles to allow for muscle strength adaptation while minimizing stress on the damaged tissue.[9,33,119,144] A larger number of studies have shown positive effects of electrical stimulation in patients with reduced quadriceps strength in patients with ACL injuries,[144] which are often accompanied by meniscal or chondral lesions.[11,44,128] Limited research has explored the use of electrical stimulation to increase thigh muscle strength following isolated meniscal or chondral injuries.

IV Fourteen randomized controlled trials have evaluated the use of electrical stimulation during ACL rehabilitation.[144] 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 to 3 times per week for 3 to 12 weeks, for 10 to 15 seconds on with 50-second rest period[33,40,119]) early in the rehabilitation process.

I A recent systematic review and meta-analysis by Bax and associates[9] investigated the effectiveness of neuromuscular electrical stimulation (NMES) as a treatment modality for strengthening of the quadriceps muscles. They analyzed 17 randomized controlled trials in adults with unimpaired quadriceps muscle torque and 18 randomized controlled trials in adults with impaired quadriceps muscle torque. For each subgroup, meta-analyses was performed for comparisons of "NMES versus no exercises," and "NMES versus volitional exercises" as primary comparisons. Despite the limited quality of the included randomized controlled trials, NMES is effective in increasing quadriceps strength. NMES appears to be more beneficial than volitional exercises in minimizing strength loss due to immobilization. In adults with unimpaired quadriceps muscle torque and in adults with impaired quadriceps muscle torque (postimmobilization), NMES can be an effective modality for augmenting volitional quadriceps strength training.

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

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 age and greater time from injury 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 subsequent to having an ACL injury. The greater a patient's age and longer 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.

C 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.

D INTERVENTIONS – SUPERVISED REHABILITATION

There are conflicting opinions regarding the best use of clinic-based programs for patients following arthroscopic meniscectomy to increase quadriceps strength and functional performance.

B INTERVENTIONS – THERAPEUTIC EXERCISES

Clinicians should consider strength training and functional exercise to increase quadriceps and hamstrings strength, quadriceps endurance, and functional performance following meniscectomy.

B INTERVENTIONS – NEUROMUSCULAR ELECTRICAL STIMULATION

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

AFFILIATIONS AND CONTACTS

AUTHORS

David S. Logerstedt, PT, MA
PhD Student
Biomechanics and Movement Sciences
University of Delaware
Newark, DE 19716
davlog@udel.edu

Lynn Snyder-Mackler, PT, ScD
Alumni Distinguished Professor
Department of Physical Therapy
University of Delaware
Newark, DE 19716
smack@udel.edu

Richard C. Ritter, DPT
Asst. Clinical Professor
UCSF/SFSU Graduate Program in Physical Therapy
San Francisco, CA 94143
rcritter@comcast.net

Michael J. Axe, MD
First State Orthopaedics
4745 Ogletown-Stanton Road,
Suite 225
Newark, DE 19713
mjaxe@udel.edu

COORDINATOR

Joseph Godges, DPT
ICF Practice Guidelines Coordinator
Orthopaedic Section, APTA Inc.
La Crosse, Wisconsin
icf@orthopt.org

REVIEWERS

Roy D. Altman, MD
Professor of Medicine
Division of Rheumatology and Immunology
David Geffen School of Medicine at UCLA
Los Angeles, California
journals@royaltman.com

Matthew Briggs, DPT
Coordinator, Sports Physical Therapy Residency
The Ohio State University
Columbus, Ohio
matt.briggs@osumc.edu

Constance Chu, MD
Department of Orthopaedics
University of Pittsburgh
Pittsburgh, Pennsylvania

Anthony Delitto, PT, PhD
Professor and Chair
School of Health & Rehabilitation Sciences
University of Pittsburgh
Pittsburgh, Pennsylvania
delitto@pitt.edu

Amanda Ferland, DPT
Clinic Director
MVP Physical Therapy
Federal Way, Washington
aferland@mvppt.com

Helene Fearon, PT
Fearon/Levine Consulting
Phoenix, Arizona
helenefearon@fearonlevine.com

G. Kelley Fitzgerald, PT, PhD
Associate Professor
School of Health & Rehabilitation Sciences
University of Pittsburgh
Pittsburgh, Pennsylvania
kfitzger@pitt.edu

Joy MacDermid, PT, PhD
Associate Professor
School of Rehabilitation Science
McMaster University
Hamilton, Ontario, Canada
macderj@mcmaster.ca

James W. Matheson, DPT
Larsen Sports Medicine and Physical Therapy
Hudson, WI
jw@eipconsulting.com

Philip McClure, PT, PhD
Professor
Department of Physical Therapy
Arcadia University
Glenside, Pennsylvania
mcclure@arcadia.edu

Paul Shekelle, MD, PhD
Director
Southern California Evidenced-Based Practice Center
Rand Corporation
Santa Monica, California
shekelle@rand.org

A. Russell Smith, Jr., PT, EdD
Chair
Clinical & Applied Movement Sciences
University of North Florida
Jacksonville, Florida
arsmith@unf.edu

Leslie Torburn, DPT
Principal and Consultant
Silhouette Consulting, Inc.
Redwood City, California
torburn@yahoo.com

REFERENCES

1. Amer Acad of Orthopaedic Surgeons. *Orthopaedic Knowledge Update: Sports Medicine 2*. 2nd ed. Rosemont, IL: Amer Acad of Orthopaedic Surgeons; 1999.
2. Aroen A, Loken S, Heir S, et al. Articular cartilage lesions in 993 consecutive knee arthroscopies. *Am J Sports Med*. 2004;32:211-215.
3. Arroll B, Robb G, Sutich E, et al. *The Diagnosis and Management of Soft Tissue Knee Injuries: Internal Derangements*. Wellington, NZ: New Zealand Guidelines Group; 2003.
4. Axe M, Snyder-Mackler L. Operative and post-operative management of the knee. In: eds. *Orthopaedic Section Independent Study Course*. La Crosse, WI: Orthopaedic Section, APTA; 2005.
5. Bachmann LM, Haberzeth S, Steurer J, ter Riet G. The accuracy of the Ottawa knee rule to rule out knee fractures: a systematic review. *Ann Intern Med*. 2004;140:121-124.
6. Bansal P, Deehan DJ, Gregory RJ. Diagnosing the acutely locked knee. *Injury*. 2002;33:495-498.
7. Barber FA. Accelerated rehabilitation for meniscus repairs. *Arthroscopy*. 1994;10:206-210.
8. Barber-Westin SD, Noyes FR, McCloskey JW. Rigorous statistical reliability, validity, and responsiveness testing of the Cincinnati knee rating system in 350 subjects with uninjured, injured, or anterior cruciate ligament-reconstructed knees. *Am J Sports Med*. 1999;27:402-416.
9. Bax L, Staes F, Verhagen A. Does neuromuscular electrical stimulation strengthen the quadriceps femoris? A systematic review of randomised controlled trials. *Sports Med*. 2005;35:191-212.
10. Bhosale AM, Richardson JB. Articular cartilage: structure, injuries and review of management. *Br Med Bull*. 2008;87:77-95. http://dx.doi.org/10.1093/bmb/ldn025
11. Biswal S, Hastie T, Andriacchi TP, Bergman GA, Dillingham MF, Lang P. Risk factors for progressive cartilage loss in the knee: a longitudinal magnetic resonance imaging study in forty-three patients. *Arthritis Rheum*. 2002;46:2884-2892. http://dx.doi.org/10.1002/art.10573
12. Bolgla LA, Keskula DR. Reliability of lower extremity functional performance tests. *J Orthop Sports Phys Ther*. 1997;26:138-142.
13. Briggs KK, Kocher MS, Rodkey WG, Steadman JR. Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for patients with meniscal injury of the knee. *J Bone Joint Surg Am*. 2006;88:698-705. http://dx.doi.org/10.2106/JBJS.E.00339
14. Brindle T, Nyland J, Johnson DL. The Meniscus: Review of Basic Principles With Application to Surgery and Rehabilitation. *J Athl Train*. 2001;36:160-169.
15. Brittberg M, Winalski CS. Evaluation of cartilage injuries and repair. *J Bone Joint Surg Am*. 2003;85-A Suppl 2:58-69.
16. Brukner P, Kahn K. *Clinical Sports Medicine*. 3rd ed. Sydney, Australia: McGraw-Hill; 2006.
17. Buckwalter JA. Articular cartilage: injuries and potential for healing. *J Orthop Sports Phys Ther*. 1998;28:192-202.
18. Buckwalter JA, Mankin HJ. Articular cartilage: tissue design and chondrocyte-matrix interactions. *Instr Course Lect*. 1998;47:477-486.
19. Buckwalter JA, Mankin HJ, Grodzinsky AJ. Articular cartilage and osteoarthritis. *Instr Course Lect*. 2005;54:465-480.
20. Buckwalter JA, Martin JA. Osteoarthritis. *Adv Drug Deliv Rev*. 2006;58:150-167. http://dx.doi.org/10.1016/j.addr.2006.01.006
21. Bugbee WD, Convery FR. Osteochondral allograft transplantation. *Clin Sports Med*. 1999;18:67-75.
22. Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: Part II. Differential diagnosis. *Am Fam Physician*. 2003;68:917-922.
23. Childs JD, Cleland JA, Elliott JM, et al. Neck pain: Clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopedic Section of the American Physical Therapy Association. *J Orthop Sports Phys Ther*. 2008;38:A1-A34.
24. Chmielewski TL, Jones D, Day T, Tillman SM, Lentz TA, George SZ. The association of pain and fear of movement/reinjury with function during anterior cruciate ligament reconstruction rehabilitation. *J Orthop Sports Phys Ther*. 2008;38:746-753. http://dx.doi.org/10.2519/jospt.2008.2887
25. Chmielewski TL, Stackhouse S, Axe MJ, Snyder-Mackler L. A prospective analysis of incidence and severity of quadriceps inhibition in a consecutive sample of 100 patients with complete acute anterior cruciate ligament rupture. *J Orthop Res*. 2004;22:925-930. http://dx.doi.org/10.1016/j.orthres.2004.01.007
26. Chu CR, Convery FR, Akeson WH, Meyers M, Amiel D. Articular cartilage transplantation. Clinical results in the knee. *Clin Orthop Relat Res*. 1999;159-168.
27. Cibere J, Bellamy N, Thorne A, et al. Reliability of the knee examination in osteoarthritis: effect of standardization. *Arthritis Rheum*. 2004;50:458-468. http://dx.doi.org/10.1002/art.20025
28. Cibulka MT, White DM, Woehrle J, et al. Hip pain and mobility deficits--hip osteoarthritis: 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*. 2009;39:A1-25. http://dx.doi.org/10.2519/jospt.2009.0301
29. Clapper MP, Wolf SL. Comparison of the reliability of the Orthoranger and the standard goniometer for assessing active lower extremity range of motion. *Phys Ther*. 1988;68:214-218.
30. Crawford K, Briggs KK, Rodkey WG, Steadman JR. Reliability, validity, and responsiveness of the IKDC score for meniscus injuries of the knee. *Arthroscopy*. 2007;23:839-844. http://dx.doi.org/10.1016/j.arthro.2007.02.005
31. Curl WW, Krome J, Gordon ES, Rushing J, Smith BP, Poehling GG. Cartilage injuries: a review of 31,516 knee arthroscopies. *Arthroscopy*. 1997;13:456-460.
32. Daniel DM, Stone ML, Dobson BE, Fithian DC, Rossman DJ, Kaufman KR. Fate of the ACL-injured patient. A prospective outcome study. *Am J Sports Med*. 1994;22:632-644.
33. Delitto A, Rose SJ, McKowen JM, Lehman RC, Thomas JA, Shively RA. Electrical stimulation versus voluntary exercise in strengthening thigh musculature after anterior cruciate ligament surgery. *Phys Ther*. 1988;68:660-663.
34. Englund M, Guermazi A, Gale D, et al. Incidental meniscal findings on knee MRI in middle-aged and elderly persons. *N Engl J Med*. 2008;359:1108-1115. http://dx.doi.org/10.1056/NEJMoa0800777
35. Enright PL. The six-minute walk test. *Respir Care*. 2003;48:783-785.
36. Ericsson YB, Dahlberg LE, Roos EM. Effects of functional exercise training on performance and muscle strength after meniscectomy: a randomized trial. *Scand J Med Sci Sports*. 2009;19:156-165. http://dx.doi.org/10.1111/j.1600-0838.2008.00794.x
37. Ericsson YB, Roos EM, Dahlberg L. Muscle strength, functional performance, and self-reported outcomes four years after arthroscopic partial meniscectomy in middle-aged patients. *Arthritis Rheum*. 2006;55:946-952. http://dx.doi.org/10.1002/art.22346
38. Eskelinen AP, Visuri T, Larni HM, Ritsila V. Primary cartilage lesions of the knee joint in young male adults. Overweight as a predisposing factor. An arthroscopic study. *Scand J Surg*. 2004;93:229-233.
39. Fitzgerald GK, Lephart SM, Hwang JH, Wainner RS. Hop tests as predictors of dynamic knee stability. *J Orthop Sports Phys Ther*. 2001;31:588-597.
40. Fitzgerald GK, Piva SR, Irrgang JJ. A modified neuromuscular electri-

cal stimulation protocol for quadriceps strength training following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 2003;33:492-501.

41. Galea A, Giuffre B, Dimmick S, Coolican MR, Parker DA. The accuracy of magnetic resonance imaging scanning and its influence on management decisions in knee surgery. *Arthroscopy*. 2009;25:473-480. http://dx.doi.org/10.1016/j.arthro.2008.10.020
42. Gobbi A, Nunag P, Malinowski K. Treatment of full thickness chondral lesions of the knee with microfracture in a group of athletes. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:213-221. http://dx.doi.org/10.1007/s00167-004-0499-3
43. Goodwin PC, Morrissey MC, Omar RZ, Brown M, Southall K, McAuliffe TB. Effectiveness of supervised physical therapy in the early period after arthroscopic partial meniscectomy. *Phys Ther*. 2003;83:520-535.
44. Granan LP, Bahr R, Lie SA, Engebretsen L. Timing of anterior cruciate ligament reconstructive surgery and risk of cartilage lesions and meniscal tears: a cohort study based on the Norwegian National Knee Ligament Registry. *Am J Sports Med*. 2009;37:955-961. http://dx.doi.org/10.1177/0363546508330136
45. Guyatt GH, Sackett DL, Sinclair JC, Hayward R, Cook DJ, Cook RJ. Users' guides to the medical literature. IX. A method for grading health care recommendations. Evidence-Based Medicine Working Group. *JAMA*. 1995;274:1800-1804.
46. Haapala J, Arokoski J, Pirttimaki J, et al. Incomplete restoration of immobilization induced softening of young beagle knee articular cartilage after 50-week remobilization. *Int J Sports Med*. 2000;21:76-81. http://dx.doi.org/10.1055/s-2000-8860
47. Haapala J, Arokoski JP, Hyttinen MM, et al. Remobilization does not fully restore immobilization induced articular cartilage atrophy. *Clin Orthop Relat Res*. 1999;218-229.
48. Habata T, Uematsu K, Hattori K, Takakura Y, Fujisawa Y. Clinical features of the posterior horn tear in the medial meniscus. *Arch Orthop Trauma Surg*. 2004;124:642-645. http://dx.doi.org/10.1007/s00402-004-0659-4
49. Hangody L, Vasarhelyi G, Hangody LR, et al. Autologous osteochondral grafting--technique and long-term results. *Injury*. 2008;39 Suppl 1:S32-39. http://dx.doi.org/10.1016/j.injury.2008.01.041
50. Heckmann TP, Barber-Westin SD, Noyes FR. Meniscal repair and transplantation: indications, techniques, rehabilitation, and clinical outcome. *J Orthop Sports Phys Ther*. 2006;36:795-814. http://dx.doi.org/10.2519/jospt.2006.2177
51. Hegedus EJ, Cook C, Hasselblad V, Goode A, McCrory DC. Physical examination tests for assessing a torn meniscus in the knee: a systematic review with meta-analysis. *J Orthop Sports Phys Ther*. 2007;37:541-550. http://dx.doi.org/10.2519/jospt.2007.2560
52. Hjelle K, Solheim E, Strand T, Muri R, Brittberg M. Articular cartilage defects in 1,000 knee arthroscopies. *Arthroscopy*. 2002;18:730-734.
53. Holder-Powell HM, Rutherford OM. Unilateral lower limb injury: its long-term effects on quadriceps, hamstring, and plantarflexor muscle strength. *Arch Phys Med Rehabil*. 1999;80:717-720.
54. Hurd WJ, Axe MJ, Snyder-Mackler L. A 10-year prospective trial of a patient management algorithm and screening examination for highly active individuals with anterior cruciate ligament injury: Part 2, determinants of dynamic knee stability. *Am J Sports Med*. 2008;36:48-56. http://dx.doi.org/10.1177/0363546507308191
55. Ingersoll CD, Grindstaff TL, Pietrosimone BG, Hart JM. Neuromuscular consequences of anterior cruciate ligament injury. *Clin Sports Med*. 2008;27:383-404, vii. http://dx.doi.org/10.1016/j.csm.2008.03.004
56. Irrgang JJ, Anderson AF, Boland AL, et al. Responsiveness of the International Knee Documentation Committee Subjective Knee Form. *Am J Sports Med*. 2006;34:1567-1573. http://dx.doi.org/10.1177/0363546506288855
57. Irrgang JJ, Pezzullo D. Rehabilitation following surgical procedures to address articular cartilage lesions in the knee. *J Orthop Sports Phys Ther*. 1998;28:232-240.
58. Irrgang JJ, Snyder-Mackler L, Wainner RS, Fu FH, Harner CD. Development of a patient-reported measure of function of the knee. *J Bone Joint Surg Am*. 1998;80:1132-1145.
59. Jakobsen RB, Engebretsen L, Slauterbeck JR. An analysis of the quality of cartilage repair studies. *J Bone Joint Surg Am*. 2005;87:2232-2239. http://dx.doi.org/10.2106/JBJS.D.02904
60. Johnson LL, Johnson AL, Colquitt JA, Simmering MJ, Pittsley AW. Is it possible to make an accurate diagnosis based only on a medical history? A pilot study on women's knee joints. *Arthroscopy*. 1996;12:709-714.
61. Johnson-Nurse C, Dandy DJ. Fracture-separation of articular cartilage in the adult knee. *J Bone Joint Surg Br*. 1985;67:42-43.
62. Jokl P, Stull PA, Lynch JK, Vaughan V. Independent home versus supervised rehabilitation following arthroscopic knee surgery--a prospective randomized trial. *Arthroscopy*. 1989;5:298-305.
63. Joseph C, Pathak SS, Aravinda M, Rajan D. Is ACL reconstruction only for athletes? A study of the incidence of meniscal and cartilage injuries in an ACL-deficient athlete and non-athlete population: an Indian experience. *Int Orthop*. 2008;32:57-61. http://dx.doi.org/10.1007/s00264-006-0273-x
64. Jurvelin J, Kiviranta I, Saamanen AM, Tammi M, Helminen HJ. Partial restoration of immobilization-induced softening of canine articular cartilage after remobilization of the knee (stifle) joint. *J Orthop Res*. 1989;7:352-358. http://dx.doi.org/10.1002/jor.1100070307
65. Kastelein M, Wagemakers HP, Luijsterburg PA, Verhaar JA, Koes BW, Bierma-Zeinstra SM. Assessing medial collateral ligament knee lesions in general practice. *Am J Med*. 2008;121:982-988 e982. http://dx.doi.org/10.1016/j.amjmed.2008.05.041
66. Kelln BM, Ingersoll CD, Saliba S, Miller MD, Hertel J. Effect of early active range of motion rehabilitation on outcome measures after partial meniscectomy. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:607-616. http://dx.doi.org/10.1007/s00167-009-0723-2
67. Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. *BMC Musculoskelet Disord*. 2005;6:3. http://dx.doi.org/10.1186/1471-2474-6-3
68. Knutsen G, Engebretsen L, Ludvigsen TC, et al. Autologous chondrocyte implantation compared with microfracture in the knee. A randomized trial. *J Bone Joint Surg Am*. 2004;86-A:455-464.
69. Kocabey Y, Tetik O, Isbell WM, Atay OA, Johnson DL. The value of clinical examination versus magnetic resonance imaging in the diagnosis of meniscal tears and anterior cruciate ligament rupture. *Arthroscopy*. 2004;20:696-700. http://dx.doi.org/10.1016/j.arthro.2004.06.008
70. Kocher MS, Steadman JR, Briggs KK, Sterett WI, Hawkins RJ. Reliability, validity, and responsiveness of the Lysholm knee scale for various chondral disorders of the knee. *J Bone Joint Surg Am*. 2004;86-A:1139-1145.
71. Konan S, Rayan F, Haddad FS. Do physical diagnostic tests accurately detect meniscal tears? *Knee Surg Sports Traumatol Arthrosc*. 2009;17:806-811. http://dx.doi.org/10.1007/s00167-009-0803-3
72. Kvist J, Ek A, Sporrstedt K, Good L. Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:393-397. http://dx.doi.org/10.1007/s00167-004-0591-8
73. Lahav A, Burks RT, Greis PE, Chapman AW, Ford GM, Fink BP. Clinical outcomes following osteochondral autologous transplantation (OATS). *J Knee Surg*. 2006;19:169-173.

74. Leeuw M, Goossens ME, Linton SJ, Crombez G, Boersma K, Vlaeyen JW. The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. *J Behav Med*. 2007;30:77-94. http://dx.doi.org/10.1007/s10865-006-9085-0

75. Lewis PB, McCarty LP, 3rd, Kang RW, Cole BJ. Basic science and treatment options for articular cartilage injuries. *J Orthop Sports Phys Ther*. 2006;36:717-727. http://dx.doi.org/10.2519/jospt.2006.2175

76. Logan M, Watts M, Owen J, Myers P. Meniscal repair in the elite athlete: results of 45 repairs with a minimum 5-year follow-up. *Am J Sports Med*. 2009;37:1131-1134. http://dx.doi.org/10.1177/0363546508330138

77. Loken S, Ludvigsen TC, Hoysveen T, Holm I, Engebretsen L, Reinholt FP. Autologous chondrocyte implantation to repair knee cartilage injury: ultrastructural evaluation at 2 years and long-term follow-up including muscle strength measurements. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:1278-1288. http://dx.doi.org/10.1007/s00167-009-0854-5

78. Lowery DJ, Farley TD, Wing DW, Sterett WI, Steadman JR. A clinical composite score accurately detects meniscal pathology. *Arthroscopy*. 2006;22:1174-1179. http://dx.doi.org/10.1016/j.arthro.2006.06.014

79. Lysholm J, Tegner Y. Knee injury rating scales. *Acta Orthop*. 2007;78:445-453. http://dx.doi.org/10.1080/17453670710014068

80. Madhusudhan T, Kumar T, Bastawrous S, Sinha A. Clinical examination, MRI and arthroscopy in meniscal and ligamentous knee Injuries - a prospective study. *J Orthop Surg Res*. 2008;3:19. http://dx.doi.org/10.1186/1749-799X-3-19

81. Magee DJ. The knee. In: *Orthopedic Physical Assessment*. Philadelphia, PA: W.B. Saunders; 1997:546-637.

82. Magnussen RA, Dunn WR, Carey JL, Spindler KP. Treatment of focal articular cartilage defects in the knee: a systematic review. *Clin Orthop Relat Res*. 2008;466:952-962. http://dx.doi.org/10.1007/s11999-007-0097-z

83. Majewski M, Susanne H, Klaus S. Epidemiology of athletic knee injuries: A 10-year study. *Knee*. 2006;13:184-188. http://dx.doi.org/10.1016/j.knee.2006.01.005

84. Man IO, Markland KL, Morrissey MC. The validity and reliability of the Perometer in evaluating human knee volume. *Clin Physiol Funct Imaging*. 2004;24:352-358. http://dx.doi.org/10.1111/j.1475-097X.2004.00577.x

85. Mariani PP, Santori N, Adriani E, Mastantuono M. Accelerated rehabilitation after arthroscopic meniscal repair: a clinical and magnetic resonance imaging evaluation. *Arthroscopy*. 1996;12:680-686.

86. Marx RG, Connor J, Lyman S, et al. Multirater agreement of arthroscopic grading of knee articular cartilage. *Am J Sports Med*. 2005;33:1654-1657. http://dx.doi.org/10.1177/0363546505275129

87. Marx RG, Stump TJ, Jones EC, Wickiewicz TL, Warren RF. Development and evaluation of an activity rating scale for disorders of the knee. *Am J Sports Med*. 2001;29:213-218.

88. Mathias S, Nayak US, Isaacs B. Balance in elderly patients: the "get-up and go" test. *Arch Phys Med Rehabil*. 1986;67:387-389.

89. Mattacola CG, Perrin DH, Gansneder BM, Gieck JH, Saliba EN, McCue FC, 3rd. Strength, functional outcome, and postural stability after anterior cruciate ligament reconstruction. *J Athl Train*. 2002;37:262-268.

90. Matthews P, St-Pierre DM. Recovery of muscle strength following arthroscopic meniscectomy. *J Orthop Sports Phys Ther*. 1996;23:18-26.

91. Mauro CS, Irrgang JJ, Williams BA, Harner CD. Loss of extension following anterior cruciate ligament reconstruction: analysis of incidence and etiology using IKDC criteria. *Arthroscopy*. 2008;24:146-153. http://dx.doi.org/10.1016/j.arthro.2007.08.026

92. Mayr HO, Weig TG, Plitz W. Arthrofibrosis following ACL reconstruction--reasons and outcome. *Arch Orthop Trauma Surg*. 2004;124:518-522. http://dx.doi.org/10.1007/s00402-004-0718-x

93. McGinty G, Irrgang JJ, Pezzullo D. Biomechanical considerations for rehabilitation of the knee. *Clin Biomech (Bristol, Avon)*. 2000;15:160-166.

94. Meredith DS, Losina E, Mahomed NN, Wright J, Katz JN. Factors predicting functional and radiographic outcomes after arthroscopic partial meniscectomy: a review of the literature. *Arthroscopy*. 2005;21:211-223. http://dx.doi.org/10.1016/j.arthro.2004.10.003

95. Meserve BB, Cleland JA, Boucher TR. A meta-analysis examining clinical test utilities for assessing meniscal injury. *Clin Rehabil*. 2008;22:143-161. http://dx.doi.org/10.1177/0269215507080130

96. Mithoefer K, McAdams T, Williams RJ, Kreuz PC, Mandelbaum BR. Clinical efficacy of the microfracture technique for articular cartilage repair in the knee: an evidence-based systematic analysis. *Am J Sports Med*. 2009;37:2053-2063. http://dx.doi.org/10.1177/0363546508328414

97. Moffet H, Richards CL, Malouin F, Bravo G, Paradis G. Early and intensive physiotherapy accelerates recovery postarthroscopic meniscectomy: results of a randomized controlled study. *Arch Phys Med Rehabil*. 1994;75:415-426.

98. Morrissey MC, Goodwin PC, Klarneta M, McAuliffe TB, El-Zebdeh M, King JB. Factors related to early recovery rate after partial knee meniscectomy. *Orthopedics*. 2008;31:752.

99. Muaidi QI, Nicholson LL, Refshauge KM, Herbert RD, Maher CG. Prognosis of conservatively managed anterior cruciate ligament injury: a systematic review. *Sports Med*. 2007;37:703-716.

100. O'Connor DP, Laughlin MS, Woods GW. Factors related to additional knee injuries after anterior cruciate ligament injury. *Arthroscopy*. 2005;21:431-438. http://dx.doi.org/10.1016/j.arthro.2004.12.004

101. Palmieri-Smith RM, Thomas AC, Wojtys EM. Maximizing quadriceps strength after ACL reconstruction. *Clin Sports Med*. 2008;27:405-424, vii-ix. http://dx.doi.org/10.1016/j.csm.2008.02.001

102. Patel AA, Donegan D, Albert T. The 36-item short form. *J Am Acad Orthop Surg*. 2007;15:126-134.

103. Phillips B, Ball C, Sackett D, et al. Levels of Evidence. Available at: http://www.cebm.net/index.aspx?o=4590. Accessed April 26, 2009.

104. Piriyaprasarth P, Morris ME. Psychometric properties of measurement tools for quantifying knee joint position and movement: a systematic review. *Knee*. 2007;14:2-8. http://dx.doi.org/10.1016/j.knee.2006.10.006

105. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*. 1991;39:142-148.

106. Ramos J, Perrotta C, Badariotti G, Berenstein G. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. *Cochrane Database Syst Rev*. 2008;CD005259. http://dx.doi.org/10.1002/14651858.CD005259.pub3

107. Reid A, Birmingham TB, Stratford PW, Alcock GK, Giffin JR. Hop testing provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther*. 2007;87:337-349. http://dx.doi.org/10.2522/ptj.20060143

108. Reinold MM, Wilk KE, Macrina LC, Dugas JR, Cain EL. Current concepts in the rehabilitation following articular cartilage repair procedures in the knee. *J Orthop Sports Phys Ther*. 2006;36:774-794. http://dx.doi.org/10.2519/jospt.2006.2228

109. Renstrom P, Johnson RJ. Anatomy and biomechanics of the menisci. *Clin Sports Med*. 1990;9:523-538.

110. Robertson A, Nutton RW, Keating JF. Dislocation of the knee. *J Bone Joint Surg Br*. 2006;88:706-711. http://dx.doi.org/10.1302/0301-620X.88B6.17448

111. Rodrigo JJ, Steadman JR, Silliman JF, Fulstone HA. Improvement of full-thickness chondral defect healing in the human knee after debridement and microfracture using continuous passive motion. *Am J Knee Surg*. 1994;7:109-116.

112. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)--development of a self-administered outcome measure. *J Orthop Sports Phys Ther*. 1998;28:88-96.

113. Roos EM, Roos HP, Ryd L, Lohmander LS. Substantial disability 3 months after arthroscopic partial meniscectomy: A prospective study of patient-relevant outcomes. *Arthroscopy*. 2000;16:619-626. http://dx.doi.org/10.1053/jars.2000.4818

114. Ross MD, Langford B, Whelan PJ. Test-retest reliability of 4 single-leg horizontal hop tests. *J Strength Cond Res*. 2002;16:617-622.

115. Ryzewicz M, Peterson B, Siparsky PN, Bartz RL. The diagnosis of meniscus tears: the role of MRI and clinical examination. *Clin Orthop Relat Res*. 2007;455:123-133. http://dx.doi.org/10.1097/BLO.0b013e31802fb9f3

116. Sgaglione NA, Del Pizzo W, Fox JM, Friedman MJ. Critical analysis of knee ligament rating systems. *Am J Sports Med*. 1995;23:660-667.

117. Shapiro ET, Richmond JC, Rockett SE, McGrath MM, Donaldson WR. The use of a generic, patient-based health assessment (SF-36) for evaluation of patients with anterior cruciate ligament injuries. *Am J Sports Med*. 1996;24:196-200.

118. Shelbourne KD, Patel DV, Adsit WS, Porter DA. Rehabilitation after meniscal repair. *Clin Sports Med*. 1996;15:595-612.

119. Snyder-Mackler L, Delitto A, Bailey SL, Stralka SW. Strength of the quadriceps femoris muscle and functional recovery after reconstruction of the anterior cruciate ligament. A prospective, randomized clinical trial of electrical stimulation. *J Bone Joint Surg Am*. 1995;77:1166-1173.

120. Sole G, Hamren J, Milosavljevic S, Nicholson H, Sullivan SJ. Test-retest reliability of isokinetic knee extension and flexion. *Arch Phys Med Rehabil*. 2007;88:626-631. http://dx.doi.org/10.1016/j.apmr.2007.02.006

121. Steadman JR, Briggs KK, Rodrigo JJ, Kocher MS, Gill TJ, Rodkey WG. Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up. *Arthroscopy*. 2003;19:477-484. http://dx.doi.org/10.1053/jars.2003.50112

122. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Phys Ther*. 2002;82:128-137.

123. Stiell IG, Greenberg GH, Wells GA, et al. Derivation of a decision rule for the use of radiography in acute knee injuries. *Ann Emerg Med*. 1995;26:405-413.

124. Stocker BD, Nyland JA, Caborn DN, Sternes R, Ray JM. Results of the Kentucky high school football knee injury survey. *J Ky Med Assoc*. 1997;95:458-464.

125. St-Pierre DM, Laforest S, Paradis S, et al. Isokinetic rehabilitation after arthroscopic meniscectomy. *Eur J Appl Physiol Occup Physiol*. 1992;64:437-443.

126. Sturgill LP, Manal TJ, Snyder-Mackler L, et al. Interrater reliability of a clinical scale to assess knee joint effusion [abstract]. *J Orthop Sports Phys Ther*. 2008;38:A28-A29.

127. Szczodry M, Coyle CH, Kramer SJ, Smolinski P, Chu CR. Progressive chondrocyte death after impact injury indicates a need for chondroprotective therapy. *Am J Sports Med*. 2009;37:2318-2322. http://dx.doi.org/10.1177/0363546509348840

128. Tandogan RN, Taser O, Kayaalp A, et al. Analysis of meniscal and chondral lesions accompanying anterior cruciate ligament tears: relationship with age, time from injury, and level of sport. *Knee Surg Sports Traumatol Arthrosc*. 2004;12:262-270. http://dx.doi.org/10.1007/s00167-003-0398-z

129. Tanner SM, Dainty KN, Marx RG, Kirkley A. Knee-specific quality-of-life instruments: which ones measure symptoms and disabilities most important to patients? *Am J Sports Med*. 2007;35:1450-1458. http://dx.doi.org/10.1177/0363546507301883

130. Tay GH, Warrier SK, Marquis G. Indirect patella fractures following ACL reconstruction: a review. *Acta Orthop*. 2006;77:494-500. http://dx.doi.org/10.1080/17453670610046451

131. Theiler R, Stucki G, Schutz R, et al. Parametric and non-parametric measures in the assessment of knee and hip osteoarthritis: interobserver reliability and correlation with radiology. *Osteoarthritis Cartilage*. 1996;4:35-42.

132. Thomee P, Wahrborg P, Borjesson M, Thomee R, Eriksson BI, Karlsson J. Self-efficacy of knee function as a pre-operative predictor of outcome 1 year after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:118-127. http://dx.doi.org/10.1007/s00167-007-0433-6

133. Tsepis E, Vagenas G, Ristanis S, Georgoulis AD. Thigh muscle weakness in ACL-deficient knees persists without structured rehabilitation. *Clin Orthop Relat Res*. 2006;450:211-218. http://dx.doi.org/10.1097/01.blo.0000223977.98712.30

134. Van Tongel A, Stuyck J, Bellemans J, Vandenneucker H. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction: a retrospective analysis of incidence, management and outcome. *Am J Sports Med*. 2007;35:1059-1063. http://dx.doi.org/10.1177/0363546507299443

135. Vervest AM, Maurer CA, Schambergen TG, de Bie RA, Bulstra SK. Effectiveness of physiotherapy after meniscectomy. *Knee Surg Sports Traumatol Arthrosc*. 1999;7:360-364.

136. Wasiak J, Clar C, Villanueva E. Autologous cartilage implantation for full thickness articular cartilage defects of the knee. *Cochrane Database Syst Rev*. 2006;3:CD003323. http://dx.doi.org/10.1002/14651858.CD003323.pub2

137. Widuchowski W, Widuchowski J, Trzaska T. Articular cartilage defects: study of 25,124 knee arthroscopies. *Knee*. 2007;14:177-182. http://dx.doi.org/10.1016/j.knee.2007.02.001

138. Williams RA, Morrissey MC, Brewster CE. The effect of electrical stimulation on quadriceps strength and thigh circumference in menisectomy patients. *J Orthop Sports Phys Ther.* 1986;8:143-146.

139. Williams SK, Amiel D, Ball ST, et al. Analysis of cartilage tissue on a cellular level in fresh osteochondral allograft retrievals. *Am J Sports Med.* 2007;35:2022-2032. http://dx.doi.org/10.1177/0363546507305017

140. World Health Organization. International Classification of Functioning DaHI. Geneva, Switzerland: 2001.

141. World Health Organization. International Classification of Functioning DaHRPI-. Geneva, Switzerland: 2005.

142. Wright RW. Knee injury outcomes measures. *J Am Acad Orthop Surg*. 2009;17:31-39.

143. Wright RW, Boyce RH, Michener T, Shyr Y, McCarty EC, Spindler KP. Radiographs are not useful in detecting arthroscopically confirmed mild chondral damage. *Clin Orthop Relat Res*. 2006;442:245-251.

144. Wright RW, Preston E, Fleming BC, et al. A systematic review of anterior cruciate ligament reconstruction rehabilitation: part II: open versus closed kinetic chain exercises, neuromuscular electrical stimulation, accelerated rehabilitation, and miscellaneous topics. *J Knee Surg*. 2008;21:225-234.

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ERRATUM

We make the following corrections to the clinical guidelines, "Knee Pain and Mobility Impairments: Meniscal and Articular Cartilage Lesions," published in the June 2010 issue of the *JOSPT*. As "John Dewitt, DPT" was listed in error as a reviewer for these clinical guidelines, we remove him from the list of reviewers on page A1 and from the Affiliations and Contacts section on page A31. To the reviewer list on page A1, we add reviewer Matthew Briggs, DPT, and to the Affiliations and Contacts on page A31, we add Matthew Briggs, DPT, Coordinator, Sports Physical Therapy Residency, The Ohio State University, Columbus, OH, matt.briggs@osumc.edu. These changes are reflected in the electronic version of the article, available at www.jospt.org (http://dx.doi.org/10.2519/jospt.2010.0304). Our apologies for these errors.

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