

Conservative Care Options for Work-Related Knee Conditions

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Purpose and Intended Use

This resource was developed by the Industrial Insurance Chiropractic Advisory Committee (IICAC) of the Washington State Department of Labor and Industries. It provides concise summaries of published clinical and scientific literature regarding utility and effectiveness of commonly used conservative care approaches for work-related knee conditions; history, examination and special studies, recommendations for supportive, manual, and rehabilitative care including practical clinical resources (useable without licensing/charge in practice for non-commercial use). It is intended to inform care options and shared decision-making. High-level information on invasive treatments is included for informational purposes for conservative care providers and not intended as a treatment guideline for such interventions. This document is not a standard of care, claim management standard, nor a substitute for clinical judgment in an individual case. This practice resource does not change L&I coverage or payment policy, nor does referencing of a research study imply a given procedure is a covered benefit.

A comprehensive search of available scientific literature on conservative assessment and intervention procedures for knee conditions was conducted by the Policy, Practice, and Quality (PPQ) Subcommittee of the IICAC and department staff during Fall 2017. Literature was reviewed, assessed for relevance and quality and summaries were drafted by consensus of the subcommittee with expert content input from consultants and reviewers, including the department's Industrial Insurance Medical Advisory Committee and selected content experts. An updated draft was posted for public comment and was revised and approved for distribution by the IICAC and department in January 2018. This resource is expected to be updated periodically by the IICAC. Interested parties are encouraged to submit new published scientific reports for consideration for future revisions.

This and other practice resources are in the public domain and are available for download at the State of Washington Department of Labor & Industries website below. Contact information for public input and submission of studies for future revisions is also available there.

<http://www.lni.wa.gov/IICAC>

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PRACTICAL APPLICATION POINTS

- Work-related knee conditions should usually be related to an identifiable workplace event or injury.
- Conservative approaches including biopsychosocial support, exercise, and mobilization/manipulation along the kinetic chain (pelvis, hip, knee and foot/ankle) appear to be effective for most uncomplicated knee conditions including ligament and tendon sprain, intra-articular cartilage, and soft tissue strain.
- Combining psychosocial interventions with active and passive approaches appear to improve effectiveness of interventions alone.
- Surgical referral should consider condition severity, work and lifestyle demands on the knee, ability to comply with rehabilitation programs and general age and fitness. Impacts vary with the individual and affected structures.

Evaluation Summary

- Risk factors for developing knee problem include age, obesity, diabetes, prior knee trauma, reduced strength, prolonged work hours and inadequate sleep. Patellofemoral pain problems are associated with a variety of foot mobility problems.
- Severe trauma and certain injuries (e.g., ACL rupture in those with high intensity jobs) may warrant urgent/early surgical referral.
- Clinical examination should aim to identify involved tissues and structure through inspection, palpation, provocative testing.
- A variety of knee and lower limb functional scales have been validated to determine degree of disability and are useful for monitoring progress.
- Knee function involves the entire kinetic chain including pelvis, hip and foot. Biomechanical stress on the knee can be related to the full kinetic chain both in terms of condition onset, and successful management.
- Early imaging may be best reserved for suspicion of fracture and more severe trauma. MRI verifies 80% of clinical diagnoses suggesting less need for imaging prior to conservative care. Clinical prediction rules for fracture reduce need for plain film.

Intervention Summary

- Cruciate ligaments are avascular and do not heal after rupture. Surgical reconstruction may be preferable for workers engaged in activities involving compressive and rotational stress to the affected knee.
- Collateral ligament injuries are often concurrent with other ligament damage (e.g. anterior cruciate and medial collateral ligaments are often both injured). Early knee mobilization and weight-bearing to tolerance followed by strengthening exercise is beneficial within the first 4 weeks.
- Meniscus injury not associated with a blocked knee should resolve well conservatively with progressive exercise emphasizing quadriceps and hamstring strength and endurance.
- Patellofemoral pain syndromes and osteoarthritis respond well to multimodal intervention including full kinetic chain exercise, manual methods, psychosocial support and taping.
- Posterior knee injuries are less common with tendinopathies (e.g. hamstring sprain/strain) and are best managed conservatively. Baker's cysts may respond better to surgical treatment if conservative measures are inadequate.

Work-Related Knee Conditions

Anterior cruciate and medial collateral ligaments are the most vulnerable knee structures to athletic and workplace trauma due to the exposure to trauma anteriorly and laterally. Patellofemoral pain related to direct force trauma, flexion injury, and extension overuse is also common. Intraarticular cartilage damage is usually the result of compression trauma (e.g., from a jump) or substantial trauma. Osteoarthritis of the knee is a common condition with age and its acceptance as a work-related condition typically requires that the condition be worsened or "lit-up" from the work injury. Fractures of the patella, distal femur, patella, proximal tibia and/or fibula can also occur.

Typical Interventions and Approximate Response Thresholds

1-2 wks	3-6 wks	7-8 wks	Beyond 8 wks
<ul style="list-style-type: none"> • Initially: Patients with red flags or persistent severe pain should be referred to a specialist for urgent evaluation. • Uncertain mechanical etiology, severe pain/restriction: rule out fracture and dislocation; expect some early measurable improvement w/ combined active exercise and manual work within patient tolerance. • Known mechanical etiology: expect early significant improvement for low grade sprains, tendinosis, etc, however recovery may be delayed in chronic and more severe conditions. • Early: Re-assess pain/function within 2-3 weeks of beginning care. 	<ul style="list-style-type: none"> • Good improvement: Function and weight tolerance improves measurably and perceptively. Continue, emphasize self-care. • Limited improvement: Conditions likely to respond slower include Grade III sprains and cruciate ligament rupture. Measureable change should be documented. • Inadequate improvement: Worsening or no change in function (e.g., higher score on FAAM or SEFAS). Consider additional diagnostics, specialist consultation. If only small improvement, consider change in intervention (e.g., supervised exercise, more intense manual work). 	<ul style="list-style-type: none"> • Demonstrable improvement should be evident. Inadequate response warrants consideration for evaluation by orthopedic specialist. • Good improvement: Significant improvement in function, scores, and activity levels. Consider transition to more self-care, periodic follow-up assessment. Higher grade sprains, more osteoarthritis, older individuals may have slower response • Inadequate improvement: Significant pain & function limitations persist, minimal improvement. Consider special studies (e.g., MRI) or specialist referral. 	<ul style="list-style-type: none"> • Resolution: Most uncomplicated knee injuries should achieve tolerance of weight bearing and normal walking. • Good improvement: Most acute knee problems (e.g., patellofemoral, milder collateral ligament sprains, meniscus problems) should resolve fully in terms of normal function. Improvement in function should be significant and measurable in more severe sprains. • Inadequate improvement: Consider additional diagnostics, specialist consultation.

KNEE PROGRESS CHECKLIST

Voluntary educational / practice aid – Not an L&I documentation requirement



Assessment / Progress

<p>Date:</p> <p><i>Work limitation:</i></p> <p><input type="checkbox"/> Off work</p> <p><input type="checkbox"/> Weight restriction: _____</p> <p><input type="checkbox"/> Activity limits: _____</p> <p><input type="checkbox"/> Weight-bearing work tolerance: _____ hrs</p> <p><i>Function Score</i> (e.g., __, __)</p> <p>Baseline: _____</p> <p><i>Pain Interference w/ activity:</i></p> <p>None Total</p> <p><u>0 1 2 3 4 5 6 7 8 9 10</u></p> <p><i>Baseline</i> (check all that apply):</p> <p><input type="checkbox"/> Difficult weight bearing</p> <p><input type="checkbox"/> Unable to walk normally</p> <p><input type="checkbox"/> Activity limited by pain</p> <p><input type="checkbox"/> _____</p>	<p>Date:</p> <p><i>Work limitation improvement:</i></p> <p><input type="checkbox"/> Off work</p> <p><input type="checkbox"/> Weight restriction: _____</p> <p><input type="checkbox"/> Activity limits: _____</p> <p><input type="checkbox"/> Weight-bearing work tolerance: _____ hrs</p> <p><i>Function Score</i></p> <p>_____</p> <p><i>Pain Interference w/ activity:</i></p> <p>None Total</p> <p><u>0 1 2 3 4 5 6 7 8 9 10</u></p> <p><i>Percent Improvement</i> (pt. perception):</p> <p>___ Weight bearing</p> <p>___ Walking</p> <p>___ Activity limitation</p> <p>___ _____</p>	<p>Date:</p> <p><i>Work limitation improvement:</i></p> <p><input type="checkbox"/> Off work</p> <p><input type="checkbox"/> Weight restriction: _____</p> <p><input type="checkbox"/> Activity limits: _____</p> <p><input type="checkbox"/> Weight-bearing work tolerance: _____ hrs</p> <p><i>Function Score</i></p> <p>_____</p> <p><i>Pain Interference w/ activity:</i></p> <p>None Total</p> <p><u>0 1 2 3 4 5 6 7 8 9 10</u></p> <p><i>Percent Improvement</i> (pt. perception):</p> <p>___ Weight bearing</p> <p>___ Walking</p> <p>___ Activity limitation</p> <p>___ _____</p>	<p>Date:</p> <p><i>Work limitation improvement:</i></p> <p><input type="checkbox"/> Off work</p> <p><input type="checkbox"/> Weight restriction: _____</p> <p><input type="checkbox"/> Activity limits: _____</p> <p><input type="checkbox"/> Weight-bearing work tolerance: _____ hrs</p> <p><i>Function Score</i></p> <p>_____</p> <p><i>Pain Interference w/ activity:</i></p> <p>None Total</p> <p><u>0 1 2 3 4 5 6 7 8 9 10</u></p> <p><i>Percent Improvement</i> (pt. perception):</p> <p>___ Weight bearing</p> <p>___ Walking</p> <p>___ Activity limitation</p> <p>___ _____</p>
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Intervention Options

- | | |
|---|---|
| <p>Manual</p> <ul style="list-style-type: none"> • Combined mobilization, initial active and passive exercise, and soft tissue work typically reduce pain and improve function for mechanical foot/ankle problems. Treatment frequency reported in trials typically 2-3 times per week. <p>Modalities/Self Care</p> <ul style="list-style-type: none"> • Full immobilization for severe conditions and fracture: R/MICE* to tolerance initially for most other knee conditions. • Consider home exercise to tolerance. • Physiotherapeutic modalities may not be particularly helpful. • NSAIDs and analgesics may be helpful for initial pain control, but prolonged use is discouraged | <p>Manual</p> <ul style="list-style-type: none"> • Incrementally increasing intensity of manual techniques within patient tolerance is advisable. In absence of meaningful functional improvement, consider modification of methods. • Consider incorporation of exercises (e.g., range of motion and strengthening approaches) as tolerance allows. Hip, knee, and foot exercises may be appropriate for optimal effectiveness • Supervised exercise may be beneficial with slower responding conditions (e.g., Grade III sprains, cruciate ruptures, intraarticular damage). <p>Response</p> <ul style="list-style-type: none"> • 30-50% improvement in function scores is considered meaningful clinical change. • Lower grade sprains typically attain this rapidly. Tendinosis usually experience slower response |
|---|---|

- Good Improvement**
- Progression of uncomplicated knee problems (e.g., Grade I sprains) is typically ~50% improvement in pain and function within first 2 weeks and fully resolved within 8 weeks.
 - For tendinosis 30-50% improvement in pain and function scores within first month can be expected.
 - Low grade sprains respond very quickly to conservative intervention. Grade III sprains, cruciate rupture, and some fractures may have significantly delayed response.
- Inadequate improvement**
- Reassessment for red flags, further diagnostics, and specialist consultation is warranted in non-responding cases.
 - Consider specialist consult for apparent low grade traumatic injuries if only minimal improvement is seen within first month.

* R/MICE = Rest/Modified pain-free activity, Ice, Compression, Elevation

Name: _____

Today's Date _____

This survey asks for your view about your knee. This information will help us keep track of how well you are able to perform different activities.

Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can so that you answer all the questions.

The following questions concern your level of function in performing usual daily activities and higher level activities.

For each of the following activities, please indicate the **degree of difficulty** you have experienced in the *last week* due to your knee problem

Degree of Difficulty

Activity	None (0)	Mild (1)	Moderate (2)	Severe (3)	Extreme (4)
1. Rising from bed					
2. Putting on socks/stockings					
3. Rising from sitting					
4. Bending to floor					
5. Twisting/pivoting on your injured knee					
6. Kneeling					
7. Squatting					

Office Use:

Raw score (0-28) is typically converted to a true interval scale following scoring instruction found in the appendix. Full use and instructions for KOOS and its variants can be found at <http://www.koos.nu/>

Name: _____

Today's Date: _____

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your lower limb problem** for which you are seeking attention. Please provide an answer for **each** activity. Today, **do you or would you have any difficulty at all with** (circle one number on each line):

ACTIVITY	Extreme Difficulty	Quite a bit of Difficulty	Moderate Difficulty	A little bit of Difficulty	No Difficulty
1. Any of your usual work, housework, or school activities	0	1	2	3	4
2. Your usual hobbies, recreational or sporting activities	0	1	2	3	4
3. Getting into or out of the bath	0	1	2	3	4
4. Walking between rooms	0	1	2	3	4
5. Putting on your shoes or socks	0	1	2	3	4
6. Squatting	0	1	2	3	4
7. Lifting an object, like a bag of groceries, from the floor	0	1	2	3	4
8. Performing light activities around your home	0	1	2	3	4
9. Performing heavy activities around your home	0	1	2	3	4
10. Getting into or out of a car	0	1	2	3	4
11. Walking 2 blocks	0	1	2	3	4
12. Walking a mile	0	1	2	3	4
13. Going down 10 stairs (about 1 flight of stairs)	0	1	2	3	4
14. Standing for 1 hour	0	1	2	3	4
15. Sitting for 1 hour	0	1	2	3	4
16. Running on even ground	0	1	2	3	4
17. Running on uneven ground	0	1	2	3	4
18. Making sharp turns while running fast	0	1	2	3	4
19. Hopping	0	1	2	3	4
20. Rolling over in bed	0	1	2	3	4
Column Totals:	_____	_____	_____	_____	_____
	Score: _____ / 80 = _____ %				

Source: Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. Phys Ther 1999;79(4):371-83.

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OCCUPATIONAL KNEE ASSESSMENT SUMMARY

Occupational Knee Conditions

Nature of knee disorders

- Urgent and serious medical conditions – infection, vascular compromise, neoplasms, metabolic conditions (e.g., gout, diabetes) warrant medical referral.
- Urgent mechanical conditions – fractures, cruciate ligament rupture, patellar tendon tears, and dislocations warrant surgical consultation. Large meniscal tears (MRI verified) that remain symptomatic for a prolonged period may warrant arthroscopic intervention.
- Mechanical conditions – ligamentous strains, subluxation, soft tissue disorders.
- Neurological conditions – peripheral neuropathy, radicular pain, sclerotomal radiation, paresthesia (Note: trauma and fracture may also involve significant neurological compromise).

Clinical presentation^[1]

- The most common knee injuries result from impacts and may include peripheral nerve root entrapment (peroneal, saphenous, sciatic), meniscus tears, cruciate ligament rupture and, collateral ligament sprains.
- Simple sprains may be associated with various ligament ruptures and/or fractures, thus careful evaluation of the mechanism of injury, follow-up, and reassessment and special studies may be needed with inadequate or sluggish recovery.
- Symptoms in the knee may be related to radiating pain from back, pelvis, hip and may also result from mechanical stresses distal to the joint.
- Knee conditions may present with a number of signs and symptoms including pain, swelling, stiffness, weakness/sensation of “giving out”, discoloration, popping/crepitus, locking, paresthesias, and/or numbness.
- Full joint swelling reflects intraarticular damage (ACL, PCL, meniscal tears, synovial/capsular bruising)
- Most knee conditions relate to ligament sprains/tears and are typically the result of an identifiable trauma to the lower extremity.
- Soft tissue and muscular stress (trigger points, overuse, prolonged or awkward position, bursitis) may also incite knee pain.
- Vascular compromise, peripheral and radicular neuropathies of the back and lower extremities may manifest with symptoms in the leg, but are not likely to be exacerbated by provocative testing of the knee region. Diabetes, myelopathy (usually canal stenosis), proximal trauma and other factors can contribute to sensory deficits with long term consequences that can contribute to, or exacerbate injury.
- Instability may be a consequence of significant knee trauma but swelling and muscle guarding can mask its appearance for many weeks.

Work place exposure: work injury types

- Direct trauma (e.g., blunt force; crush injuries): consider contusion, patellar fracture, fat pad inflammation
- Valgus forces: consider medial collateral ligament (MCL) sprain; if combined with rotational force, e.g. planted foot, ACL, MCL and intra-articular damage may have occurred.
- Compression (e.g., “dashboard” injuries from an auto collision): consider intra-articular damage and fracture
- Hyperextension: consider anterior cruciate ligament (ACL) tear
- Hyperflexion: consider posterior cruciate ligament (PCL) tear

Work place exposure: occupational disease

- When activities outside of work may also contribute to knee problems, case law requires establishing that the workplace activities contributed to the development or worsening of the condition on a more-probable-than-not basis compared to the risks in everyday life. (Dennis V. Dept. of Labor & Industries, 1987) This can be particularly relevant when considering repetitive stress (e.g., prolonged standing, overuse, working on a hard surface) as a potential contributor.

Diagnostic corroboration

- History (e.g., mechanics of exposure - trauma, assessment of contributing factors, concurrent conditions).
- Pain localization – symptomatic area typically identifies affected structures and should correlate with exposure onset
- Plain film imaging may be helpful to assess for:
 - Osseous damage/fracture with substantial trauma and when swelling and tenderness immediately follow an injury.
 - Non-mechanical etiology such as tumor or infection.
- More severe sprains are likely to result in instability that over time may damage joint surfaces and lead to degeneration.

HISTORY – Diagnostic/Severity Indicators

Patient Presentation

Symptom type and location

- Determine the principle symptom(s) (pain/tenderness, swelling, stiffness, locking, paresthesia, instability/apprehension/weakness)
- Determine where the symptom is located (anterior or posterior, medial or lateral, consider tendinous insertions.)

Mobility

- Stiffness, looseness, crepitus should be assessed as should associated deformities (e.g., those related to rheumatoid conditions)
- Ligamentous laxity may be suspected if looseness with passive movement can be demonstrated compared to the unaffected side.

Onset

- Sudden – Clarify the following:
 - Positional (flexion, hyper-extension, medial or lateral bend, rotational stress)
 - Trauma (direct, blunt force, sudden load, e.g., from a jump, dashboard or crush injury)
- Gradual/prolonged – Assess:
 - Repetitive midrange flexion-extension may contribute to popliteal tendinosis and/or iliotibial band irritation
 - Repeated jumping may contribute to patellar tendinosis
- Insidious – Consider:
 - Non-mechanical causes (unexplained erythema, swelling, elevated tissue temperature, pain at rest) warrant consideration for specialist referral.
 - Degenerative changes
 - Associated symptoms (weakness, numbness, fever, lymphadenopathy, warmth and/or reddening)
- In all cases, determine what tasks and activities attended onset:
 - Specific triggering incident/accident
 - Usual work task/activity
 - Unique work task/activity

Age

- Instability may be a more substantial problem in older individuals.
- Joint degeneration is associated with normal aging, obesity, as well as the sequelae of a trauma to a joint.

HISTORY - Prognostic Indicators

Risk Factors for Developing Knee Problems

Several factors have been reported to predispose individuals to developing knee problems including age, obesity, concurrent degenerative disease, diabetes, previous knee or leg trauma, reduced isokinetic strength, hours/day worked and sleep hygiene.^[2-5]

- In a 2015 report, 5689 US Air Force and Navy cadets with no prior history of ACL reconstruction were followed for 4 years. Subsequent diagnoses of ACL were identified in 117 of the subjects. A previous history of ankle sprain was predictive of the ACL injury while prior history of shin splints, knee swelling or clicking, patellofemoral pain or hip injury was not.^[5]
- A systematic review of studies of lower leg injuries identified 10 studies of sports activities resulting in lower leg injuries. Factors associated with injuries were identified with increasing age and previous calf strain injury are the most predictive of future calf injury.^[3]
- A 2009 cross-sectional survey was conducted on 1185 office workers from 54 workplaces in Bangkok to determine the relationships between the self-reported prevalence of musculoskeletal symptoms in the hip, knee and ankle/foot and individual, work-related physical and psychosocial factors.^[4] Suffering from a chronic disease, the average number of working hours/day, sleep quality and self-rated perception of air circulation in the office were significantly related to the prevalence of experiencing knee symptoms. Significant associations were found between the prevalence of experiencing ankle/foot symptoms and sleep quality, self-rated perception of the ergonomics of the desk and size of office space and frequency of feeling frustrated during the previous 4 weeks.

Risk Factors for Prolonged Disability

Some of the above factors also correlate with greater likelihood of prolonged disability with knee conditions including:

- Prior knee and lower extremity injuries
- Older age, obesity, general deconditioning
- Psychosocial factors such as low recovery expectations or activity avoidance due to fear that it will aggravate the injury

Predictors of Effective Treatment

Some information is available for predicting who is likely to respond to conservative knee interventions:

- The association between subjects with patellofemoral pain and potential prognostic factors and treatment effect modifiers was addressed in a 2016 systematic review.^[6] The review identified 24 studies evaluating 180 participant characteristics; 12 studies investigated prognosis, and 12 studies investigated potential treatment effect modifiers. Important methodological limitations were identified (e.g., retrospective design, too many variables for the sample size). Longer duration of symptoms (>4 months) was the most reported. Preliminary evidence suggests increased midfoot mobility may predict those who have a successful outcome to foot orthoses.
- Fifteen low-quality cohort studies (no randomized trials) were identified in a 2014 systematic review of 205 conservative management outcome predictor variables with conservative treatment of patellofemoral pain.^[7] Nineteen (9%) were found to significantly predict a successful outcome. Very limited evidence identified higher functional index questionnaire scores (mean 0.82, 95% confidence interval [CI] 0.18-1.46), greater forefoot valgus (mean 0.67, 95% CI 0.05-1.28) and greater rearfoot eversion magnitude peak (mean -0.93, 95% CI -1.84 to -0.01) to significantly predict improved outcomes with orthoses interventions. Shorter symptom duration ($p = 0.019$), lower frequency of pain ($p = 0.012$), younger age, faster vastus medialis oblique reflex response time ($p = 0.026$), negative patella apprehension, absence of chondromalacia patella, tibial tubercle deviation of <14.6 mm and greater total quadriceps cross-sectional area on magnetic resonance imaging ($p = 0.01$), and reduced eccentric average quadriceps peak torque ($p = 0.015$) significantly predicted exercise intervention success following multivariate statistical analysis. Limited evidence identified increased Q-angle (mean 0.38, 95% CI 0.05-0.72) and very limited evidence identified greater usual pain (mean 0.43, 95% CI 0.01-0.85) to predict taping intervention success. This systematic review provides a comprehensive summary of current derivation level studies identifying indicators of prediction for conservative PFP management. The overall strength of evidence was low. With appropriate caution, clinicians should consider taping for those with greater usual pain, orthoses for older individuals and exercise for younger individuals, and orthoses intervention for patients with greater forefoot valgus and rearfoot eversion magnitude peak. RCTs with evaluation of outcome prediction as a primary aim are clearly warranted to provide clinicians with robust evidence and facilitate evidence-informed, tailored intervention to this heterogeneous patient population.

CLINICAL EXAMINATION – Inspection

Observation

Skin changes (e.g., erythema), temperature, and deformity should be noted and quantified where possible. Detailed attention to location and extent of size differences should be given with circumference measurements, photographing of bruising, use of skin-marking, etc. Such baseline information can inform progress as well as consistency of patient's subjective complaints. Objective findings include: ^[1]

- Swelling
- Atrophy
- Deformity

Palpation

Tissue consistency, specific location of tenderness, and temperature should be assessed and ideally compared to the unaffected side. This baseline should be carefully assessed to serve as a comparison at follow-up. Palpation of the patellar tendon may be particularly helpful in identifying patellar tendon width, however palpation of the tendon width may be more accurate than length.^[8] Point tenderness over various bursa should be noted (patellar, deep and superficial infrapatellar, pes anserine). Post-traumatic localized pain over bony prominences and long bones may be indicative of fracture. Tenderness of tendon insertion areas may reflect contusions, hypertonic associated muscles and/or trigger points.^[1]

Neuro-vascular Assessment

Peripheral pulses, temperature, trophic skin changes, sensation along peripheral and radicular nerve distributions, reflex symmetry, and strength symmetry should be documented. The knee may also be the site of referred pain from lumbar radiculopathy and other peripheral neuropathies so consideration of rule-out tests (e.g. Straight Leg Raising, femoral nerve tension testing, slump test) may be appropriate if localized knee assessment proves non-confirmatory.

CLINICAL EXAMINATION – Functional Deficit

Range of Motion

Restricted knee motion may suggest intraarticular lesions (joint mice, effusion, meniscal or cartilage damage, cruciate damage) or musculotendinous involvement (tight musculature, contracture). Qualitatively, passive movement that is pain free compared to active movement suggests contractile tissue involvement. Stability and laxity is typically compared qualitatively to the unaffected side. Utility and evidence regarding systematic laxity tests are described in the section below on provocation tests.

Strength

Careful muscle strength testing can be particularly helpful in identifying nerve damage that could result from an occupational injury.

- Painful resisted contraction typically suggests irritation or damage to the muscles and/or tendons involved.
- Asymptomatic weakness compared to an unaffected side suggests a neurological etiology
- Peripheral nerve damage from injury, diabetes, or rheumatoid arthritis

Functional Disability Questionnaires

Most knee-specific scales were designed to address degree of functional limitation resulting from degenerative joint disease and frequently include hip function as well.^[9-11] A 2004 review of 16 patient-reported knee scales concluded that the KOOS and Oxford Scales have good evidence for reliability, content validity, construct validity and responsiveness.^[12] Scales applicable to knee conditions that have some evidence of validity include:

- **Knee Injury and Osteoarthritis Outcome Score Short Form (KOOS-PS)** – Derived from the KOOS and validated primarily for osteoarthritis. It contains 7 questions related to straight forward activities involving the knee, it is easily administered and scored, thus attractive for clinical use, and can augment use of regular patient report (e.g., pain and pain interference scales). Minimal clinical difference studies have not been reported. <http://www.koos.nu>
- **Knee Injury and Osteoarthritis Outcome Score (KOOS)** – A comprehensive 42 question patient filled out scale addressing 5 domains of knee symptoms and function: pain frequency/severity, knee stiffness/swelling/clicking/restriction, activity difficulty, and knee-related quality of life. The KOOS has strong psychometric performance and has demonstrated responsiveness to change in

both surgical and non-surgical conditions. Minimal clinical difference has been determined (6-12 points for injuries; 13-21 for osteoarthritis). The KOOS is freely available and can be administered and scored on-line. <http://www.koos.nu>

- **Lower Extremity Functional Scale (LEFS)** – A 20 question, 0-4 point scale developed for orthopedic conditions of the leg that limit function addresses activities and positions common to daily living and recreation. A maximum of 80 possible points reflects full function. LEFS has been validated with a minimal detectable change of 9 points.^[13, 14]
- **Oxford Knee Score (OKS)** – A brief 12 question scale developed for assessing pain severity, mobility, limping, standing up, kneeling, giving way, and several activities of daily living with total knee replacement patients. A revised version with more straightforward scoring is available on line. It appears to be helpful in predicting success for knee replacement, but minimal clinical difference has not been reported. http://www.orthopaedicscore.com/scorepages/oxford_knee_score.html
- **International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC)** – Published and validated against the SPK-36 in its current version in 2001 normative data was also published in 2006 and is considered useful in orthopedic care, frequently knee replacement surgery.^[15, 16] The scale is 10 questions and may be found in an online version. http://www.orthopaedicscore.com/scorepages/international_knee_documentation_comitee.html
- **Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL)** – Several versions of this scale have been published. Originally designed as a 17 point scale (7 for symptoms, 10 for function) for use with a variety of knee conditions, several variants have been published (shorter versions and alternative scoring approaches). The scale is reliable, valid and responsive to change, particularly with patients undergoing physical therapy.^[17] <https://ct1.medstarhealth.org/content/uploads/sites/108/2016/11/KOS-2014.pdf>
- **Lysholm Knee Scoring Scale (LKSS)** – Originally designed to assess function related to ligament damage the eight item scale is administered by the clinician to capture patient perception of limp, support, locking, instability, pain, swelling, stair climbing and squatting. Each item is scored on an arbitrary increasing scale which totals to 100, with the higher score representing no disability. Content validity has not been established and inconsistencies have been reported in administration and consistency with different conditions.^[9, 18]
- **Activity Rating Scale (ARS)** – A four item scale assessing running, cutting, decelerating and pivoting, the ARS is useful for a variety of knee conditions related to participation in sports activities. Items are scored 0-4 with increasing score reflecting more frequent performance of the activity weekly. Because of its specific focus on more elite sporting activities, it might best be considered as an adjunct to other scales for individuals engages in athletics.^[19]
- **Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)** – Aimed at hip and knee osteoarthritis, WOMAC is available in numerous variants using 5 point Likert scales, 100mm visual analog scales and 11 box rating scales. Three subscales capture pain severity during various movements and position, joint stiffness severity and difficulty in daily activities. Scoring is somewhat involved and permission and licensing is required to use the scale. It is commonly used for osteoarthritis, but may not be as useful for more difficult functional tasks. Information is obtainable on line: <http://www.womac.org>
- **Tegner Activity Score (TAS)** – Originally developed for use with anterior cruciate ligament injury in conjunction with the LKSS, this 11 item scale lists activities of daily living, recreational and athletic activities for which the patient rates their level of participation. The scale has been used with multiple knee disorders and is scored to a level of 10 based on the activities selected by the patient. A score of 0 reflect that they are disabled and/or on sick leave due their knee problems while a score of 10 reflects participation elite athletic competition.^[20]
- **Lower Limb Outcome Questionnaire (LLOQ)** – The LLOQ was developed by the American Academy of Orthopedic Surgeons and numerous other orthopedic organizations. It is made up of 7 items addressing symptoms and activities related to the lower extremity over the previous week. Test-retest reliability within 24 hours of re-administration has been reported as well as comparability to SF-36 measures.^[21] The instrument and a scoring worksheet is available online: http://www.aaos.org/research/outcomes/outcomes_list.asp#low

Pain Interference

Specific attention to how a patients' pain interferes with their ability to perform usual activities has been shown to be useful in predicting chronicity for low back and other musculoskeletal problems, particularly in injured worker populations. Although imperfect, patient reported outcomes such as pain interference have proven useful (and have been validated for low back and leg pain).^[22, 23] A fast and simple approach to track the impact of the patient's pain on their function could be a simple anchored 0-10 scale such as:

In the last month, how much has your ankle pain/problem interfered with your daily activities? (Use a scale from 0 to 10, where 0 is "no interference" and 10 is "unable to carry on any activities")

CLINICAL EXAMINATION – Provocation - Relief

Stability Tests

Meniscal and ligament injuries of the knee can generally be diagnosed through careful physical examination.^[24] Advanced imaging is best reserved for complex or doubtful cases. Exam and imaging combined show high sensitivity for anterior cruciate and medial collateral ligament lesions, while specificity is higher for lateral meniscus lesions. A systematic review from 2002 concluded that anterior drawer, Lachman's and Pivot shift tests were the most useful ligament stability tests.^[25]

Anterior Cruciate Ligament Stability Tests

- **Lachman's Test** – Performed with patient supine and knee flexed 15-30 degrees, one hand is placed behind the proximal tibia with the examiners thumb on the tibial tuberosity and the other hand stabilizing the distal thigh. The tibia is pulled anteriorly. Normally this should result in a hard, firm end feel. A soft or mushy end feel or excessive anterior translation indicate ACL instability. A 2015 systematic review of assessing diagnostic accuracy concluded that Lachman's was sensitive for full tears (compared to imaging and arthroscopy) but less so for partial tears. However pooled specificity is very high.^[26]
- **Pivot-Shift Test** – With the patient supine and the hip passively flexed about 30 degrees, the lower leg and ankle is grasped (from the lateral side) applying about 20 degrees of internal tibial rotation. The knee is fully extended while the opposite hand grasps the leg laterally at the level of the superior tibiofibular joint, increasing the force of internal rotation. While maintaining internal rotation, a valgus force is applied to the knee while it is slowly flexed. If the tibia's position on the femur reduces as the knee is flexed in the range of 30 to 40 degrees or if there is an anterior subluxation felt during extension the test is positive for instability. Pivot-shift test is less sensitive than Lachman's and may produce more discomfort. However its specificity is somewhat higher than Lachman's.^[26]
- **Anterior Drawer Sign** – Similar to Lachman's, but typically done with the knee flexed to 90 degrees. However, this appears to be even less sensitive than Lachman's or Pivot-Shift tests, particularly in acute injuries due to hamstring tightness.^[1, 26]

Collateral Ligament Sprain/Stability Tests

Collateral ligament stress testing is not well studied for diagnostic accuracy. One older study evaluating inter-examiner reliability did not show much agreement.^[27] Collateral ligament sprains are categorized as:

- Grade 1: Primarily minor pain and tenderness noted on valgus or varus stress usually distally where ligaments attach.
 - Grade 2: Looseness in the knee should be observable with a joint space opening of about 5-10mm is present when laterally stressed. Significant pain over the damaged structure is present and swelling is typically observable.
 - Grade 3: Noticeable looseness with a joint space opening of >10mm can be observed with varus or valgus stress indicating a full tear. Considerable pain is present and such trauma usually also involves the anterior cruciate ligament.
- **Valgus Stress Test (Medial Collateral Ligament)** – The medial collateral ligament (MCL) is more frequently injured than the lateral collateral ligament (LCL). It is tested by placing a valgus stress on the knee joint with the knee in full extension. The test is positive if the joint space opens medially and some lateral bend is observed. When this position is negative the test should be repeated in about 30 degrees of flexion.

Compressive Meniscus Provocation Tests

- **Varus Stress Test (Lateral Collateral Ligament)** – The lateral collateral ligament (LCL) is tested by placing a varus stress on the knee joint with the knee in full extension. The test is positive if the joint space opens laterally and some lateral bend is observed. When this position is negative the test should be repeated in about 30 degrees of flexion.
- **Distraction (Apley’s) Test** – Performed with patient prone and knee flexed 90 degrees and clinician stabilizing posterior thigh (e.g. with clinician’s knee). Grasping the distal tibia above ankle the leg is lifted toward ceiling and applying internal and external rotation. Pain at either collateral ligament region is believed to be suggestive of collateral damage.

In general, compressive and rotational stresses to the knee that produce pain and popping during extension appear to be fairly specific for a meniscal tear but appear to lack sensitivity.^[28, 29] However, based on a 2007 meta-analysis, no single physical examination test appears to accurately diagnose a torn tibial meniscus.^[30] Differences in the way the tests are defined, performed, and interpreted suggest that it might be best to utilize a standardized approach utilizing multiple tests combined with history to estimate the probability of a meniscus tear.^[1, 31]

- **McMurray’s Test** – A provocative knee extension maneuver which stresses the posterior aspect of the meniscus with the patient supine and consists of two phases:
 - With the hip flexed, the knee is maximally flexed (heel against buttock) while internal and external tibial rotation is performed. Palpating the joint line the clinician assesses for pain/discomfort along with clicking and/or popping that may be suggestive of medial meniscus tear.
 - The second maneuver involves extending the knee from the maximally flexed position with both lateral and torsional stress during extension to around 90 degrees. Although designed to help localize which meniscus is involved, specificity has not been borne out compared to arthroscopic or imaging findings.
- **Thessaly Weight Bearing Rotation Test** – From a standing position, the patient raise the unaffected leg and partially squats to about 20 degrees of knee flexion (the clinician should help stabilize the patient supporting them with their contralateral arm). The patient then twists on the flexed leg internally and externally assessing for joint discomfort, clicking or locking.
- **Compression (Apley) Grind Test** – This is essentially similar to weight-bearing rotation but done in a prone, knee flexed position with the examiner applying compressive and rotational force during passive extension. As with the previous compressive provocation tests, joint midline pain and/or clicking suggests a meniscal tear.
- **Dynamic Lateral Meniscus Test** – With the patient supine and with both hip and knee flexed, the examiner rotates the hip into adduction while applying a valgus stress to the lower leg which essentially compresses the lateral compartment of the knee joint. The test is considered positive if pain is produced during the maneuver while the examiner applies direct pressure to the lateral joint space. Both sensitivity and specificity were reported to be fairly good.^[32]

Patellofemoral Disorders

Patellofemoral conditions arising from work exposures appear to be related to: tracking problems throughout knee flexion and extension (likely related to damage to muscles, tendons and/or ligaments of the thigh or upper tibia), kneecap instability (typically related to post traumatic subluxation or dislocation from the trochlea), or sub-patellar chondral inflammation or damage resulting in patellofemoral pain, along with degenerative changes (chondromalacia patella). Trauma of a magnitude to damage the patellofemoral compartment may also be associated with cruciate, collateral ligament damage and/or meniscal tears.^[1]

- **Patellofemoral Tracking Observation and Palpation** – During a full squat, palpate the kneecap to assess for tenderness, especially before the maximal squat position is reached. Simply observing what the kneecap does during a squat and assessing for excessive external or internal foot rotation while seated is suggestive of external or internal tibial torsion respectively. Additionally, moving the patella sideways (both medially and laterally) during extension may produce palpable crepitus inferiorly suggestive of plica.
- **Stability Assessment** – Similar to stress testing for suspected collateral ligament sprain, patellar stability can be dynamically tested by first slightly flexing the knee and applying gentle lateral pressure to the medial side of the patella to assess for pain or apprehension. If negative this can be repeated in full extension. Gentle pressure should be underscored as instability can be painful and may dislocate the patella.

Functional Ability Testing

- **Patellar Compression and Inhibition** – With the knee slightly flexed, the patella is directly compressed posteriorly (against the femur). If pain is produced, sub patellar inflammation (likely related to chondromalacia patella) is suspected. Additionally, stabilizing the top of patella caudally while the knee is extended (quadriceps contraction) may be painful when subpatellar structures are irritated.

Lower extremity performance can be assessed during common activities such as unsupported standing up from a seated position and sitting back down, brisk walking (from a seated position and for timed distance or duration), and climbing stairs. Used primarily for osteoarthritis or general physical function in older adults, reliability and validity of such testing appears limited. A 2012 systematic review noted some support for a couple of performance tests.^[33] Allow a few attempts for practice to allow the patient to become familiar with the activity before scoring them. These tests can be used as a baseline and repeated at periodic interval to determine progress. Examples and videos can be found online (<https://www.oarsi.org/research/physical-performance-measures>).

- **40 Meter Self-Paced Walk** – This may be best done with a 10 meter (33 foot) length marked at each end, have the patient go back and forth twice. The patient is asked to walk as quickly as possible (without running). The time it takes to complete the 40 meters is the score.
- **30 Second Chair Sit Stand Test** – With the patient seated and hands crossed on their chest have the patient stand up and sit back down as many times as possible in 30 seconds from a stabilized chair (e.g. against a wall so the chair doesn't move around). Record the number of completed attempts (stand and return to sitting completed). The test may be repeated with assistance (e.g., using hands to push off on their legs or the chair).
- **Get Up and Go Test** – From a seated position, the patient is asked to stand up, walk 10 meters, turn around and walk back returning to a seated position. The time to complete the task is the score.

Soft Tissue Assessments

Soft tissues adjacent to the knee that have been injured or have become tight and irritated may produce symptoms in the knee area. Tendinous insertions from knee flexors and extensors as well as abductors can be painful when respective muscles have become stiff or tight.^[1] Range of motion may be restricted. It is important to differentiate knee stiffness due to internal joint derangements from stiffness related to tight muscles. With external muscles and ligaments, stretching and myofascial work usually are followed by an immediate reduction of pain and increase in knee range of motion, while intraarticular condition may be more painful on attempts to increase joint range.

- **Iliotibial Band Assessment** – With the patient lying on their side with the affected leg up, extend the hip (posteriorly) a few degrees and adduct the leg to stretch the iliotibial band while stabilizing the iliac crest (Ober's Test). If this produces pain similar to the patient's complaint, or if the knee cannot be lowered into adduction, iliotibial band and tensor fascia lata tightness may be a cause or contributor. Alternatively, direct pressure in the vicinity of the lateral femoral epicondyle (Noble's Test) that reproduces the symptoms suggest ITB involvement.
- **Popliteus Assessment** – Tenderness at the insertion of the popliteus tendon (primarily around the anterior aspect of the lateral collateral ligament) may indicate popliteus tightness or tendinosis. This may be best elicited with internal rotation of the thigh and resisted contraction. This can be done passively in side lying or weight bearing into a slight squat with the knee internally rotated.
- **Hamstring Disorders** – Hamstring muscles (semitendinosus and semimembranosus) are tested with the patient prone with knee flexed and contracted against resistance. Sprains graded as follows:
 - **Grade 1** – Normal ability to walk but with discomfort and unable to exert much, however resisted contraction may not be particularly painful.
 - **Grade 2** – Obvious limp with significant twinges of pain on activity, particularly exertion (e.g. running). Resisted contraction will be painful.
 - **Grade 3** – A severe injury resulting in a tear to more than half of the muscle. Walking will be difficult. Rapid swelling occurs and bruising often shows up within a day or two.
- **Quadriceps Disorders** – Simply extending the knee (with or without resistance) from a seated position will typically produce discomfort in the anterior thigh where it is tight, sprained or irritated. In the maneuver produces pain below the patella, patellar tendinosis, infrapatellar bursitis, or fat pad syndrome are more likely culprits.

Deep Vein Thrombosis

- **Lower Leg** – Guarding of calf muscles, shin splints, and gait issues may cause knee symptoms secondary to the primary problem.

Deep vein thrombosis (DVT) may be a complication in any lower extremity condition involving trauma or prolonged immobilization associated with significant swelling, pain or elevated temperature. Suspicion may be enhanced with a history of surgery in the leg, obesity, prior thrombo-embolism disorders, cardiovascular disease, pregnancy and inflammatory bowel disease. Evaluation should look for unilateral warmth, unilateral thigh or calf swelling, and/or pain and tenderness along major veins.^[34] When suspected, diagnostic ultrasound and higher Wells scores are most likely to support the diagnosis.^[35, 36]

IMAGING STUDIES

More than 80% of primary clinical diagnoses made on physical exam have been shown to be verified on MRI or arthroscopy suggesting that routine knee imaging typically is not necessary.^[37] Additionally unnecessary plain film radiography may be avoided using clinical prediction rules such as the Ottawa or Pittsburgh rules.^[38] A key issue when considering imaging is to anticipate how the result of an imaging study would modify a conservative care trial. For most uncomplicated pain and restriction conditions associated with a workplace exposure, imaging should only be considered if the condition does not respond to 4 weeks of conservative treatment.

Circumstances where imaging should be considered include:^[1, 39]

- Acute, severe trauma (blunt force, landing on feet, abnormal shape/suspicion of dislocation).
- Non-mechanical pain (unrelenting pain at rest, constant or progressive symptoms and signs, pain not reproduced on assessment-particularly if patient has history of cancer, enlarging mass, unexplained deformity, pain at multiple sites, age > 50, pain at rest, unexplained weight loss).
- Suspicion of infection (red skin, fever, systemically unwell, history of immunosuppression, penetrating wound).
- Substantial activity and/or work restriction lasting beyond 4 weeks.
- Failure to respond to conservative care by 4 weeks (e.g., no change, worsening, increasing disability).

The American College of Radiology publishes evidence-based condition and circumstance appropriateness criteria for imaging studies which can be accessed on their website: <http://www.acr.org/Quality-Safety/Appropriateness-Criteria>

Plain Film

Plain film knee imaging to rule in suspicion of fracture may be determined if the acute knee injury patient meets any one of the either the Ottawa or Pittsburgh knee imaging clinical prediction rules.^[40, 41] Implementation of these rules with knee trauma patients significantly reduced rates of radiography, cost and wait times without missing any significant fractures. Routine plain films should include a two view non-weight bearing: AP (anterior to posterior) and lateral with knee flexed about 30 degrees. Addition views may include weight bearing PA in 45 degrees flexion to help visualize joint surfaces and a tunnel view if joint mice are suspected Tangential patellar views (e.g., sunrise) can visualize the subpatellar surface. Weight-bearing x-rays are recommended when determining the presence or extent of degenerative disease, and inclusion of Kellgren-Lawrence (K-L) scores are important if surgery is being considered.

Ottawa Rules:

- Inability to bear weight immediately post injury, or take at least 4 steps at time of presentation
- Inability to flex knee to 90 degrees
- Significant tenderness over the fibular head OR at the patella
- Age above 55 years

Pittsburgh Rules:

- Inability to walk four weight-bearing steps in the emergency department
- Blunt trauma or a fall as mechanism of injury plus either of the following:
 - Age younger than 12 years or older than 50 years

Advanced Imaging

Advanced imaging includes magnetic resonance imaging (MRI), computed tomography (CT), diagnostic ultrasonography (US) and scintigraphy (bone scans). These should typically be reserved for cases where conservative care has failed to resolve the problem. Generally, plain film and MRI are preferable to CT scans for knee problems as intra-articular structures are better visualized. Soft tissue damage seen on MRI include meniscus, cruciate and collateral ligaments. In addition bone infections, infarcts and tumors can be visualized. Because of anatomic variability and limitations of MRI, high false positives may be common particularly in the anterior meniscus region.^[42] It is particularly important to correlate clinical findings with imaging findings.

- A prospective study on 72 patients compared physical exam and MRI to arthroscopic findings to determine the concordance, accuracy, sensitivity and specificity of the tests.^[24] Physical exam showed sensitivity of 75.00%, specificity of 62.50% and accuracy of 69.44% for medial meniscal (MM) lesions, while it showed sensitivity of 47.82%, specificity of 93.87% and accuracy of 79.16% for lateral meniscal (LM) lesions. For anterior cruciate ligament (ACL) injuries, PE showed sensitivity of 88.67%, specificity of 94.73% and accuracy of 90.27%. For MM lesions, MRI showed sensitivity of 92.50%, specificity of 62.50% and accuracy of 69.44%, while for LM injuries, it showed sensitivity of 65.00%, specificity of 88.46% and accuracy of 81.94%. For ACL injuries, MRI showed sensitivity of 86.79%, specificity of 73.68% and accuracy of 83.33%. For ACL injuries, the best concordance was with PE, while for MM and LM lesions, it was with MRI ($p < 0.001$). Meniscal and ligament injuries can be diagnosed through careful physical examination, while requests for MRI are reserved for complex or doubtful cases. PE and MRI used together have high sensitivity for ACL and MM lesions, while for LM lesions the specificity is higher
- The accuracy of magnetic resonance imaging in detecting clinically significant lesions of the anterior horn of the meniscus was assessed in a 2002 review of 947 consecutive knee magnetic resonance imaging reports.^[42] Of these, 76 (8%) indicated a tear of the anterior horn of the medial or lateral meniscus. Thirty-one of these 76 patients underwent a subsequent arthroscopic examination, and their operative reports were reviewed. The 45 patients who were not examined arthroscopically were contacted and interviewed for clinical follow-up. Among the 31 patients who underwent arthroscopic examination, 8 anterior horn tears were noted in the predicted area (26% true-positive results), 23 patients had intact anterior horns (74% false-positive results), and 18 had normal intact menisci in all zones. Of the 45 patients who did not undergo arthroscopic surgery, 6 had isolated anterior horn tears reported on magnetic resonance imaging, and 5 of the 6 were asymptomatic at follow-up. The other 39 patients had multiple pathologic conditions noted on the magnetic resonance imaging report and continued to report knee pain at the follow-up interview. Increased signal intensity at the anterior horn of the meniscus seen on magnetic resonance imaging commonly does not represent a clinically significant lesion. We recommend correlation with the physical examination when interpreting this “positive” finding on knee magnetic

DIAGNOSTIC CATEGORIZATION

General Diagnostic Classification

Diagnostic conclusions for occupational knee conditions require elements of workplace exposure related to condition onset, presentation, and clinical findings.

General Categorization for Care Triage

- **Urgent and serious medical conditions** – infection, vascular compromise, neoplasms, metabolic conditions (e.g., gout, diabetes) warrant consideration for specialty referral
- **Urgent mechanical conditions** – fractures, tendon ruptures, dislocations, severe sprains, and compartment syndrome warrant consideration for specialty management
- **Mechanical conditions** – sprains, strains, subluxation, and soft tissue disorders are typical examples warranting consideration for conservative management

- **Neurological conditions** – peripheral neuropathy, radicular pain, sclerotomal radiation, and paresthesias warrant close monitoring under conservative care and may warrant consideration for specialty co-management.

Ligament Sprain Grading (by degree of swelling, pain and bruising)

- **Grade 1 (1st Degree)** – Overstretching with some microscopic damage to ligament fibers. Pain and swelling may arise after a few hours. Weight bearing is tolerated; Splinting/casting not indicated; rehab exercise to tolerance indicated.
- **Grade 2 (2nd Degree)** – Partial tearing of ligament tissue. Pain and swelling typical soon after injury. Loosening of affected joint may be demonstrable compared to contralateral ankle. Ecchymosis possible. Temporary splint (e.g., air splint) immobilization usually appropriate; incrementally increasing mobilization, range of motion, stretching and strengthening exercise indicated.
- **Grade 3 (3rd Degree)** – Complete/large ligament tear. Significant pain, swelling and instability evident following injury. Ecchymosis typical. Immobilization appropriate; incrementally increasing rehabilitation work indicated. Depending on extent and severity of tear, surgical reconstruction may be needed. May involve dislocation.

Likelihood of Occupational Exposure

Not surprisingly, most of the research on knee injuries is on athletes where sudden loading and impact on the lower extremity is a regular occurrence. One systematic review of prevalence of occupational musculoskeletal disorders in Iran noted that knee injuries had the highest prevalence (42.1%) of all work-related lower limb conditions.^[43] Typically an identifiable trauma to the knee in the workplace would be expected and the mechanics of exposure should not differ from sports or recreational activities. Substantial lateral to medial force to the knee impacts the medial collateral ligament, compressive and rotational force the menisci, hyperflexion or extension the respective patellofemoral or hamstring structures. Perhaps the biggest challenge clinically and adjudicative relates to osteoarthritis that becomes symptomatic at the workplace with usual activities. In this instance the importance of history, prior knee conditions, previous treatment all factor into determination of likelihood of work relatedness. A more detailed discussion regarding determination of pre-existing conditions relationship to accepted occupational conditions can be found in [IICAC's Documentation Best Practices for Washington State Workers' Compensation](#) resource.

WORKERS' COMPENSATION ASSESSMENT ISSUES

Causation & Work Relatedness

Exceptionally clear clinical justification for specific work exposure(s) is essential for fair and timely decisions in nearly all workers compensation claims. Typically, an identifiable incident or incidents on the job shortly before the conditions onset would be expected. To be accepted by the department as a cumulative trauma leading to an occupational disease, specific additional legal requirements must be met (RCW 51.08.100). Generally, pain and other manifestations of both industrial injuries and occupational diseases become evident within 3 months of an inciting event. There is reasonably good literature support that work activities including kneeling, squatting, lifting, and climbing can cause or aggravate osteoarthritis of the knee.^[44]

To establish a diagnosis of an occupational disease, all of the following are required:

1. **Exposure:** Workplace activities that contribute to or cause the specific foot and/or ankle condition(s), and
2. **Outcome:** A diagnosis of a foot and ankle condition that meets reasonable diagnostic criteria such as those delineated in this resource, and
3. **Relationship:** For a knee condition to be allowed as an occupational disease, the provider must document that, based on generally accepted scientific evidence, the work exposures created a risk of contracting or worsening the condition relative to the risks in everyday life, on a more-probable-than-not basis (Dennis v. Dept. of Labor and Industries, 1987). In epidemiological studies, this will usually translate to an odds ratio (OR) ≥ 2 .

More information on filing a claim for an occupational disease, including billing information, can be found in the Attending Provider's Handbook: <http://www.Lni.wa.gov/FormPub/Detail.asp?DocID=1669>

- A 2012 systematic literature review identified 40 studies reporting work activities being associated with osteoarthritis of the knee.^[44] (Palmer 2012) Quality assessment included clarity regarding sources of recruitment, study design and study period; definitions of knee OA; methods of exposure assessment and the timing of assessed exposures relative to onset of disease, diagnosis or study recruitment; exposure definitions and contrasts; and estimated relative risks (RR) with 95% confidence intervals (95%CI) for each type of reported exposure. Squatting, kneeling, heavy lifting and obesity were strongly associated with knee osteoarthritis. Combinations of activities carried even higher risks. Certain industries such as floor laying had significantly greater prevalence of the condition.
- Acute workplace trauma has been linked to tendinosis, tenosynovitis, fractures, and ligament strains. Stress fractures have been reported with substantial increases in walking and weight-bearing activities (for example, a worker who normally has a sedentary job that is required to spend a day moving heavy equipment over long distances, or engage in tasks that required prolonged running for which they were not conditioned.^[45] (ACOEM 2011)

Assessment of
Re-exposure on
Return to Work

No studies were identified with current search strategies.

Physical
Capacity & Work
Restrictions

No studies were identified with current search strategies.

GENERAL INTERVENTION SUMMARIES BY CONDITION

Knee injury and pain is most common in the anterior, lateral and medial areas due to lower extremity mechanics and exposure. In general, uncomplicated knee injuries do well with conservative care (MICE, rehabilitation exercise, soft tissue work, kinetic chain management). Comparative studies with surgery, even in more severe cases, suggest similar long term functional outcomes. However with higher stress and performance occupations, surgical options may be more expedient for earlier return to activity and work.

Overall, taking a global functional ability approach directed at the worker's performance needs may make the most sense. Ability to squat (including on a single leg), walk, how gait and bilateral lower extremity positioning and posture are affected may be as informative and important to follow as specific provocative testing. How such normal activities and exertion (e.g. running) affect knee symptoms may clarify mechanics of problems and serve to be markers for improvement. Kinetic chain function and strength can be vital to good knee mechanics and function (e.g., hip abductor and flexor strength, foot and ankle rhythm/pronation, and even the role of core strength and function in global knee efforts such as squatting). Utilizing lower extremity self-report functional scales can be particularly helpful in assessing recovery.

For conservative management, determination of precise location and extent of internal joint derangements may not be particularly helpful as global measures would not be modified. Advanced diagnostics may be best reserved for cases with inadequate response to a 2-4 week conservative trial. Greater specificity of external derangements may help target interventions. In general, beginning knee rehabilitation with isometric exercise in extended or slightly flexed positions is helpful. Facilitation of quadriceps and hamstring contraction, followed by progression through pain-free ranges of motion with isotonic exercise, then gradual loading and a progressive return to their activities of daily living (ADL) or job requirements is recommended.

- A comprehensive systematic review for well-done trials and reviews for treatment of musculoskeletal conditions generally was reported in 2017.^[46] A total of 3588 unique reviews were identified with 146 studies being included for this review after removal of redundant or low quality studies. Moderate to strong evidence suggests that exercise therapy and psychosocial interventions are effective for relieving pain and improving function for musculoskeletal pain. NSAIDs and opioids reduce pain in the short-term, but the effect size is modest and the potential for adverse effects need careful consideration. Corticosteroid injections were found to be beneficial for short-term pain relief among patients with knee and shoulder pain. However, current evidence remains equivocal on optimal dose, intensity and frequency, or mode of application for most treatment options.

Conditions

General Approaches
for Common Work
Related Conditions

Cruciate Ligament Injury

With all cruciate ligament injuries, assessing their function and potential ability to cope with conservative care is helpful in identifying good responders. Cruciate ligaments are essentially avascular and do not heal well on their own leading to residual permanent laxity. Depending on a worker's job and lifestyle demands, some people can function adequately in the absence of intact cruciate ligaments.^[47] Typically, better functional outcomes are believed to occur with anterior cruciate ligament repair, than with conservative care alone when high demand stress on the knee is likely. [L&I's Surgical Guideline for Work-related Knee Injuries](#) addresses indication criteria for arthroscopic anterior cruciate ligament reconstruction. However a systematic review of surgical repair of combined anterior cruciate and collateral ligaments indicated better outcomes when surgery was delayed to allow a return to near normal knee range of motion.^[48] The decision to manage surgically or conservatively should consider the worker's age, occupation, desired level of activity (particularly pivoting, cutting or twisting activities) and their capacity to engage in and sustain extensive rehabilitation. In patients with partial or even full rupture of the ACL, it is important to identify potential responders for conservative care.^[49] A subset of the population who scores highly can return to activity/sport without operative reconstruction of the ACL. However, there is a likelihood of increased meniscal stress. A very dated low quality study reported that of younger patients who were treated non-operatively and returned to high level activity, 51% sustained significant re-injury at 1 year and only 36% were able to continue high level activity at 5.5 years.^[47]

Conservative management with mild sprain

Acute phase treatment is dominated by control of swelling, pain and acute reflex inhibition. Progressive active exercise and rehabilitation over the first 2-4 weeks is critical in restoring motion and stability. Once the patient has full range of motion, controlled effusion and sufficient strength for dynamic ranges of motion indicate progression to the second phase of strength building and proprioceptive control.

Patellofemoral Pain

Patellofemoral pain is a very common condition that contributes to limited function in a host of important daily tasks. Several biomechanical factors may be at work in any patient and therefore the treatment of PFPS is often multifactorial and looks at the whole lower extremity kinetic chain. Importance is placed on closed chain exercises to replicate function and open chain for strength building. There should be an early focus on movement pattern retraining and control, often using eccentric loads initially for quadriceps and gluteal exercises. Addition of hip and core strengthening is promising and may contribute to improved outcomes. Lastly, improving biomechanics through posterior chain stretching, hypomobile joint manipulation or orthoses for excessive motion is beneficial.

An Australian Best Practice Guide synthesized findings from six high-quality systematic reviews in a 2015 report summarizing evidence for conservative care interventions for patellofemoral pain.^[50] In addition, structured key informant interviews were conducted with 17 experts who had at least 5 years clinical specialist and research focus with patellofemoral pain. Multimodal intervention including exercise to strengthen the gluteal and quadriceps musculature, manual therapy and taping possessed the strongest evidence. Evidence also supported use of foot orthoses and acupuncture. Interview transcript analysis identified 23 themes and 58 subthemes.

Four key over-arching principles to ensure effective management included:

- An individually tailored multimodal approach (gluteal and quadriceps strengthening, patellar taping and activity modification)
- Immediate pain relief to gain patient trust and compliance
- Emphasizing active over passive interventions to facilitate patient engagement
- Patient education and activity modification.

Meniscus Injury

In most instances, meniscus tears can be managed conservatively with exercise assuring it is progressive and within patient tolerance. In fact, pain and function outcomes appear to be no better with arthroscopic surgery.^[51, 52] Early mobilization and early progressive return to activity is appropriate following most surgical meniscal repairs. Cautious application of weight bearing exercise as patient can tolerate should emphasize quadriceps and hamstring strength and endurance. In instance where meniscus injury is severe enough to cause a locked knee, and any associated degenerative change is more severe (indicated by higher KL scores), meniscectomy may be indicated. Refer to the [L&I's Surgical Guideline for Work-related Knee Injuries](#) for specific information on indication criteria and KL scoring for degenerative change. The American Physical Therapy Association has produced a comprehensive [evidence-based guideline on functional management of meniscal and cartilage lesions](#) as well.

Collateral Ligament Strain

Medial collateral ligament injuries often co-occur with anterior cruciate and other ligament strains which should be evaluated initially. Lateral collateral ligament injury is less common, but would be managed similarly. Early mobilization of the knee to include flexion and extension and gradual weight bearing has the best outcomes in the first 1-2 weeks. Braces may be useful but have limited evidence of effectiveness. Any underlying weakness or instability may be addressed in the following 2-4 weeks with strengthening exercise.^[53-55] With grade I-II strains that continue to experience limitations past three months, advanced imaging (MRI) should be considered to assess extent of the lesion. Lateral collateral ligament injury is uncommon, but would be managed similarly. If response to conservative care is inadequate, earlier diagnostics may be appropriate.

Posterior Knee

The most common work-related conditions of posterior aspect of the knee and popliteal fossa, involve:

- Hamstring tendinopathies (biceps femoris, semitendinosus and semimembranosus) and sprains
- Calf tendinopathies (gastrocnemius, popliteus, soleus) and sprains
- Popliteus tendinopathies and sprain
- Bursas (Baker's cysts)
- Popliteal artery injury and aneurysm

Tendinopathies - (hamstrings, calf or popliteus) In tendinopathies of the lower extremity both local and oral NSAIDs are increasingly not being recommended for anything more than very short term pain relief (e.g., a week or two post injury).^[56] Conservative management including MICE, myofascial work, and gentle stretching in associated muscles is helpful and gradually increasing loaded walking (as pain becomes tolerable) is useful. Eccentric knee flexion exercises have been shown to be effective for rehabilitation hamstring strain injury.^[57] Soft tissue work may also be helpful for reduction of muscle and tendon pain due to tightness and stress on tendinous attachments. Calf tendinopathies are often associated with foot and ankle conditions (and are fully addressed in [IICAC's Work-Related Foot and Ankle Conditions](#) resource)

Bursas (Baker's cysts) – Baker's cysts are commonly associated with knee trauma and osteoarthritis and tend to involve chronic, nonspecific inflammation.^[58] Conservative management should focus on maintaining knee flexibility and avoiding stiffness and guarding due to pain. Recurrence rates of non-operatively managed cysts are high due to the likelihood of intra-articular pathology that is causing the increased effusion rates resulting in symptomatic cyst formation. Consider imaging and surgery in cases extending beyond two months.

Popliteal Artery Injury - Blunt trauma to the lower extremity has been associated with a 28% to 46% rate of injury to the popliteal artery in the form of transection, occlusion, laceration, perforation, arteriovenous fistula, or intimal injury.^[59, 60] This arterial injury is frequently associated with knee dislocation and following total knee replacement. In addition, aneurysm can occur, albeit rarely, making it an important consideration posterior knee pain unexplained or unremitting origin. Occlusion, aneurysm, and rupture typically require surgical repair.

Joint Dysfunction/Subluxation

Generally active mobilization from coordination and strengthening exercise of the knee overcomes joint dysfunction. Some localized posterolateral symptoms have been reported to respond to fibular head mobilization, manipulation.^[61, 62] Overall, an approach toward restoring proper biomechanical motion along the entire kinetic chain (hip, knee, foot, ankle) with lower extremity dysfunction is supportable. Tibiofibular joint manipulation is not well studied but provided it can be done within near full passive ranges of motion appears safe and has case level reports of benefit. Typically done unloaded neutrally in full flexion, cavitation may also occur loaded during normal squatting and walking. Hypomobility in ankle or foot joints may alter function higher in the leg and warrants clinical exploration.^[50]

Osteoarthritis

Degenerative change in the knee can be due to normal aging, mechanical stress from non-work-related causes (e.g., athletics, obesity), and/or work-related injuries. Determining work-relatedness of OA can be a particular challenge with an aging workforce. For osteoarthritis (OA) to be accepted as part of the initial work-related condition, it typically must be aggravated directly following the occupational injury, where it would be considered a "lighting up" of a pre-existing condition. Trauma induced osteoarthritis (e.g., a long term effect from an intraarticular fracture) may be an accepted condition provided the appropriate history of the occupational trauma is

available. Proactively, it is important to document such trauma and the prognostic likelihood of trauma-induced OA at the time of an initial closing examination.

Key management consideration for OA include general mobility and strengthening exercise for the hip and knee.^[63] Consideration of manipulative and mobilization for the knee and associated kinetic chain may also be helpful, particularly to assist with improving tolerance to exercise.^[61] Psychosocial interventions are also effective, particularly patient engagement in remaining active and pain coping skill.^[63] Psychosocial approaches combined with exercise may be the most helpful. Oral analgesics and NSAIDs provide short-term palliation but prolonged use is associated with side effects.

Stress Fractures

Frank distal femur and proximal tibia or fibular head fracture warrants expeditious orthopedic management. Some minor evulsions and stress fractures may be managed conservatively. Stress fractures may be categorized as low vs high risk based on the risk of fracture promulgation and non-union.^[64, 65] Postero-medial tibial diaphysis fracture and minor evulsions of the anterior tibia are low risk, however patellar fractures and anterior tibial diaphysis fractures are higher risk. Multiple radiographic classification systems (e.g., Arendt and Federicson scales for MRI, and Torg classification with plain film) characterize fracture grades . Attention should be given to site of stress fracture as a decision between conservative or surgical management may take into account the site affected.

In general, lower risk stress fractures may be handled by minimizing weight bearing and resting of the anatomical site during the first 6-8 weeks, with increasing partial weight bearing to tolerance over the next 6 weeks. During recovery, maintain aerobic fitness, avoid NSAIDs which may slow bone healing. Progression to weight bearing should be based on patient tolerance and minimal impact aerobic exercise should be the focus of maintaining conditioning. About two weeks after pain free walking and light exercise can be sustained, begin progressive return to usual activity. Chronic and recurrent risk factors for fracture may warrant hormonal and nutritional management.^[66]

Trauma-Induced Nerve and Vascular Syndromes

Work-relatedness can be difficult to establish for nerve syndromes due to multivariate in etiologies and various anatomic structures that may become associated with persistent or recurrent nerve pain. However, common

- **Tibial nerve injury:** Knee trauma, particularly to the back of the knee may injure the tibial nerve. Direct force and/or ischemia from soft tissue damage impacting blood supply to the nerve may be causal. Symptoms frequently impact the foot (numbness, tingling, or pain on the plantar foot surface and toes). Motor function impairment may manifest with weakness of foot, ankle or toe muscles. Usually, simply retaining mobility and management of potential lesions affecting the nerve are adequate for complete remission. However, extensive damage may be more problematic requiring physical therapy, orthopedic, occupational or vocational assistance for rehabilitation, retraining of affected muscles, or potential permanent effects such as foot deformity, sensation loss, or prolonged pain.^[67]
- **Deep vein thrombosis (DVT):** DVT can be a serious complication from any injury or damage to a vein that results in clot formation. Knee surgery, and prolonged immobilization have also been related to clot formation and DVT. The popliteal vein runs along the posterior knee so direct force or fracture in the knee area are potential flags for development of DVT. Heavy smokers, hormone therapy including birth control pills, obesity, and diabetes may increase risk. Unilateral ankle swelling, calf pain and cramping, unexplained foot or ankle pain, and unexplained erythema are potential flags of DVT following knee injury. Anticoagulant therapy and leg mobility are the usual treatments (both preventative and for active DVT treatment).^[68-70]
- **Complex regional pain syndrome (CRPS):** Typically affecting a particular limb (arms, legs, hands, or feet), CRPS is a chronic pain condition that would need to be causally associated with an occupational injury or trauma to that limb. CRPS pathophysiology is poorly understood, however one form, called CRPS II, has been attributed to damage of peripheral nerves and or the central nervous system. It is characterized by persistent mild to severe pain and is associated with changes in skin

color, temperature, sweating, and/or edema in the affected region thus implicating the sympathetic as well as the somato-sensory nervous system. Symptoms and findings may be highly variable. This, along with poorly understood mechanisms, contributes to diagnostic uncertainty and resultant controversy about the condition. Vitamin C (500mg per day) administered after extremity trauma or surgery has been shown to prevent development of CRPS and may be useful if begun early in onset of symptoms.^[71] Treatment approaches with evidence of benefit include CRPS-focused physical/occupational therapy including desensitization & neuromuscular re-education to improve neuromuscular function, progressive active exercise to improve blood supply and flexibility, functional goal development including weight bearing and gait training, and training in self-management including home exercise. Medications for symptom management include NSAIDs for pain control and others linked to individual presentation. Cognitive behavioral therapy may be considered for individuals with fear avoidance or psychological barriers to using the affected limb. Some cases have been documented to respond to lumbar sympathetic blocks. In refractory cases a multidisciplinary pain management program may be helpful. Early referral should be made to specialists in management of CRPS. L&I has a medical treatment guideline addressing diagnostic criteria and other issues for CRPS as an accepted occupational condition. <http://www.Lni.wa.gov/ClaimsIns/Files/OMD/MedTreat/ComplexRegionalPain2011.pdf>

EVIDENCE SUMMARIES BY INTERVENTION

Early Mobilization

Collateral Ligament Sprains

Early mobilization may be considered a functional intervention that typically involves valgus and varus support while allowing weight bearing as well as flexion and extension movements during healing. Both short and long term follow-up with Grade 3 medial collateral ligament sprains suggest it is comparable in effectiveness to traditional immobilization and surgical approaches.^[72] There are a variety of braces, supports, boots, tapes/wraps utilizing pneumatics, gels, fabrics and plastics on the market. Head-to-head comparative studies of styles and brands of different products were not identified using the current search strategy. Most studies compared rigid casting to semi-rigid support. Utility of many studies was confounded by small samples, access to multiple co-interventions, and questionable comparison groups among other limitations.

Stress Fractures

The tibia and femur are common sites for stress fractures particularly with those engaging in repetitive, high intensity activity.^[64] As with many knee conditions, published clinical studies frequently consider the entire lower extremity, thus specific recommendations for knee bracing tend to derive from consensus opinion.

- A 2011 narrative review summarized information from consensus efforts, systematic reviews, and lesser quality studies offering the following key points for managing stress fractures ^[64] :
 - Reduce activity to the level of pain-free functioning
 - Consider acetaminophen, which may be favored over nonsteroidal anti-inflammatory drugs
 - Stretch and strengthen supporting structures in rehabilitative program
 - Increase activity in graduated fashion after several weeks of rest and improved symptoms
 - Use pneumatic compression device (e.g., a stirrup leg brace, compression walking boots) or other biomechanical stress-relieving measures (e.g., crutches) for lower-extremity stress fractures
 - Encourage cross training to maintain cardiovascular fitness
 - Consider surgery for patients with recalcitrant or high-risk stress fractures

Manipulation and Mobilization

Overall, the knee joint is integral to the lower extremity's overall kinetic chain which includes the low back and hip as well as the lower extremity. Manual therapies (soft tissue work, mobilization, manipulation) and rehabilitation (exercise, functional activity) are typically directed along the entire kinetic chain (low back, hip, thigh, knee, shin, ankle and foot). Systematic reviews tend to support such an approach, however most studies to date are of low to moderate quality.^[61, 62, 73]

Patellofemoral Pain Syndrome

- A 2012 systematic review of 48 trials of manipulative care for lower extremity problems utilized the Scottish Intercollegiate Guidelines Network (SIGN) ranking system to assess quality and concluded that there was B level evidence for short-term and C level for long-term treatment of patellofemoral pain.^[61]
- A small 2000 randomized trial of 28 anterior knee pain patients compared low back manipulation to no treatment.^[74] Pre- and post-treatment measures included knee-extensor moments, muscle inhibition (MI), and muscle activation during full effort, isometric knee extensions. After sacroiliac joint manipulation, a significant decrease in MI of 7.5% was observed in the involved legs of the treatment group. MI did not change in the contralateral legs of the treatment group or the involved and contralateral legs of the control group. There were no statistically significant changes in knee-extensor moments and muscle activation in either group.

- A 2017 systematic review identified five RCTs with an acceptable methodological quality (Jadad ≥ 3) addressing manual therapies and physical therapy for treatment of PFPS.^[73] The studies demonstrated some effect on reducing pain and improving function in PFPS, especially when applied on the full kinetic chain and when strengthening hip and knee muscles. The authors indicated that emphasis to proximal stabilization and full kinetic chain treatments in PFPS was associated with better alleviation of symptoms.

Osteoarthritis

- A 2012 systematic review of 48 trials of manipulative for lower extremity problems utilized the Scottish Intercollegiate Guidelines Network (SIGN) ranking system to assess quality and concluded that there was B level evidence for short-term and C level for long-term treatment of knee osteoarthritis.^[61] Manual methods including mobilization and manipulation combined with multimodal or exercise therapy for osteoarthritis of the knee were reported in 2 high quality randomized trials, 6 moderate quality RCTs and two lower quality trials. Treatment approaches averaged 10 sessions over 6 weeks with a range of 1-24 sessions. Manual treatments combined with exercise tended to have better effects than manual treatment or exercise alone.

Generally, electrical modalities (e.g., diathermy, electrical stimulation, low level laser therapy, ultrasound) do not have high quality evidence supporting their efficacy for improving function in most knee injuries and conditions. Systematic reviews of available studies with osteoarthritis of the knee report weak evidence for cupping therapy^[75]; little to no support for low level laser therapy.^[76, 77] Several systematic reviews suggest R/MICE for acute extremity injuries with increasing use of passive movement (e.g., mobilization, manipulation) and incrementally increasing active exercise (reviewed below).

Osteoarthritis

Ultrasound

- A 2010 Cochrane Review included RCTs or quasi-RCTs comparing therapeutic US with a sham or no intervention in patients with knee or hip osteoarthritis.^[78] Summary results indicate that there was a small statistically significant improvement in VAS pain scores (-1.2, 95% CI -1.9 to -0.6) and a non-significant effect in favor of ultrasound for functional improvement on WOMAC scores. No distinction was made via pulsed vs continuous being better.

Transcutaneous Electrostimulation (TENS)

- No evidence was found that TENS is effective for pain relief in knee osteoarthritis patients in a 2009 Cochrane Review.^[79] Included RCTs and quasi-RCTs compared TENS with a sham or no intervention group. Reviewed studies were at best inconclusive, but the authors indicated higher quality trials would be more definitive.

Low level laser therapy (LLLT)

- A 2017 systematic review of 14 randomized trials meeting quality criteria (out of 823) identified studies noted a significant difference between Low Level Laser Therapy and placebo in pain at rest, pain at activity, total pain, WOMAC function, WOMAC stiffness and WOMAC total in favor of the LLLT.^[77] However, there was no significant difference between LLLT and placebo in WOMAC pain ($P=0.09$) and range of motion ($P=0.1$). Although promising, research to date has not yielded much guidance on important factors related to application including wavelength, energy density, treatment duration, numbers of sessions the treatment, severity of KOA and site of application.
- In a 2015 systematic review of LLLT, nine RCTs (seven double-blind, two single-blind, totaling 518 patients) met the criteria for inclusion.^[76] In seven studies, the standard mean difference in visual analog scale (VAS) pain score within 2 weeks after the therapy was not significantly different between LLLT and no treatment controls. No significant difference was identified in studies conforming to the World Association of Laser Therapy (WALT) recommendations (four studies) or on the basis of OA severity. There was no significant difference in the delayed response (12 weeks after end of therapy) between LLLT and control in VAS pain (five studies). Similarly, there was no evidence of LLLT effectiveness based on Western Ontario

and McMaster Universities Arthritis Index (WOMAC) pain, stiffness or function outcomes (five and three studies had outcome data right after and 12 weeks after therapy respectively).

Cupping

- In a 2017 systematic review, seven randomized trials (mostly low quality) of cupping therapy for the treatment of osteoarthritis of the knee were identified.^[75] Weak evidence suggest that dry or wet cupping as an adjunct to usual (pharmacological) care is slightly more effective than usual care on its own. Dry cupping therapy plus Western medicine therapy group showed significantly greater improvements in the pain, stiffness and physical function domains of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) compared to participants in the Western medicine only group. This was not seen with use of visual analog scale. Meta-analysis of four RCTs suggested favorable statistically significant effects of wet cupping therapy plus western medicine on the Lequesne Algofunctional Index compared to Western medicine alone.

Tendinosis, tendinopathy, strains and bursitis

- A 2016 systematic review evaluated effectiveness and safety of physical agents for soft tissue injuries of the lower limb, primarily addressing foot and ankle conditions.^[80] Of 10261 screened articles, 23 RCTs had a low risk of bias and were included in the analysis. The available higher-quality evidence suggests that patients with persistent plantar fasciitis may benefit from ultrasound or foot orthoses, while those with persistent midportion Achilles tendinopathy may benefit from shockwave therapy. However, the current evidence does not support the use of shockwave therapy for recent plantar fasciitis, low-Dye taping for persistent plantar fasciitis, low-level laser therapy for recent ankle sprains, or splints for persistent midportion Achilles tendinopathy. Finally, evidence on the effectiveness of the following interventions is not established in the current literature: (1) shockwave therapy for persistent plantar fasciitis, (2) cryotherapy or assistive devices for recent ankle sprains, (3) braces for persistent midportion Achilles tendinopathy, and (4) taping or electric muscle stimulation for patellofemoral pain syndrome.

Soft tissue techniques

Massage, Myofascial Release Therapy, Trigger Point, Passive Stretch

Studies on soft tissue techniques are numerous, of variable quality, often fail to adequately describe technique details (e.g., superficial, deep, trigger point) and frequently focus of general factors such as sports performance, flexibility and strength, rather than as a specific intervention for a particular diagnosed condition. Additionally, studies often group interventions confounding discrete analysis. Generally brief (5-15 minute) and more superficial treatment sessions do not appear to show substantial treatment versus no-treatment regarding differences in functional measures, but may be associated with higher perceived satisfaction, relaxation, and well-being.^[81] There is some effectiveness data for deeper myofascial procedures, particularly when combined with manipulation or exercise.

Tendinosis, tendinopathy, strains and bursitis

- A 2014 Cochrane review addressed deep transverse friction massage in the management of lateral knee tendinosis.^[82] One study included 17 participants with iliotibial band friction syndrome for knee "tendinitis" comparing deep transverse friction massage plus physical therapy intervention to physical therapy intervention alone. At two weeks, deep transverse friction massage with physical therapy intervention showed no statistically significant differences in the three measures of pain relief on a 0 to 10 VAS when compared with physical therapy alone: daily pain (MD -0.40, 95% CI -0.80 to -0.00; absolute improvement 4%), pain while running (scale from 0 to 150) (MD -3.00, 95% CI -11.08 to 5.08), and percentage of maximum pain while running (MD -0.10, 95% CI -3.97 to 3.77). For the pain outcome, absolute improvement showed a 4% reduction in pain. However, the quality of the body of evidence received a grade of "very low." The small sample size precludes generalization.

Patellofemoral Pain Syndrome

- A small clinical trial with 18 patients with a clinical diagnosis of anterior knee pain analyzed the effect of adding myofascial techniques to an exercise program for patients with anterior knee pain.^[83] Half of the subjects were treated with hip muscle strengthening exercises, the other received both hip strengthening and myofascial techniques. Numeric Pain Rating Scale (NPRS) and the Lower Extremity Functional Scale (LEFS) were used as outcomes. The strengthening exercise group showed an improvement in pain ($p = 0.02$), but not in the mean degree of disability. The group with myofascial work added showed an improvement in pain ($p = 0.01$), as well as the degree of disability ($p = 0.008$). The effect size analysis showed that participants of the myofascial group had a greater impact on clinical pain and disability (Cohen's $d = .35$ and $.30$, respectively).

Exercise

Exercise therapies include any active therapy and may be directed by a healthcare professional or self-directed by the patient after appropriate training. Exercise is prescribed to improve or restore flexibility, range of motion, strength, as well as muscle coordination (normalization of muscular firing patterns, and/ or proprioceptive sense). There are many specific approaches within the physical therapy, sports medicine, and chiropractic literature with much of the work in this area focusing on quadriceps, hip internal and external rotators and general leg stability.

- A comprehensive systematic review for well-done trials and reviews for treatment of musculoskeletal conditions generally was reported in 2017.^[46] A total of 3588 unique reviews were identified with 146 studies being included for this review after removal of redundant or low quality studies. Moderate to strong evidence suggests that exercise therapy and psychosocial interventions are effective for relieving pain and improving function for musculoskeletal pain.

Exercise should be performed gradually with incremental increases in range of motion as condition and comfort permit. Exercise typically includes at least active-assisted range of motion and home based strengthening exercises. Regular incremental increases in active range of motion and loading appear to be essential to successful rehabilitation. Neuromuscular coordination/balance training is common in rehab with more robust impact on reducing likelihood of re-injury as opposed to direct recovery of injury. It is expected that age, general conditioning, degeneration, and concurrent disorders such as diabetes may have significant impact on recovery.

Exercises targeting knee injuries focus on four general types:

- **General mobility:** Early mobilization, i.e., return to movement and weight bearing within tolerance, from acute injury is fairly well established. Active movement and normal weight bearing and walking should be part of patient education generally. Studies regarding early mobilization are summarized in a previous section.
- **Stretching Exercise:** Frequently directed at leg musculature, stretching aims to reduce muscle tightness that may directly cause pain, but which impacts biomechanics of the lower extremity as well as added stress on tendons and their insertions.
- **Strengthening Exercises:** Regarding knee and hip, strengthening tends to fall within two distinct approaches:
 - Concentric loading involves active contraction of a muscle against a load. Standing from a squat would require concentric extending of the knee and hip by action of the quadriceps and gluteus muscles, respectively. (the contraction phase of the movement).
 - Eccentric loading involves lowering the body back to the starting position. Squatting down from standing would require eccentric flexing of the knee and hip by the quadriceps and gluteus muscles.

Generally, concentric loading is more demanding in terms of forces on muscles and tendons, so for rehabilitation of injuries, eccentric approaches are typically preferred.

- **Neuromuscular (Balance, Proprioception, Coordination, and Gait) Training:** Balance training is particularly common in sport medicine for knee rehabilitation to gain stability. There are many kinds of exercise ranging from standing four-way kicks, single leg standing or squatting exercises. As a progression this may include using wobble or rocker boards or more sophisticated training and loading programs. Generally speaking this work has been focused on improving responsiveness of leg musculature to sudden load or surface changes to provide greater muscular support for chronic instability, thus

particularly relevant for prevention of re-injury, more so than injury recovery per se. This may involve open and/or closed kinematic chain exercises.

Patellofemoral pain syndrome

Stretching exercise

- In a 2015 systematic review, findings from 10 clinical trials of moderate to high quality were evaluated to determine the effectiveness of physical exercise as conservative management for patellofemoral pain syndrome. The most effective interventions for relieving pain and improving function in patellofemoral pain syndrome included proprioceptive neuromuscular facilitation stretching and strengthening exercises for the hip external rotator and abductor muscles and knee extensor muscles. This approach appeared to be more beneficial than classic stretches when combined with active exercise.^[84]

Quadriceps strengthening exercise

Addressing the imbalance between quadriceps muscles vasti medialis and lateralis has long been the standard approach for treating PFPS. There is moderate to strong evidence that training quadriceps does balance these forces and lead to improvements in pain and function.^[85, 86] There is strong evidence that quad strengthening is important in pain reduction but not function out to one year, with or without other interventions, as compared to advice, information or placebo.^[87] It is difficult to separate the effect of manual therapy, stretching and other lower limb exercises from quad strengthening alone and suggests that no single exercise is superior.^[88, 89]

- A 2015 systematic review identified seven studies of low quality, but consistent in demonstrating quadriceps strengthening for PFPS may result in clinically important reduction in pain and improvement in functional ability, as well as enhancing long-term recovery.^[89] However, there is insufficient evidence to determine the best form of exercise therapy. There is some very low quality evidence that hip plus knee exercises may be more effective in reducing pain than knee exercise alone.
- A systematic review from 2008 did not identify any RCTs that supported hip strengthening to effectively treat PFPS, however, strong evidence for open kinetic chain (joint movement without weight bearing) and closed kinetic chain (multiple joint movement under load or weight bearing) exercise was effective in reducing PFPS pain.^[85]
- A systematic review searching for conservative treatment for PFPS in 2011 identified 10 higher quality trials that supporting general quadriceps strengthening improved PFPS pain whether done weight bearing or non-weight bearing.^[86] Hip strengthening was considered promising, though current results were not conclusive.
- A 2016 systematic review identified eight RCTs of which 3 had low risk of bias and were included.^[90] One RCT found statistically significant improvements in pain and function favoring clinic-based progressive combined exercises over a "wait and see" approach for patellofemoral pain syndrome. A second RCT suggests that supervised closed kinetic chain exercises may lead to greater symptom improvement than open chain exercises for patellofemoral pain syndrome. One RCT suggests that clinic-based group exercises may be more effective than multimodal physiotherapy in male athletes with persistent groin pain. The use of clinic-based exercise for the management of soft tissue injuries of the lower extremity may be particularly useful with patellofemoral pain syndrome and persistent groin pain.
- A systematic review and meta-analysis of RCTs published in 2012 indicated that multimodal PT, including 8 weeks of manual therapy, stretches, vasti retraining and patellofemoral joint taping, showed significant effects compared to no treatment or education, but not significantly different than manual therapy, stretches, and lower limb exercises.^[88] Exercise showed significant effects compared to no-treatment controls. Treatment options very heterogeneous, so pooling of data was limited.
- Fifteen German and English language studies (from MEDLINE, Physiotherapy Evidence Database (PEDro), International Clinical Trials Registry Platform, and Cochrane databases), with a total of 748 participants, were included and pooled for a

2014 meta-analysis.^[91] Six studies compared the effect of exercise therapy with a control group receiving neither exercise therapy nor another intervention. Four compared the exercise therapy alone to exercise with an additive therapy, and 5 studies compared different exercise interventions. Overall, exercise therapy resulted in strong pain reduction and improvement of patient-reported activity measures with significant short-term effects (≤ 12 weeks) on pain levels and patient report of activity, whereas long-term effects (≥ 26 weeks) were observed only with patient reported activity measures.

Hip strengthening exercise

There is substantial correlation between faulty hip mechanics and PFPS which suggests proper hip position and muscular function proximal to the knee may be useful as a treatment strategy focus.^[92] Utilizing hip strengthening in combination with knee strengthening exercises appears to have superior and more consistent results than knee exercise alone, both in short term and long term follow-up for pain and function.^[93-95] While hip strengthening exercises appear to be ineffective for increasing strength, addition of hip exercise in a strengthening program using closed or open kinematic chain exercises does consistently decrease pain and improve function.^[85, 93, 96]

- A 2017 Systematic review and meta-analysis of 14 trials and 673 found hip and knee strengthening reduced pain and increased activity compared to no training/placebo as well as to knee strengthening alone.^[93] These results persisted through follow-up but no concurrent strength change was measured.
- In a 2015 systematic review of hip muscle strengthening for patellofemoral pain, seven studies meeting PEDro quality criteria compared to alternative and non-intervention groups.^[96] Studies were mixed regarding measurable improvement in strength, but consistently decreased pain level and showed improvement in five of the seven studies
- Fourteen studies were found addressing proximal muscle strengthening for patellofemoral pain with seven meeting quality criteria including adequate effect size were included in a 2015 systematic review.^[94] Strong evidence indicated that including proximal hip exercise combined with quadriceps rehabilitation decreased pain and improved function in the short term, with moderate evidence for medium-term outcomes. Moderate evidence indicated that proximal when compared with quadriceps rehabilitation decreased pain in the short-term and medium-term, and improved function in the medium term. Limited evidence indicated proximal combined with quadriceps rehabilitation decreased pain more than quadriceps rehabilitation in the long term. Very limited short-term mechanistic evidence indicated proximal rehabilitation compared with no intervention decreased pain, improved function, increased isometric hip strength and decreased knee valgum variability while running.
- An extremely rigorous Cochrane review from 2015 reported findings consistent with the above systematic reviews but was more restrained in its assessment of study quality.^[89] Concluding that insufficient evidence was available to determine the best form of exercise therapy, and indicating it was unknown whether results would be applicable to all cases of patellofemoral pain, the review concluded that patellofemoral exercise approaches may result in clinically important reduction in pain and improvement in functional ability.
- Eight studies (three randomized controlled trials, one clinical controlled trial, three cohort studies and one case series) of moderate to high methodological quality met the inclusion criteria for a 2013 systematic review of proximal (hip) exercise for patellofemoral pain.^[95] Proximal exercise programs showed a consistent reduction of pain and function while knee only exercise programs had variable outcomes.

Meniscal injury

- A 2013 Randomized controlled trial found arthroscopic surgery followed by exercise therapy was not superior to exercise therapy alone in patients with a medial meniscal tear and low-grade OA.^[97] Patients were randomly assigned to either arthroscopic treatment followed by exercise therapy for 2 months or to the same exercise therapy alone. At the start of the study and at 24 and 60 months the patients answered the KOOS, Lysholm Knee Scoring Scale and Tegner Activity Scale and made pain ratings on the Visual Analogue Scale (VAS). Exercise included PT supervised, 8 week program with a home program twice a week. Both groups exhibited significant improvements ($p < 0.0001$) from the start to 24 months and

the improvements were unchanged from 24 to 60 months on KOOS scale, and there were no significant differences between groups in VAS, Lysholm score, or Tegner scale.

- A 2013 RCT found no significant differences between arthroscopic meniscectomy and nonoperative treatment in terms of pain relief, improved function, or increased satisfaction at 2 year follow-up.^[98] Patients were randomized to meniscectomy or nonoperative treatment with strengthening exercises and compared via VAS, Lysholm score, Tegner activity scale, and subjective knee pain and satisfaction. No significant differences were found between groups for VAS, Average Lysholm Score, Tegner scale, or subjective satisfaction at final follow up.
- A systematic review and meta-analysis of RCTs found Arthroscopic surgery does not show a significant minimally important difference from non-operative treatment in regards to long-term functional outcomes (Standardized mean difference 0.07, 95% CI -0.10 to 0.23), short term pain scores (mean difference 0.20, 95% CI -0.67 to 0.26), or long term pain scores (mean difference -0.06, 95% CI -0.28 to 0.15).^[51] This evidence suggests that there is no benefit to arthroscopic meniscal debridement for a degenerative meniscal tear compared to non-operative or sham treatments.
- A 2013 randomized trial examined the effect of intra-articular steroids compared to arthroscopic debridement for degenerative lesions of the medial compartment. 120 patients were randomized to receive either intra-articular steroid injection of arthroscopic debridement, and were followed for up to a year to determine improvement via the Oxford Knee Score. Both groups showed significant improvement in scores at one month, with the arthroscopy group showing significantly higher scores. At final one year follow-up, the groups were not significantly different in scores, indicating that there is only limited benefit of surgical debridement over steroid injection.^[99]
- A 2013 RCT of 351 patients found that there were no significant differences in outcomes between patients with a meniscal tear and mild-to-moderate osteoarthritis when they were randomized to either surgery or to standardized physical therapy.^[100] Both group saw significant improvement via WOMAC scores at 6 months, with surgical patients improving an average of 20.9 points post treatment and physical therapy patients improving an average of 18.5 points post treatment.

Cruciate & Collateral Ligament Sprains

- A 2016 Cochrane Review assessed RCTs comparing surgical vs conservative interventions in participants with an ACL rupture, however only one trial of 141 active adults was identified.^[101] ACL reconstruction (of all types) followed by structured rehabilitation (62 participants) was compared to structured rehabilitation alone (N = 59). No significant difference was seen in KOOS-4 scores at 2 years and 5 years with no significant difference in general quality of life at 5 years. Additionally, there was no significant difference in return to activity or sport at 5 years, RR=1.13, 95% CI 0.57-2.23. However, knee stability measures favored ACL reconstruction, RR=2.37, 95% CI 1.60-3.51 at 5 years and 30 of 59 in the conservative group eventually underwent ACL reconstruction within 5 years.
- In a 1995 prospective case series of 45 patients with complete rupture of ACL and rupture of one or all medial ligament structures and no other ligamentous deficiency, surgical reconstruction was performed within 10 weeks of original injury and followed at 2 years after reconstruction.^[102] Patients were put into one of two groups based on severity of medial ligament injury: Patients were treated via hinged bracing with limited extension, and assisted ROM exercises several times a day. Weightbearing progressed more rapidly in patients with a superficial MCL rupture as opposed to those with a complete medial ligament rupture. More patients reported good to excellent results following treatment if their MCL injury was only superficial. The authors favor performing nonoperative treatment of the medial ligaments followed by ACL reconstruction after knee muscle and motion have returned.
- A 2017 review focused on the re-injury of anterior cruciate ligament (ACL) in an athletic population.^[103] Faulty mechanics during dynamic movement that cause excessive valgus force at the knee appear to increase the risk of ACL injury. Lateral displacement of the trunk, unequal limb loading, and lack of control to avoid the valgus knee position appear to contribute. Altered movements that place the ACL at risk are best identified in a fatigued state; however, could be recognized in a standard dynamic assessment. The faulty movement patterns are modifiable and should be addressed in an injury

prevention program. Prevention programs might include various modes of exercise such as plyometrics, neuromuscular training, and strength training, and appear to be more useful in younger individuals.

Hamstring Sprains and Strains

- A 2017 systematic review sought to identify strengthening regimes that mitigated the risk of hamstring injury.^[57] Several studies indicated that eccentric knee flexor conditioning reduces the risk of hamstring strain injury probably mediated by increases in biceps femoris long head fascicle length and improvements in eccentric knee flexor strength. Hamstring muscle activation patterns appear to differ significantly between different exercises. Relatively higher levels of biceps femoris long head and semimembranosus activity have been observed during hip extension-oriented movements, whereas preferential semitendinosus and biceps femoris short head activation have been reported during knee flexion-oriented movements. An evidence-based approach to strength training for the prevention of hamstring strain might best target these groups accordingly.

Osteoarthritis

Degenerative change in the knee is extremely common from normal aging and mechanical stress from daily living, especially when combined with obesity. In and of itself it is unlikely attributable to a singular work event, at least in an acute or subacute situation, however, it can have implications for recovery from a knee injury. Overall the best interventions long term appear to be weight loss, agility training, and general exercise programs. There is very little strong evidence to determine the most effect exercise programs, but all seem to do well reducing pain and improving function in the short term. The most evidence based strategies are detailed below.^[63] Individualized programs seem to perform better than class or home based care and both high-intensity and low intensity exercise appear to have similar outcomes. Strength training may improve overall strength but has equivocal effects on pain and disability.

General exercise

- A 2017 comparative effectiveness review from the US Agency for Healthcare Research and Quality concluded that a variety of interventions demonstrate shorter term beneficial effects on pain and function.^[63] With the exception of weight loss, agility training, and general exercise programs, few have been tested for or show long-term benefits.
- In a 2015 Cochrane Review comparing land-based exercise to a non-exercise or non-treatment group for treating knee OA, Pooled results showed exercise reduced pain immediately following treatment (reduction of 12 points on 100 point scale, high quality evidence, 32 vs. 44 in control group, with lower score indicating less pain).^[104] At 2-6 months, this was reduced to a 6 point improvement. Pooled results for function showed exercise improved function immediately following treatment, with a reduction in loss of function of 10 points on a 100 point scale, 28 vs. 38 in control group. At 2-6 months, this reduced to a 3 point difference. Both groups had similar withdrawal rates (14% in exercise vs 15% in control). Individualized programs were more effective than class-based or home-based exercise programs.
- High intensity vs. Low intensity land based exercise for osteoarthritis was addressed in a 2015 Cochrane Review.^[105] RCTs of people with knee or hip OA comparing high versus low intensity physical activity or exercise programs between the experimental and control groups. Low-quality evidence suggests small improvements in pain and function for high-intensity vs low-intensity exercise in patients with knee OA, but the difference is unlikely to be clinically important. For high-intensity exercise groups, WOMAC pain scores improved mean 0.84 points on a 20 point scale compared to low-intensity groups, and for high-intensity exercise WOMAC function scores improved mean 2.65 points on a 68 point scale compared to low-intensity groups.
- Aquatic exercise was assessed in a 2016 Cochrane Review comparing aquatic exercise to a control group for participants with knee or hip OA.^[106] Aquatic exercise appeared to have a small, statistically significant, short term improvement in both pain and disability compared to the control group. Scores corresponded to a 5-point (95% CI 3-8) change on a 100-point scale for mean pain and mean disability compared to control groups.

Strength Training

- In a 2017 systematic review and meta-analysis of strengthening exercise for osteoarthritis, 45 eligible trials with 4699 participants and 56 comparisons were included.^[107] Exercise interventions following the ACSM criteria for strength training provided superior outcomes in knee extensor strength. However, no differences were observed regarding effects on pain and disability. The meta-regressions indicated that increases in knee extensor strength of 30-40% would be necessary for a likely concomitant beneficial effect on pain and disability, respectively.
- In a 2008 systematic review of RCTs, eighteen studies enrolling 2,832 subjects were reviewed; the mean cohort age range was 55–74 years.^[108] At least 8 out of 12 quality criteria were accounted for in the studies. Self-reported measures of pain, physical function, and performance, along with muscle strength (mean 17.4%), maximal gait speed and chair stand time, and balance improved significantly following resistance training in 56–100% of studies where they were measured. Ten of the 18 studies reviewed showed significant improvements in pain following strength training with the authors concluding that resistance training improved muscle strength and self-reported measures of pain and physical function in 50–75% of the cohort and 50–100% of the studies reported a significant improvement in all but 1 performance-based physical function measure (walk time).

Stress Fracture

- A 1987 case series analyzed 320 athletes with bone scan-positive stress fractures (M = 145, F = 175) seen over 3.5 years and assessed the results of conservative management.^[109] The most common bone injured was the tibia (49.1%), followed by the tarsals (25.3%), metatarsals (8.8%), femur (7.2%), fibula (6.6%), pelvis (1.6%), sesamoids (0.9%), and spine (0.6%). Stress fractures were bilateral in 16.6% of cases. A significant age difference among the sites was found, with femoral and tarsal stress fractures occurring in the oldest, and fibular and tibial stress fractures in the youngest. Running was the most common sport at the time of injury but there was no significant difference in weekly running mileage and affected sites. A history of trauma was significantly more common in the tarsal bones. The average time to diagnosis was 13.4 weeks (range, 1 to 78) and the average time to recovery was 12.8 weeks (range, 2 to 96). Tarsal stress fractures took the longest time to diagnose and recover. Varus alignment was found frequently, but there was no significant difference among the fracture sites, and varus alignment did not affect time to diagnosis or recovery. Radiographs were taken in 43.4% of cases at the time of presentation but were abnormal in only 9.8%. A group of bone scan-positive stress fractures of the tibia, fibula, and metatarsals (N = 206) was compared to a group of clinically diagnosed stress fractures of the same bone groups (N = 180), and no significant differences were found. Patterns of stress fractures in athletes are different from those found in military recruits. Time to diagnosis and recovery depends on the fracture site. Conservative treatment of stress fractures is satisfactory in the majority of cases. Key active approaches included stretching and strengthening for supporting structures and encouraging cross training to maintain cardiovascular fitness. Increased activity was done in a graduated fashion after several weeks of rest and improved symptoms.

Braces, wraps
supports, &
taping

Patellofemoral pain syndrome

- In a 2017 systematic review of published trials evaluating efficacy of taping techniques for patellofemoral pain syndrome, five RCTs with 235 total patients were identified.^[110] Three different comparison groups were identified: tension taping and exercise versus placebo taping and exercise, placebo taping and exercise versus exercise alone, and tension taping and exercise versus taping alone. Taping strategies included McConnell and Kinesiotaping. Visual analog scale (VAS) scores indicated improvement in all 3 comparison groups (group 1: 91 patients, 39% of total, mean VAS improvement 44.9 [tension taping + exercise] vs 66 [placebo taping + exercise]; group 2: 56 patients, 24% of total, mean VAS improvement 66 [placebo taping + exercise] vs 47.6 [exercise alone]; and group 3: 112 patients, 48% of total, mean VAS improvement 44.9 [tension taping + exercise] vs 14.1 [taping alone]) This systematic review supports knee taping only as an adjunct to traditional exercise therapy for PFPS; however, it does not support taping in isolation.

- A 2011 systematic review of conservative patellofemoral pain interventions noted that, overall, data was inconclusive regarding patellar taping and bracing, knee braces, and foot orthoses in the treatment of patellofemoral pain.^[86] However, limited to moderate improvement in pain using patella bracing, neoprene knee sleeve, and home exercise in combo with patella bracing. Foot orthoses in conjunction with physical therapy exercise (primarily quadriceps and hip strengthening) showed moderate improvement in pain, but orthoses alone showed only weak improvement.
- A 2014 report systematically reviewed 20 studies and conducted a meta-analysis addressing effects of patellar taping on pain and lower-limb biomechanics in individuals with patellofemoral pain.^[111] The authors concluded that there was moderate evidence that tailored (customized to the patient to control lateral tilt, glide and spin) and untailored patellar taping provides immediate pain reduction of large and small effect, respectively and that tailored patellar taping promotes earlier onset of vastus medialis oblique (VMO) contraction (relative to vastus lateralis contraction which has been a traditional approach for patellar tracking and pain problems). There was also limited evidence that tailored patellar taping combined with exercise provides superior pain reduction compared to exercise alone at 4 weeks; untailored patellar taping added to exercise at 3-12 months has no benefit; and tailored patellar taping promotes increased internal knee extension moments.
- The effect of McConnell taping on knee biomechanics in individuals with anterior knee pain was assessed in a review of eight heterogeneous studies with a total sample of 220.^[112] All of the studies had a moderate to low risk of bias and pooling of data was possible for three outcomes: average knee extensor moment, average VMO/VL ratio and average VMO-VL onset timing. None of these outcomes revealed significant differences suggesting that evidence is currently insufficient to justify routine use of the McConnell taping technique in the treatment of anterior knee pain.
- Controlled studies evaluating the effects of Kinesio or McConnell taping in patellofemoral pain syndrome patients were analyzed in a 2015 Taiwanese report.^[113] Eleven of 91 retrieved articles met quality criteria. Kinesio taping can reduce pain and increase the muscular flexibility of PFPS patients, and McConnell taping also had effect in pain relief and patellar alignment. Meta-analysis showed small effect in pain reduction and motor function improvement and moderate effect in muscle activity change among PFPS patients using Kinesio taping.

Meniscal injury

Short term bracing during post-surgical rehabilitation of a meniscus injury is a standard of care that is slowly changing. For non-complicated/peripheral post-surgical meniscal repair, an accelerated rehabilitation program consisting of unlimited weight bearing, full motion, no restrictions on pivoting sports and no bracing has shown no significant differences in outcomes to conventional rehabilitation methods, but some trends to faster healing and return to activity are seen in the accelerated groups. Motion restrictive bracing may not be critical to good outcomes.^[114, 115]

There is little evidence on use of bracing in conservative meniscal injury that is not post-surgical rehabilitation. Overall, compressive braces/wraps can be used to help reduce knee swelling during an acute phase and motion restrictive braces are used in return to activities that have a high risk of sudden unexpected loads, but the evidence on whether this is protective is lacking.

Motion restrictive bracing appears to be most beneficial in complex repairs or transplantation, but not useful in peripheral repair surgeries.^[116]

Cruciate & Collateral Ligament Sprains

Bracing for anterior cruciate ligament (ACL) and medial collateral ligament (MCL) tears has long been a common conservative strategy, particularly with instability under possible exposure to sudden loading. However, bracing lacks well-done trials to assess comparative effectiveness to exercise alone, different types of braces or more complete immobilization. A few trials and reviews have explored post-reconstruction bracing. Even less information exist for less common lateral collateral or posterior cruciate injury.

- A systematic search of both the PubMed and Embase databases to identify studies that reported clinical and/or in vivo biomechanical results of functional bracing versus nonbracing after ACL reconstruction was published in 2017.^[117] Study design, surgical reconstruction techniques, postoperative rehabilitation protocols, objective outcomes, and subjective outcomes scores were considered. The in vivo biomechanical data collected included kinematics, strength, function, and proprioception. Subjective clinical outcomes scores were collected when available. Quality appraisal analyses were performed using the Cochrane Collaboration tools for randomized and nonrandomized trials to aid in data interpretation. Fifteen studies met the selection criteria (including 3 randomized trials [level II], 11 nonrandomized trials [level II], and 1 retrospective comparative study [level III]), with follow-up intervals ranging from 3 to 48 months. Most studies were designed to compare the effects of functional bracing versus non-bracing on subjective and objective results in patients who underwent previous primary ACL reconstruction. Functional bracing significantly improved kinematics of the knee joint and improved gait kinetics, although functional bracing may decrease quadriceps activation without affecting functional tests, range of motion, and proprioception. Four studies reported no differences in subjective outcomes scores with brace use; however, one study reported increased patient confidence with brace use, whereas another study reported decreased pain and quicker return to work when the brace was not used. Overall, some data suggest that functional bracing has benefit with regard to in vivo knee kinematics and may offer increased protection of the implanted graft after ACL reconstruction without sacrificing function, range of motion, or proprioception. However, limited evidence exists supporting the use of routine functional bracing to decrease the rate of re-injury after ACL reconstruction.
- A very dated narrative review from 1993 assessed the role of exercise, continuous passive motion, proprioceptive exercise, and knee bracing in rehabilitation of the anterior cruciate ligament.^[118]
- A 2016 evidence review of posterior cruciate ligament rupture interventions noted no clear prognostic factors predict outcomes, and that ideal management remains uncertain.^[119] Nonsurgical management is advocated for isolated grade I or II posterior cruciate ligament injuries or for grade III injuries in patients with mild symptoms or low activity demands. Surgical management is reserved for high-demand athletes or patients in whom nonsurgical management has been unsuccessful. Although biomechanical studies have identified differences between single-bundle, double-bundle, transtibial, and tibial inlay reconstruction techniques, the optimal surgical technique has not been established. No high-quality evidence is available regarding immobilization, weight-bearing, bracing, or rehabilitation protocols for patients treated either nonsurgically or surgically.

Osteoarthritis

- A 2015 Cochrane review assessed RCTs testing braces and foot/ankle orthoses for knee osteoarthritis compared to active control or no treatment groups.^[120] At 12 months, one low quality study showed no effect on pain (VAS), function, or health related quality of life from bracing compared to no treatment. Other short term studies found small significant improvement in pain, function, and QOL at short term follow-up, though. One low-quality study found lower anchored pain scale scores in patients who had a laterally wedged insole after nine months. In 3 moderate quality studies comparing laterally wedged vs neutral insole, data was pooled and found that after 12 months there was no significant effect on numerical pain score or WOMAC stiffness or function scores. Comparing braces to foot/ankle orthoses data was not able to be pooled, but the results suggested that both groups showed improvement in pain and function, albeit not significant.

Stress Fracture

- A 2005 Cochrane review of prevention and treatment trials for stress fractures in young adults identified 16 quality studies, most of which were on military recruits.^[121] Ten prevention trials tested the effects of various foot inserts and other footwear modifications. While pooling of data was not possible, the four trials evaluating the use of "shock-absorbing" boot inserts versus control found fewer stress injuries of the bone in their intervention groups. Two cluster-randomized prevention trials found no significant effect of leg muscle stretching during warm up before exercise. Pooled data from three small but very

different trials testing the use of pneumatic braces in the rehabilitation of tibial stress fractures showed a significant reduction in the time to recommencing full activity (weighted mean difference -33.39 days, 95% confidence interval -44.18 to -22.59 days). The use of shock absorbing inserts in footwear probably reduces the incidence of stress fractures in military personnel. There is insufficient evidence to determine the best design of such inserts but comfort and tolerability should be considered. Rehabilitation after tibial stress fracture may be aided by the use of pneumatic bracing but more evidence is required to confirm this.

- An evidence-informed best practice algorithm was developed for athletes returning to play following diagnosis of stress fractures.^[122] Recommendations were based on a review of retrospective case series, a few evidence-based papers, and the clinical experience of 4 experienced sports medicine team physicians. Literature was almost entirely case series without control groups. Fractures were categorized as either high-risk or low-risk based on the biomechanical environment and natural history of the fracture. High-risk stress fractures occur in the superolateral femoral neck, anterior tibial shaft, tarsal navicular, proximal fifth metatarsal, and talar neck. Low-risk stress fractures occur in the lateral malleolus, calcaneus, 2nd through 4th metatarsals, and the femoral shaft. Undertreatment of high-risk stress fractures was associated with more fracture progression and prolonged loss of playing time. Overtreatment of low-risk stress fractures can result in unnecessary deconditioning and unneeded loss of playing time.

Psychological factors have long been associated with osteoarthritis pain, particularly in the knee, and psychological interventions appear to reduce the pain experience.^[123, 124] A number of trials have considered psychosocial interventions alone or in combination with other treatments.^[46] Overall, high quality evidence for psychological intervention is lacking for knee pain specifically, but it is established as effective with low back conditions and musculoskeletal conditions generally. Structured patient education alone does not seem to be as effective as other interventions.^[125]

Patellofemoral pain syndrome

- A 2017 systematic review explored whether psychological characteristics of individuals with patellofemoral pain (PFP) differ from asymptomatic controls and the correlations between psychological characteristics and PFP severity.^[126] In contrast to other persistent musculoskeletal conditions, for which non-physical, psychological features are implicated, PFP remains largely conceptualized in mechanical terms. Twenty-five studies were included based on quality based on PRISMA guidelines. Psychological constructs were reported under four groupings: mental health, cognitive factors, behavioral factors and other factors. Features demonstrating linear correlations with pain and physical function included anxiety/depression, catastrophizing, praying and hoping, and pain-related fear. Anxiety, depression, catastrophizing and fear of movement may be elevated in individuals with PFP and correlate with pain and reduced physical function.
- A systematic review of structured patient education for extremity injuries in 2015 identified two randomized trials with a low risk of bias.^[125] The authors conclude that providing health education material alone may be less effective than multimodal care for the management of persistent patellofemoral pain syndrome. Overall, little is known about the effectiveness of structured patient education for the management of musculoskeletal disorders and injuries of the extremities.

Osteoarthritis

- A comprehensive systematic review for well-done trials and reviews for treatment of musculoskeletal conditions generally was reported in 2017.^[46] A total of 3588 unique reviews were identified with 146 studies being included for this review after removal of redundant or low quality studies. Moderate to strong evidence suggests that exercise therapy and psychosocial interventions are effective for relieving pain and improving function for musculoskeletal pain.
- A 2007 meta-analysis on the efficacy of psychosocial interventions for arthritis pain and disability identified 27 randomized trials from Cochrane, EMBASE, Ovid MEDLINE, and Ovid PsycINFO data sources.^[127] Pain intensity was the primary outcome. Secondary outcomes included psychological, physical, and biological functioning. Small effect size of 0.177 (95% CI=0.256-0.094) indicated that patients receiving psychosocial interventions reported significantly lower pain than patients

in control conditions (combined $p=.01$). Meta-analyses also supported the efficacy of psychosocial interventions for the secondary outcomes. Evidence for the additional benefit of such interventions over and above that of standard medical care was found.

- An older narrative review of psychosocial factors associated with variation in pain reporting among individuals with knee OA reported on lower quality evidence that psychosocial interventions may reduce knee pain without apparent halting or reversing of structural damage.^[123] Simple interventions included monthly telephone calls, self-management programs, and cognitive-behavioral approaches designed to teach patients ways of coping with their pain. These programs appear to be more effective if the spouse is involved. At least one study has shown that formal cognitive-behavioral therapy is no better than didactic education at improving pain and function in knee OA (though both are beneficial). Many studies suffered from poor design.
- In a longitudinal study of 256 hip and knee osteoarthritis pain patients, subjects were interviewed weekly for 12 weeks recording self-report measuring WOMAC pain subscale and 5-item Mental Health Inventory (MHI-5).^[124] Mean age was 65.0, gender was 191 women and 71 men, with mean BMI 31.5. 82% had knee as their primary site. The mean WOMAC score was 2.93 in the quartile with the highest MHI-5 as compared with a mean WOMAC of 4.57 in the quartile with the lowest MHI-5 (p for trend across quartiles <0.001). In the case crossover analysis (91 subjects), periods with the worst MHI-5 quartile had 2.1 times the odds of a pain flare the subsequent week as compared to periods with the best MHI-5 quartile ($p<0.001$). An association between worsened measures of mental health and OA pain and risk of pain flares was demonstrated. General mental health is a modifiable component of health and may represent a new avenue for prevention of OA pain flares.

Other Non-surgical Interventions

This resource addresses conservative care, with particular emphasis on manual, active, and self-care strategies. It does not provide a comprehensive review of pharmacological evidence and management. However, a high level overview of drug classes typically employed for knee conditions is included. Additionally, a number of alternative and emerging interventions are available for foot and ankle conditions. Available published studies rarely address worker populations or activity outcomes critical to workers compensation and many new and emerging technologies may not be covered in Washington state. This holds particularly true for interventions high-cost technologies for which existing effective, and cost-effective alternatives are available, interventions that are not directly condition-oriented, and for interventions that have been associated with safety or adverse event concerns. Inclusion here reflects only a brief summary of retrieved evidence and is presented for educational purposes and does not imply authorization in an individual circumstance.

Non-steroidal anti-inflammatory Drugs (NSAIDs)

Tendinopathy Generally

Because the histological nature of tendinopathies and tendinosis is not inflammatory, and because NSAIDs may have longer term deleterious effects on tendon healing, NSAIDs are generally not recommended. For pain control, R/MICE, activity modification and analgesics reflect usual medical care.^[128]

- A comprehensive systematic review for well-done trials and reviews for treatment of musculoskeletal conditions generally was reported in 2017.^[46] A total of 3588 unique reviews were identified with 146 studies being included for this review after removal of redundant or low quality studies. Moderate to strong evidence suggests that exercise therapy and psychosocial interventions are effective for relieving pain and improving function for musculoskeletal pain. NSAIDs and opioids reduce pain in the short-term, but the effect size is modest and the potential for adverse effects need careful consideration. Corticosteroid injections were found to be beneficial for short-term pain relief among patients with knee and shoulder pain. However, current evidence remains equivocal on optimal dose, intensity and frequency, or mode of application for most treatment options.

Patellofemoral Pain

- Controlled trials (randomized or not) comparing pharmacotherapy with placebo, different types of pharmacotherapy, or pharmacotherapy to other therapies for patellofemoral pain syndrome were the subject of a 2004 Cochrane Review.^[129] Regarding NSAIDs: Aspirin compared to placebo in a high quality trial produced no significant differences in clinical symptoms and signs. (High quality study) Naproxen produced significant short term pain reduction when compared to placebo, but not when compared to diflunisal. Laser therapy to stimulate blood flow in tender areas led to more satisfied participants than tenoxicam, though not significantly.

Stress Fracture

- A 2005 narrative review indicated that evidence exists from laboratory studies and animal subjects that NSAIDs can slow fracture healing.^[130] This link has not been proved or disproved in human subjects, particularly for stress fractures. However, due to high usage of NSAIDs in treating musculoskeletal disorders, more research is required to investigate whether the healing of stress fractures is affected by these drugs. Acetaminophen may be a preferable alternative.

Topical NSAIDs

At the time of publication, there were three diclofenac-based topical NSAID formulations on the market. All have similar effectiveness to oral NSAIDs. However, topical NSAIDs have very specific FDA-approved indications (Voltaren gel for osteoarthritis in extremities, Pennsaid solution for osteoarthritis of the knee, and Flector patch for acute sprain, strain and contusion). Under Washington workers' compensation, use of these products requires prior authorization and must meet coverage criteria including that the FDA-approved indication is an accepted, work-related condition for the claim. Additionally, there must have been a failure of a trial of oral alternatives. Occasionally, an exception may be made for patients who have conditions that preclude oral NSAID use (e.g., kidney failure).

Injected Steroids

There is general consensus that the potential long term harm from glucocorticosteroids in or around tendons far outweigh short term benefits and use is contraindicated.^[131] Tissue degeneration, tendon rupture, and nerve injury are among reported adverse events.^[132, 133]

Osteoarthritis

- A 2015 Cochrane Review included RCTs or quasi-RCTs comparing intra-articular corticosteroids with sham injection or no treatment in patients with knee osteoarthritis.^[134] Pooled estimates indicate that Intra-articular corticosteroids were more beneficial in reducing pain than control interventions, though no benefits were seen at long term follow-up (beyond 6 weeks). Functional improvement was seen, but pooled estimates were not significant beyond 6 week follow-up. Overall, Meaningful results from injection beyond 6 weeks were not present in the summary results, and the meaningful results seen at early follow-up are unclear due to low quality evidence.
- Pooled analysis of viscosupplementation injections against placebo control suggested the effectiveness comparable to NSAIDs, and long term benefits were noted in comparison to intraarticular corticosteroids.^[135]

Patellofemoral pain syndrome

- Controlled trials (randomized or not) comparing pharmacotherapy with placebo, different types of pharmacotherapy, or pharmacotherapy to other therapies for people with patellofemoral pain syndrome were the subject of a 2004 Cochrane Review.^[129] Trials of particular interest included:

- Two high quality RCTs for glycosaminoglycan polysulphate (GAGPS):
 - Twelve intramuscular injections of GAGPS over six weeks resulted in significantly less pain while going down stairs compared to placebo injections (RR 1.85; 95%CI 1.07 to 3.19), but pain when squatting was not significantly different (RR 1.38; 95%CI 0.73 to 2.62).^[136] Cochrane authors determined some very limited beneficial effect of GAGPS.
 - Five weekly intra-articular injections of GAGPS and lidocaine were compared with intra-articular injections of saline and lidocaine or no injections, all with concurrent quadriceps training.^[137] The number of people without symptoms during a full squat differed significantly after 6 weeks (RR 2.20; 95%CI 1.03 to 4.68), however, the Cochrane authors found no beneficial effect of GAGPS when examining the reported data.
- A low quality study of the intramuscularly injected anabolic steroid nandrolone phenylpropionate (anabolic steroid, injected) significantly improved both pain and function compared to placebo injections, (RR 17.39; 95%CI 2.56 to 118.26)

Chronic Pain

Opioids

Although opioids are often employed to treat severe pain, usually short term post-operatively, their use, especially beyond a one-time initial prescription, has been associated with increased disability in workers compensation.^[138] Appropriateness, effectiveness of, and dosing for opioids is the subject of several guidelines.^[139, 140] In terms of conservative management for Washington workers' compensation patients, any use of opioids in Washington workers' compensation requires compliance with L&I's Guideline for Prescribing Opioids. <http://www.lni.wa.gov/ClaimsIns/Providers/TreatingPatients/ByCondition/Opioids/default.asp>

Autologous Blood, Autologous Conditioned Plasma, Platelet Rich Plasma (PRP) Injection

There is inadequate evidence suggesting effectiveness for autologous blood injections.^[141] The procedure is not covered under Washington workers' compensation.

Tendinopathy

- A Cochrane review including randomized and quasi-randomized controlled trials on the effects of platelet rich plasma for soft tissue injuries (of the ankle and foot, elbow, knee and shoulder) and concluded that there is currently insufficient evidence to support the use of PRP for treating musculoskeletal soft tissue injuries.^[142]
- In a 2017 meta-analysis two trials were considered that addressed platelet rich plasma injections compared to extracorporeal shockwave treatment and dry needling in refractory cases of patellar tendinosis in athletes.^[143] No difference in VISA-P functional outcome scores was seen in either comparison, however a statistically significant (but unclear if it was clinically meaningful) difference was noted in long term (over 6 month) follow-up compared to no-treatment control.

Osteoarthritis

- A systematic review of studies investigating the use of platelet rich plasma (PRP) in knee osteoarthritis and following total knee replacement (TKR) was performed for high quality trials utilizing pain, knee function and quality of life scales.^[141] A total of 2328 participants were analyzed across 17 included studies and pooled results demonstrated no long-term statistically significant improvement in patient validated outcomes and secondary outcomes both in patients with knee osteoarthritis or following TKA for osteoarthritis. However some shorter term reductions in pain have been reported but it is unclear if it is better than palliative pharmacological management.

Surgical Interventions

This resource is not intended to inform surgical decision-making, nor evaluate the safety and effectiveness of the procedures covered in this section. A comprehensive review and evidence-based guideline for surgical options for work-related knee injuries was approved by L&I's Industrial Insurance Medical Advisory Committee (IIMAC) in 2016 and can be accessed online: <http://www.lni.wa.gov/ClaimsIns/Providers/TreatingPatients/ByCondition/Kneesurgery.asp>

Knee conditions and surgeries that have evidentiary support include:

- Patellar tendon realignment (indicated for recurrent dislocation or continued instability of the patella)
- Anterior cruciate ligament reconstruction, particularly emphasizing early surgery in large or complete acute tears
- Uni- or total knee arthroplasty with accepted osteoarthritis conditions
- Meniscal allograft transplantation or meniscectomy (full or partial) and repeat meniscectomy with blocked knee
- Marrow stimulation with microfracture, or if subchondral drilling or abrasion is involved

Additional conditions highlighted in knee guideline include

- Acute medial collateral ligament injury should routinely be addressed with non-surgical options
- Posterior cruciate ligament tears rarely occur alone, but would typically be managed conservatively.
- Autologous chondrocyte implantation was determined to have insufficient evidence to be a covered procedure.

WORKERS' COMPENSATION INTERVENTION ISSUES

Employer Contact for Accommodation

This is considered a best practice in occupational health in order to facilitate effective return to work, however no studies were found specific to occupational foot and ankle conditions.

- Interviews of injured workers in Ontario with prolonged claims identified numerous system and bureaucratic issues that were significant factors in prolonging a claim, particularly systematic issues impeding implementation of return-to-work options.

Administrative Interventions Breaks, Duration

No studies on administrative interventions specifically regarding recovery from occupational knee injuries were identified in our searches.

Ergonomic Interventions Engineering Interventions, Work Site Modification

- A 2016 study of an 8 week multifaceted ergonomic program (ergonomic training, workstation modification, regular exercise) versus no-intervention control of 102 male dentists in Iran reported a significant reduction in all musculoskeletal complaints in the intervention group compared to control at 3 months and 6 months.^[144]

Conditioning & Work Hardening Interventions

- A single blind randomized controlled Danish trial testing a one-year exercise intervention (specific neck/shoulder resistance training, all-round physical exercise, versus a reference intervention) for musculoskeletal pain symptoms in all regions of the body was performed among 549 office workers.^[145] Pain symptoms were recorded using screening questionnaires for 12 selected body regions. Intensity of pain decreased significantly more in the neck, low back, right elbow and right hand in cases of the two exercise groups compared with the reference group ($P < 0.0001-0.05$). In individuals with no or minor pain at baseline, development of pain was minor in all three groups. In conclusion, both specific resistance training and all-round physical exercise for office workers caused better effects than a reference intervention in relieving musculoskeletal pain

symptoms in exposed regions of the upper body but apparently not with the lower body. It should be noted that office work would seem to be associated with greater upper body stress than lower leg stress.

Return-to-Work
Assistance

No studies were identified with current search strategies.

Personal
Controls
Ergonomics Training,
Braces, Biofeedback,
On-the-job Exercise
Programs

No studies were identified with current search strategies.

Workflow/task
Modifications

Well-done studies demonstrating clinical benefit or reductions in work-related knee conditions were not identified with the current search strategy.

Exercise Approaches

General mobility – Early mobilization involves maintaining movement and weight bearing within tolerance, during initial phases of recovery. Principally, active movement and normal weight bearing are incrementally included for most ankle conditions (excluding some fractures and severe sprains which require a period of immobilization).

Neuromuscular (Balance, Proprioception, Coordination, and Gait) Training

– Numerous approaches exist for neuromuscular training usually aimed at increasing responsiveness and coordination of lower leg and postural musculature. Examples include wobble boards, standing on one leg, to more sophisticated training and loading.

Stretching – Directed at reducing muscle tightness that may affect irritation of structures (e.g. tendon insertions) or biomechanics of lower extremity movement. Thigh and lower leg muscular are typically targeted for stretch which is usually self-administered.

Strengthening – Aimed at improving both fiber recruitment and building muscular capacity, a number of various exercise regimens have been promulgated.

- o Concentric loading involves active contraction of a muscle against a load. Knee extension against resistance from surgical tubing would be an example.
- o Eccentric loading is usually less demanding in terms of forces on muscles and involves lowering a load back to a starting position. An example might be slowly returning an extended knee to a flexed position under resistance

Exercise Types

Active – Any active movement of a muscle or muscle group by the patient. Examples include box squats for kinetic chain strengthening with foot and ankle injuries, resistance weight training, or muscle energy techniques performed with a healthcare provider.

Passive – Provider-directed movement of the patient while the patient is relaxed. Some examples of passive therapies could include passive, static stretching performed by a healthcare provider or ballistic, passive stretching performed by a healthcare provider.

Static – Activities where a single position is maintained throughout. Examples of static activities include the classic runners stretch for the gastroc-soleus complex and foot intrinsic isometric strengthening exercises (e.g., Andreo Spino program).

Dynamic – Involves movement of a muscle or muscle group, typically through its full range of motion when possible. Repetitive calf raises and repetitive end-range stretching of the Achilles through a heel drop off of a step without holding the stretch are examples

Open-chain – Movements performed in a non-weight bearing position for the extremity being exercised. “A, B, C’s” traced with foot movements in the seated position for post-acute ankle sprains and tubing exercises of the foot while seated are examples.

Closed-chain – Closed-chain movements of the foot and ankle are movements performed in a weight bearing position for the extremity being exercised. Single leg stands, with or without a rocker or wobble-board, box squats, and single leg “pistol” squats are closed-chain exercises.

Perturbation – The action of challenging a statically held position with the intention of retraining proprioceptive capacity. Perturbation can be achieved as simply as tapping a patient’s shoulder while they are holding a single leg stand or as challengingly as having them catch a medicine ball while maintaining a single leg stand during rehabilitation.

Imaging Indications:

In general, knee imaging may not be routinely needed initially unless substantial trauma or suspicion of fracture or non-mechanical pathology is involved.

Indications for imaging include:

- Acute, severe trauma (blunt force, landing on feet, abnormal shape/suspicion of dislocation). Use Ottawa or Pittsburg prediction rules when concerned about possible fracture.
- Non-mechanical pain (unrelenting pain at rest, constant or progressive symptoms and signs, pain not reproduced on assessment-particularly if patient has history of cancer, enlarging mass, unexplained deformity, pain at multiple sites, age > 50, pain at rest, unexplained weight loss).
- Suspicion of infection (red skin, fever, systemically unwell, history of immunosuppression, penetrating wound).
- Substantial activity and/or work restriction lasting beyond 4 weeks.
- Failure to respond to conservative care by 4 weeks (e.g., no change, worsening, increasing disability).

Types of orthoses

Braces and supports – Items such as air casts, boots, or devices independently attached to the lower extremity utilized as a temporary measure to facilitate safe movement or limit unsafe movement

Soft Tissue Techniques

Manual deep tissue release – Passive pressure to muscles to stimulate relaxation; typically on palpably taut/tender regions, or ‘trigger points’ which elicit an involuntary twitch response. Examples include trigger point pressure, pressure point therapy.

Instrument assisted deep tissue release – Typically incorporate blunt, contoured ceramic or metal instruments that may assist application of effleurage-like pressure or stimulation at muscle-tendon junctions. Examples include Nimmo, Functional Kinetic Treatment with Rehab (FKTR), Graston, GuaSha.

Reflex relaxation techniques – Manual stimulation of muscles, fascia, tendons aimed at stimulating proprioceptive rich structures or processes that mediate muscle relaxation. Examples include cross fiber friction (e.g., Cyriax, Barnes), muscle energy (contract – relax), active release technique (ART).

Additional Resources

- Hegman KT. (ed). ACOEM’s Occupational Medicine Practice Guidelines, 3rd Edition, Volume 4 Lower Extremity Disorders. 2011 American College of Occupational and Environmental Medicine, Elk Grove, IL. www.acoem.org
- Michaud TC. Human Locomotion – The Conservative Management of Gait-Related Disorders. 2011 Newton Biomechanics, Newton, MA. www.newtonbiomechanics.com
- Souza TA. Differential Diagnosis and Management for the Chiropractor – Protocols and Algorithms. 2016 Jones and Bartlett Publishers, Sudbury, MA. www.jbpub.com

Knee Rehabilitation Tips

- Physical capacity, gender, and age considerations should be taken into account for exercise prescription
- Resistance bands or surgical tubing offer low tech, easy to comply with approaches to safely perform home knee flexion and extension exercises
- Resistance dynamics for agonist/antagonist ration of hamstring group to quadriceps muscle group should be about 3:2
- Initial 2-4 week of rehabilitation should focus on exercises within 10-20°+ to 70-90°+ positions in order to prevent external rotation of tibia in full extension and internal rotation of tibia in full flexion
- Patient education and lifestyle modifications should include:
 - proper biomechanics in walking, lifting, squatting and sit-stand/stand-sit movements
 - moderation/modification of activity type and intensity
 - recommendation/support for weight loss with obese patients

Muscle Relationships

Muscles that affect the:

- **Lateral knee:** iliotibial band and biceps femoris
- **Medial knee:** semi-tendinosis, semi-membranous , gracilis, sartorius
- **Anterior knee:** quadriceps
- **Posterior knee:** popliteus and hamstrings

Low Tech Knee Exercises

For flexibility be sure to include gentle, incrementally increasing stretching to the: hamstring group, quadriceps group, calf muscles, hip flexors and gluteal muscles.

For strengthening simple options include:

- Walking
- Step ups
- Lunges
- Wall squats
- Single leg "mini" squat

Helpful On-line Resources

Videos demonstrating clinical test for medial meniscus tears:

<http://www.thesportsphysiotherapist.com/identifying-medial-meniscus-tears-the-diagnostic-accuracy-of-clinical-tests/>

Summary of diagnostic accuracy of knee physical exam tests:

<http://www.acpj.org/Content/136/3/issue/ACPJC-2002-136-3-113.htm>

Orthopedic Scores website (functional scales for clinicians and patients):

<http://www.orthopaedicscores.com/>

Knee exercise resources:

Stretching exercises: <http://www.knee-pain-explained.com/knee-strengthening-exercises.html>

General knee pain exercises: <https://www.webmd.com/pain-management/knee-pain/injury-knee-pain-16/slideshow-knee-exercises>

General conditioning exercises: <https://orthoinfo.aaos.org/en/staying-healthy/knee-exercises/>

Exercises for arthritis: <https://www.arthritis-health.com/treatment/exercise/knee-exercises-arthritis>

Exercises for runners: <https://www.runnersworld.com/workouts/6-exercises-that-keep-your-knees-healthy>

KOOS-PS SCORING INSTRUCTIONS

KOOS-PS can be scored in two directions, from no difficulty (0) to extreme difficulty (100), as in the original KOOS-PS publication (table 1b) and from extreme difficulty (0) to no difficulty (100) (table 1a) in accordance with KOOS.^[146] To avoid confusion always be explicit about what scoring algorithm you have used.

KOOS and HOOS were developed in 1999 and 2003 in an orthopedic context where scores traditionally are scored from extreme difficulty (0) to no difficulty (100). This scoring direction is also aligned with some major generic scoring scales like SF-36 and EQ-5D. This scoring direction is achieved when using table 1a to convert the raw summed KOOS-PS score. When using table 1a to score KOOS-PS the score direction of KOOS-PS is aligned with all KOOS subscales. Scoring with table 1a is preferred if you are using KOOS-PS, the Physical function Short scale derived through Rasch-analysis from the two KOOS subscales ADL and Sport/Rec, together with the other KOOS subscales Pain, Symptoms and QOL.

KOOS-PS was originally scored from no difficulty (0) to extreme difficulty (100). This scoring direction is achieved when using table 1b to convert the raw summed scores. KOOS-PS was developed in 2008 as a standalone short measure of function under the auspices of Osteoarthritis Research Society International (OARSI) and OMERACT. To align with the concurrently developed pain measure (ICOAP) it was decided that both measures should be scored from best (0) to worst (100), as is the tradition in measures developed within rheumatology.

Table 1a: Nomogram for converting raw summed KOOS-PS scores to 0 representing extreme difficulty and 100 representing no difficulty.

Raw summed score (0-28)	Person interval level score (0 to 100 scale)
0	100
1	94.4
2	89.5
3	85.2
4	81.4
5	78.0
6	75.1
7	72.5
8	70.3
9	68.2
10	66.4
11	64.7
12	63.0
13	61.4
14	59.7
15	58.0
16	56.0
17	53.9
18	51.5
19	48.8
20	45.6
21	42.1
22	38.0
23	33.4
24	28.2
25	22.3
26	15.7
27	8.2
28	0.0

Table 1b: Nomogram for converting raw summed KOOS-PS scores to 0 representing no difficulty and 100 representing extreme difficulty as in the original publication of KOOS-PS.

Raw summed score (0-28)	0 (no difficulty) to 100 (extreme difficulty) scale
0	0.0
1	5.6
2	10.5
3	14.8
4	18.6
5	22.0
6	24.9
7	27.5
8	29.7
9	31.8
10	33.6
11	35.3
12	37.0
13	38.6
14	40.3
15	42.0
16	44.0
17	46.1
18	48.5
19	51.2
20	54.4
21	57.9
22	62.0
23	66.6
24	71.8
25	77.7
26	84.3
27	91.8
28	100.0

Intervention/Experimental Studies

Randomized Controlled Trial (RCT) – A study that randomly allocates patients to treatment groups, usually blinding patients, therapists and/or study evaluators. Typically of high quality as randomization assures similarities of subjects within treatment groups.

Observational Studies

Cohort Design – Cohort (retrospective or prospective) – A study that follows patients who self-allocate to treatment groups through the course of their care for a given occurrence of a condition. Larger, well-designed cohort studies may be of good quality, but lack of randomization predisposes to heterogeneity issues within groups, some of which may be able to be adjusted for with statistical methods.

Cross sectional – Involves observing a population to measure disease and exposure status. It is usually thought to be a “snapshot” of the frequency and characteristics of a disease in a population at a specific given time.

Case control – Is a study that compares patients who have an outcome (cases) of interest with patients who do not have the disease or outcome (controls). The study may retrospectively to compare how frequently the exposure was present in a group to determine risk factors.

Case series – Is a study that describes a series of patients with an outcome of interest, may be of variable quality. Better designs use consecutive patients and include robust baseline and follow up outcome measures.

Case reports – Describes an individual case, typically only achieving publication if it represent a unique or unusual clinical experience.

Blinding

Blinding minimizes potential bias. Typically three levels of blinding are sought: patient, treating provider and evaluator. Many conservative interventions do not allow for patient blinding (e.g. someone is likely to know if they received a splint or a pill). At a minimum, single blinding of the evaluator as to what group a subject was in is expected.

Literature Reviews

Quantitative systematic reviews – Studies that review previously published clinical trials that include quantitative comparisons (e.g. meta-analyses). Systematic reviews should have rigorous and comprehensive methodology to identify relevant published research and include appraisal of study quality. Cochrane reviews frequently are of this type.

Qualitative systematic reviews – Similar to quantitative reviews but without systematic quantitative comparison or data pooling.

Narrative literature reviews – Such reviews typically do not include rigorous study selection methodology and may be subject to significant author bias

Literature Retrieval and Review

1. **Initial systematic searches** of electronic databases (e.g. PubMed). Search terms used typically included MeSH terms for tests and interventions with conditions being addressed. Follow-up searches also included population attributes (e.g., workers compensation, occupational).
2. **Abstract screening** for relevance.
3. **Original paper retrieval** with review for relevance, quality, outcome meaningfulness, and effect magnitude.
4. **Additional studies identified** through clinical summaries (e.g., reviews, texts), citation tracking, and feedback from public.

About Evidence for Physical Examination and Conservative Interventions

Conservative musculoskeletal care is typically care of first resort based on long standing practices. Typically ‘low tech,’ low cost, with minimal and rare side effects, it is frequently delivered in primary care settings, and by various health providers. The rigor and quality expected of high cost, higher risk, emerging, and tertiary interventions is less common for many routine physical examination procedures and conservative interventions. Much of the evidence summarized here would be considered Class “C” or “III” in ratings systems. Thus, the committee has not presented explicit *recommendations*, rather, *evidence summaries* guided by expert consensus to assist in formulating care options. Further, significant emphasis is made regarding tracking and documenting meaningful functional improvement with patients. Study attributes most likely to strengthen or limit confidence are characterized in the evidence descriptions.

Assessing Study Methodologic Quality

Attributes of study methodology quality vary according to the clinical procedure (eg, diagnostic, therapeutic intervention) looked at, and specific research questions being studied. The American Academy of Neurology’s Clinical Practice Guideline Process Manual offers a comprehensive guide to systematic evidence review, quality attributes and consensus process that generally serves as the approach taken by IICAC.

General attributes identified when extracting evidence from studies include identification of population, the intervention and co-interventions and outcomes being addressed in each study. The clinical questions addressed such as diagnostic accuracy, therapeutic effectiveness, or causation are determined. Studies are extracted into evidence tables including quality attributes and/or ratings which are reviewed both by department staff and committee members (usually 2 per study).

Specific quality attributes include: Diagnostic Accuracy – design, spectrum of patients, validity and relevance of outcome metric; Therapeutic Interventions – comparison groups (no treatment, placebo, comparative intervention), treatment allocation, blinding/masking (method and degree: single, double, independent), follow-up (period and completion), and analysis (statistical power, intent-to-treat). Specific attention is paid to several factors including reporting of outcomes (primary vs. secondary), relevance of outcome (eg, function vs. pain), and meaningfulness (clinically important change vs minimally detectable change).

Synthesizing Evidence

Consideration of study quality (class), significance (statistical precision), consistency across studies, magnitude of effect, and relevance to populations and procedures were taken into account in preparing draft summaries. Special attention was given to clarifying conclusions related to the clinical questions of interest. Evidence, particularly with low tech and highly diffused examination and conservative procedures addressed here, is rarely truly “definitive,” even when multiple studies exist. Inconsistent conclusions typically reflect error (systematic, random) and/or bias in studies. Data pooling via meta-analysis is useful to reduce random error when studies are of sufficient power and methodologic strength. Larger meaningful effect size may increase confidence in findings.

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