Treatment Guideline for Work-Related Knee Injuries

TABLE OF CONTENTS

I. Review Criteria for Knee Surgery

Kellgren Lawrence (KL) Scoring System and Modified Outerbridge Classification

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Knee arthroscopy for diagnosis or for osteoarthritis	Diagnosis: MRI is now the diagnostic method of choice. Arthroscopy for diagnostic purposes will only be considered if an MRI is contraindicated, (e.g. for a patient with a cochlear implant or pacemaker). Osteoarthritis: Arthroscopic debridement and lavage is not covered as treatment for osteoarthritis; see 2008 HTA decision.				
Chondroplasty	Chondroplasty is most commonly done in conjunction with a meniscal surgery or marrow stimulating procedure; it is rarely done as a stand-alone procedure. A chondroplasty, by itself, is covered only when: a. During a previously authorized surgery that was aborted, a chondral lesion was discovered and documented with intraoperative imaging (e.g. photo), **OR** b. A chondral lesion, such as a loose flap, is seen preoperatively on MRI and surgery is indicated to remove or correct it.				
Autologous Chondrocyte Implantation (ACI)	Non-covered procedure (for explanation, see Autologous Chondrocyte Implantation in the narrative section)				
Patellar tendon realignment procedure with or without lateral retinacular release	Patellar dislocation	History of acute traumatic dislocation	Lateral tracking of the patella **OR** Recurrent effusion **OR** Positive patellar apprehension test **OR** Synovitis with or without crepitus **OR** Recurrent dislocations	MRI (not x-ray or CT scan) shows: Medial Patellofemoral Ligament (MPFL) disruption **OR** Osseous contusion **OR** Cartilage injury	6 weeks of physical therapy is required for first time dislocation; physical therapy is not required for recurrent dislocations or if loose osteochondral body is confirmed by MRI or x-ray and needs to be surgically addressed.

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Meniscectomy, full or partial (in a **non-degenerative** knee)	Acute meniscal tear in an otherwise **non-degenerative** knee **AND** Onset of symptoms within 12 weeks of injury	Discrete event associated with the acute onset of any of the following symptoms: • Pain • Swelling • Locking, catching, or popping	Positive McMurray's sign **OR** Anatomically consistent joint line tenderness **OR** Effusion **OR** Limited range of motion **OR** Mechanical locking, catching, or popping Note: The combination of positive McMurray's sign with joint line tenderness has a higher predictive value than any one sign alone.	MRI shows: Non-degenerative meniscal tear **AND** KL score < 2 on weight bearing x-rays	Not required for locked or blocked knee If not locked or blocked, recommend: At least 6 weeks (post-injury) of: Physical therapy **OR** Non-narcotic medications **OR** Activity modification
Repeat arthroscopic meniscectomy in the absence of new injury (in a **non-degenerative** knee)	Knee is still symptomatic with continued disability **AND** At least 12 weeks has passed since meniscectomy for original acute tear	Continued symptoms of: • Pain • Swelling • Locking, catching, or popping	Positive McMurray's sign **OR** Anatomically consistent joint line tenderness **OR** Effusion **OR** Limited range of motion **OR**	A **NEW** MRI shows: Meniscal tear **AND** KL score < 2 on weight-bearing x-rays	<u>Recommended</u>: Physical therapy during 12 weeks post-op period after initial injury as long as there is no mechanical locking

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
			Mechanical locking, catching, or popping Note: The combination of positive McMurray's sign with joint line tenderness has a higher predictive value than any one sign alone		
Meniscectomy, full or partial (in a **degenerative** knee)	Acute or chronic Meniscal tear in a **degenerative** knee (Degenerative is defined as a KL score ≥ 2)	History of locking of the knee	Mechanical locking **OR** Effusion **OR** Restricted motion	MRI shows: Large meniscal flap or fragment **AND** KL score ≥ 2 on weight-bearing x-rays	Not required
Repeat arthroscopic meniscectomy in the absence of new injury (in a **degenerative** knee)	Acute or chronic Meniscal tear in a **degenerative** knee (Degenerative is defined as a KL score ≥ 2)	History of locking of the knee	Mechanical locking	A **NEW** MRI shows: large meniscal flap or fragment **AND** KL score ≥ 2 on weight-bearing x-rays	Not required

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Meniscal Allograft Transplantation (MAT)	A previous acute, work-related event that caused the need for a meniscectomy	Knee pain that has not responded to conservative treatment	Previous meniscectomy with at least 2/3 of the meniscus removed **AND** Stable knee with intact ligaments, or intent to repair torn ligament; with normal alignment or intent to realign, and normal joint space; has sufficient articular cartilage in the affected compartment to ensure the continued integrity of the allograft meniscus **AND** Age < 50 **AND** BMI < 35	MRI demonstrates absence of meniscus **AND** Weight bearing AP and lateral x-rays with or without notch view show a KL score < 2 **AND/OR** Chondrosis meeting Modified Outerbridge Scale, Grade I or II **OR** Grade III with evidence that articular surface is sufficiently free of irregularities to maintain integrity of transplanted meniscus. **Exclusion criteria**: Grade III (with or without debridement) without an articular surface capable of maintaining integrity of the transplanted meniscus **OR** Grade IV	<u>Recommended:</u> Physical therapy **OR** NSAID **OR** Activity modification

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Anterior Cruciate Ligament (ACL) reconstruction	ACL tear resulting from an acute work-related event associated with new onset of symptoms	Instability of the knee, potentially described as "buckling or giving way" **OR** Pain and swelling that limits normal function Note: Pain alone is not an indication for surgery	Positive Lachman's sign **OR** Positive pivot shift **OR** Positive anterior drawer	MRI shows: ACL disruption	Not required for up to 3 months after acute injury If surgery is requested after 3 months, physical therapy is recommended before surgery to strengthen the surrounding muscles Bracing
Marrow stimulating techniques: Microfracture *or* Subchondral drilling *or* Abrasion arthroplasty	A full-thickness chondral defect resulting from a previous acute, work-related event	Joint pain **AND** Complaints of joint swelling	Knee is stable with intact ligaments or intention to correct ligaments **AND** Normal knee alignment or intention to correct alignment	MRI shows: Single chondral defect < 2.5 cm^2 **AND** KL score ≤ 1on weight bearing x-rays	May consider: Non-narcotic medication **AND/OR** Physical therapy

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Osteochondral autograft/allograft transplantation (mosaicplasty or OAT procedure for the knee)	A single, focal, full thickness chondral defect resulting from a previous acute, work-related event	Joint pain **AND** Complaints of joint swelling	Knee is stable with intact ligaments or intention to correct ligaments **AND** Normal knee alignment or intention to correct alignment **AND** Age < 50 **AND** Does not have degenerative and/or inflammatory arthritis	MRI shows: Single large chondral defect **AND** KL score ≤ 1on weight bearing x-rays and normal joint space	May consider: Non-narcotic medication **AND/OR** Physical therapy
Uni-compartmental Knee Arthroplasty (UKA – partial knee replacement)[i]	End stage osteoarthritis in only one compartment	Pain limiting activities of daily living **AND** Pain interfering with ability to work **OR** Pain limiting ambulation **OR** Pain interfering with sleep	BMI < 35 **AND** Angular deformity of < 15 degrees that is passively correctable **AND** A range of motion arc > 90 degrees, with < 5 degree flexion contracture	KL score of 3 or 4 in only one compartment on weight bearing x-rays	May consider any combination of: Strengthening exercises, activity modification, assistive devices, bracing, corticosteroid injections, NSAIDs or other non-narcotic medication

A request may be appropriate for	If the patient has	AND the diagnosis is supported by all the following subjective and objective findings and imaging results:			Required or recommended
Surgical Procedure	**Condition or Diagnosis**	**Subjective**	**Objective**	**Imaging**	**Non-operative care**
Total Knee Arthroplasty (TKA)[i,ii]	End stage osteoarthritis, where one or more compartments are affected	Pain limiting activities of daily living **AND** Pain interfering with ability to work **OR** Pain limiting ambulation **OR** Pain interfering with sleep	BMI < 40 **AND** Decrease in knee range of motion **OR** Knee effusion	KL score of 3 or 4 in one or more compartment on weight bearing x-rays	May consider any combination of: Strengthening exercises, activity modification, assistive devices, bracing, corticosteroid injections, NSAIDs or other non-narcotic medication
	[i] This surgical criteria is consistent with the Health Technology Clinical Committee's 2010 knee arthroplasty decision. [ii] Fasciotomy, iliotibial tenotomy (IT Band release) cannot be billed separately when done with a total knee arthroplasty.				

Figure 1: Osteoarthritis (OA) and Chondral Lesion Grading Scales

Kellgren Lawrence (KL) Scoring System
The KL scale is one of the most widely used and accepted method of grading radiographic OA severity.[1]
• **Grade 0**: No radiographic features of osteoarthritis are present • **Grade 1**: Doubtful narrowing of joint space and possible osteophytic lipping on anteroposterior weight-bearing radiograph • **Grade 2**: Definite osteophytes, definite narrowing of joint space • **Grade 3**: Moderate multiple osteophytes, definite narrowing of joint space, some sclerosis and possible deformity of bone contour • **Grade 4**: Large osteophytes, marked narrowing of joint space, severe sclerosis and definite deformity of bone contour
Modified Outerbridge Classification
The Modified Outerbridge Classification is the most widely used and accepted method of classifying chondral lesions. This grading system is based on the depth of the chondral lesion. Originally the Outerbridge was based on direct visual observation in the 1960's but was later modified to reflect the medical standard of MRI use.[2, 3]
• **Grade I**: Articular cartilage softening • **Grade II**: Chondral fissures that do not reach the subchondral bone and are < 1.5 cm in diameter • **Grade III**: Chondral fissures that reach the subchondral bone and are > 1.5 cm in diameter • **Grade IV**: Exposed subchondral bone

II. Introduction

This guideline reflects a best practice standard for surgical treatment of certain knee conditions sustained by injured workers treated in the Washington State workers' compensation system under, Title 51 Revised Code of Washington (RCW). Providers who are in the department's Medical Provider Network are required to follow this guideline as it applies to the treatment they provide to workers [a]. The surgical criteria are used in the department's utilization review program, as the supporting evidence has shown these provide the best chance for injured workers to have a good surgical outcome. To help ensure that diagnosis and treatment of knee conditions are of the highest quality, this guideline emphasizes:

- Conducting a thorough assessment and making an accurate diagnosis
- Appropriately determining work-relatedness
- Making the best treatment decisions that are curative or rehabilitative [b]
- Facilitating the worker's return to health, productivity, and work

The guideline was developed in 2015-2016 by a subcommittee of the Industrial Insurance Medical Advisory Committee (IIMAC). The subcommittee was comprised of physicians in various medical specialties, including rehabilitation medicine, occupational medicine, orthopedic surgery, and family medicine. The guideline recommendations are based on the weight of the best available clinical and scientific evidence from a systematic review of medical literature, and on a consensus of expert opinion when scientific evidence was insufficient or inconclusive. Visit the department's Medical Treatment Guidelines webpage for detailed information on the guideline development process.

A. Background and Prevalence

Injuries to the knee are common, with over 6.5 million visits to US emergency departments from 1999-2008, or 2.29 knee injuries per 1,000 people, and 10-60% of the general population displaying knee pain reflecting a variety of conditions.[4, 5] Among fulltime workers, the Bureau of Labor Statistics found that the incidence of knee injuries in 2014 was 9.6 per 10,000 workers, with knee sprains, strains, or tears accounting for nearly 50% of injuries resulting in lost work time.[6] Knee injuries may arise from acute trauma, work-related musculoskeletal disorders, or non-traumatic soft tissue disorders and can happen to any of the structures that make up or support the knee joint, including ligaments, cartilage, muscles and bones.[7]

In a study of State Fund claims accepted in the Washington State workers' compensation system from 1999-2007, knee conditions accounted for 7% of work-related musculoskeletal disorders and consumed 10% of the costs, translating to nearly 25,000 knee injuries and just under $500 million. Industries most often associated with knee injuries were construction and building contractors.[5] Top industries for

[a] http://app.leg.wa.gov/RCW/default.aspx?cite=51.36.010
[b] http://app.leg.wa.gov/wac/default.aspx?cite=296-20-01002

compensable claims (i.e. wage replacement was paid) were carpenters and truck drivers for men, and nursing aides and housekeepers for women. Though the claims had overlapping diagnoses, most were sprains (~86%), meniscal/ligamentous disruption (~42%), chondromalacia patellae (~12%), and tendonitis/bursitis/enthesopathy (~11%).[5]

B. Establishing Work-relatedness

A knee injury sustained during the course of employment is defined in Washington State statute as "a sudden and tangible happening, of a traumatic nature, producing an immediate or prompt result, and occurring from without, and such physical conditions as result therefrom." [c] This is based on medical opinion with a more probable than not degree of medical certainty.

Occupational disease is defined in RCW 51.08.140 as a "disease or infection that arises naturally and proximately out of employment."[d]

A thorough occupational and non-occupational exposure history is essential for determining whether a knee condition is work-related and whether it is due to an acute or chronic exposure. For chronic exposures, it is important to document where, when, and for how long they occurred, as they could span multiple employers who would then share liability for an occupational disease. Providers should submit the completed work history to the department or self-insurer as soon as possible.

Osteoarthritis

A complicating factor when trying to establish work-relatedness is the presence of osteoarthritis (OA). Osteoarthritis is a normal degenerative process and a progressive condition that results from loss or deterioration of articular cartilage. It is the most common arthritic disease, it is the most common cause of long-term disability in persons older than 65, and it is expected to become the world's 4th leading cause of disability by 2020.[8, 9] Those with diagnosed OA have nearly double the risk of increased sick leave, with around 2% of all sick days being attributable to knee OA, and are 40-50% more likely to receive a disability pension.[10]

While osteoarthritis is considered a normal degenerative process, if certain movements such as squatting, kneeling, and heavy lifting are a regular part of one's job and are thus performed repeatedly or intensively over an extended period of time, they may contribute to the development and severity of osteoarthritis, and in these situations, may be considered work-related. Obesity is a leading independent non-work related risk factor for developing symptomatic knee osteoarthritis, with the risk increasing as BMI increases.[9, 11-13]

[c] http://app.leg.wa.gov/RCW/default.aspx?cite=51.08.100
[d] http://app.leg.wa.gov/RCW/default.aspx?cite=51.08.140

III. Assessment

A. History and Clinical Examination

Knee injuries may be complex, often involving more than a single tissue or anatomic element. Different knee problems can present with similar findings, such as limited and painful motion and effusion, so during the assessment process it is important to determine which compartment(s) of the extremity are affected and tailor a treatment plan accordingly. Aside from the occupational history described above, taking a thorough patient history should include a precise description of the event(s) leading up to the internal derangement/condition and whether there were any prior exposures, injuries, or surgeries in the affected area. Degree, location, and nature of pain, including how it may manifest during sleep, and presence of any instability, locking, or problems with mobility and weight bearing are all important to assess. Clinical examination typically assesses and documents: range of motion, effusion, crepitus, tenderness, stability, and provocative tests e.g. McMurray's, patellar apprehension, Apley's, and Lachman's tests.

Clinically meaningful improvement in function is an improvement in pain and function of 30% over baseline [14]. This can be measured using patient-reported outcome measures (PROMs). These are useful tools in the comprehensive assessment relying on a combination of patient self-report and clinical exam. An example of a widely used PROM is the KOOS, see Appendix A. The non-physical areas assessed are the patient's ability to perform activities of daily living (ADLs), engage in work or recreation, and perceived quality of life. Repeated use of these instruments allows the practitioner to trend the degree of knee related impairment and determine if the patient has any clinically meaningful improvement.

B. "Overuse Syndrome" and Contralateral Effects

It is sometimes contended that work-related injuries involving one part or side of a body ("ipsilateral") cause pain and impairment in a different part or opposite side ("contralateral") due to overuse, altered use, or other similar postulated mechanism. The appearance of contralateral symptoms or signs is often referred to as "overuse syndrome". There is an absence of high-grade medical literature upon which to base conclusions regarding the etiology of "overuse syndrome" in contralateral body regions following injuries, so careful assessment is critical. Additionally, it sometimes occurs that at the time of injury, a non-work-related degenerative condition is already present at the injury site and not uncommonly, elsewhere in the body. In Washington State's workers' compensation system, medical and surgical care is limited to treatment of only those conditions for which an industrial injury or occupational disease was a proximate cause. It is therefore important to identify the nature and etiology of "overuse syndromes" that are contended to be work-related, and support contentions of relatedness with careful documentation.

A contention that a condition in a contralateral body part or region has arisen as a proximate result of an occupational injury should be supported by at least the following documentation:

1. The specific contralateral condition that has been diagnosed, and the ICD-10 code for that condition;
2. Citations to medical literature that document a causal relationship between the condition(s) for which liability has been accepted in the workers' compensation claim and the contralateral condition, or a statement indicating that such medical literature could not be identified;
3. A statement as to whether the contralateral condition was present to any degree prior to the onset of the ipsilateral condition that is contented to be a cause of the contralateral condition. If the contralateral condition was present to any degree at or before the onset of the ipsilateral condition, the nature and extent of the contralateral condition at the time the ipsilateral condition arose must be documented, including, whenever possible:
    a. The symptoms it reportedly caused;
    b. Signs of the condition that were documented in the medical record;
    c. Objective evidence that the condition was present, such as imaging studies, lab test results, electrodiagnostic studies, etc.;
4. A statement as to whether there is objective evidence of the development or worsening of the contralateral condition since the onset of the ipsilateral condition, and, if so, a description of the evidence of its development or worsening;
5. If the contralateral condition is degenerative in nature, the evidence supporting the contention that the present state of the contralateral condition is a proximate result of a condition for which the department has accepted liability in the claim, and not the natural progression of a degenerative disease process.

C. Diagnostic Imaging

The recommended imaging procedures for various knee surgeries are specified in the criteria table. 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 for surgical consideration (see Appendix A). Magnetic resonance imaging (MRI) is most commonly used to diagnose injuries to the meniscus, ligaments or tendons. MRI is not recommended for every case of acute knee pain or for degenerative joint disease, and L&I requires prior authorization for all MRIs. Computed tomography (CT) is generally not recommended for the knee except in rare cases when MRI is contraindicated. Visit the Advanced Imaging Guidelines web page for complete information.

IV. Non-Operative Care

Many knee injuries can be treated effectively without surgery, and studies demonstrate that various conservative interventions can help reduce pain and improve function. Often a trial period of non-operative care is attempted, with the length and intensity varying by patient specific factors.

Symptoms related to acute knee injury may resolve following the conservative treatment acronym RICE: Rest, Ice, Compression, and Elevation. Immobilization beyond 3 days carries the risk of knee stiffness or

muscle atrophy and is therefore not recommended, with the exception of fracture, dislocations or muscle/ ligament rupture.[15] Exercise, strength training, and activity modification should be incorporated when there is adequate range of motion and pain management. Physical therapy or a prescribed home exercise program may be indicated for continued improvement in range of motion and function, especially with more chronic conditions.

Multiple options for pain control are available and depend on patient and practitioner preference. Non-narcotic medications are usually sufficient for managing pain and are readily available. Another option includes steroid injections. Corticosteroid injections may produce a moderate short term reduction in pain and a small improvement in physical function, but the quality of the evidence is low and results are inconclusive.[16] If needed, these should be done with caution when other conservative measures have not been successful. The worker should be advised that the injections may be of limited value and multiple injections should not be done without clinically meaningful improvement (CMI) of at least 30% in pain and function (see Appendix A). If this has not occurred within 4 -6 weeks of conservative treatment, the worker should be referred to a specialist.

V. Surgical Procedures

Under Washington States' Title 51 workers' compensation, knee surgeries must be pre-authorized and are subject to the utilization review process. Review criteria for authorizing knee surgery are in the table at the beginning of this guideline. If a proposed surgery is not listed, other standard review criteria may be used. Visit the department's Utilization Review Program page for further information on the requirements.

Preoperative Planning

Preoperative planning for postoperative recovery can help minimize the risk of untoward events. It is important to discuss expectations for pain management, recovery and functional improvement with the patient and treatment team. Although general surgical risks and complications are reviewed, special emphasis should be placed on tobacco cessation and use of opioids. These two areas may carry additional risk of harm and should be closely reviewed with the patient.

When using opioids, care should be taken during the preoperative period to help plan for a successful recovery. All patients should understand that effective pain management requires a multimodal strategy of which opioids are only one part. For patients who are on chronic opioid therapy or otherwise have a higher risk for opioid related complications, it is especially important to create a pain management plan prior to surgery. This allows the patient and practitioner to reach a common understanding and set realistic expectations about pain management. For a more detailed resource in pain management, please review L&I's Guideline for Prescribing Opioids to Treat Pain in Injured Workers.

Tobacco use has been shown to increase surgical complications and is linked to poor surgical outcomes. In patients who received tobacco cessation treatment before surgery, the risk of complications can be reduced by one-half to two-thirds. These complications are related to wound healing, cardiopulmonary

events, and the need for postoperative intensive care.[17, 18] For a more detailed resource in tobacco cessation treatment, please visit L&I's Tobacco Cessation Coverage Policy.

A. Marrow Stimulation Procedures

Articular cartilage has little or no capacity to regenerate and repair itself due to its avascularity. By penetrating subchondral bone to expose the underlying vascular cancellous bone, mesenchymal stem cells can be stimulated to produce fibrocartilage. Though inferior to hyaline cartilage, fibrocartilage can have a therapeutic and healing effect.[19] One of three techniques may be used: drilling, abrasion (using a motorized burr), or microfracture (making microperforations with a pick or awl). Studies suggest that microfracture is the preferred technique, especially for lesions less than 2.5cm^2, and has the advantage of not removing bone.[19-21]

Marrow stimulating procedures are usually reserved for patients with small full thickness chondral defects on the weight bearing portion of the medial or lateral femoral condyle. The knee should be stable and intact with fully functional menisci and ligaments, normal knee alignment, and normal joint space.[19, 20, 22] Several studies have shown the repaired tissue does not last and up to a third result in subchondral bone thickening, bone overgrowth (spurs) and subchondral cysts.[23] In addition patients with multiple or bipolar lesions and those with large nonfocal chondral lesions are less likely to achieve long-term benefit.[24, 25]

B. Autologous Chondrocyte Implantation

Autologous chondrocyte implantation (ACI) is a two-stage technique done to treat localized cartilage defects in the femoral condyle, trochlea, or patella. The first stage is the harvesting and culturing of cartilage cells. In the second stage, these cells are implanted into the area of cartilage defect, with the goal of stimulating generation of cartilage in hopes of preventing or slowing the onset of osteoarthritis. For Washington States' injured workers, ACI is not a covered procedure for the following reasons:

1. ACI is a secondary or "last resort" procedure that is only done after previous attempts to repair cartilage have failed, yet studies show that these previous repair attempts increase the failure rate of ACI itself. One cohort study found that patients undergoing marrow stimulation prior to ACI had a 3-fold increase in failure rate, with another study showing a 25% failure rate compared to a 3.6% failure rate in patients who had not previously undergone microfracture.[23, 26] Previous bone marrow stimulation was found to be significantly associated with reintervention surgery following ACI.[27]
2. Current literature demonstrates that other procedures such as OAT and marrow stimulation procedures (e.g. microfracture, subchondral drilling, or abrasion arthroplasty) may be more effective. In five randomized controlled trials comparing ACI with marrow stimulation procedures, pooled analysis showed no significant difference in pain score outcomes at 24 months. In three trials comparing ACI with OAT, two studies found the techniques yield comparable functional outcomes, while one study found OAT demonstrated superior outcomes at 24 months.[28]

C. Patellar Tendon Realignment Procedure

Patellar Tendon Realignment is indicated for recurrent dislocation or continued instability of the patella. There are two approaches to surgery, both with the goal of bringing the patella back into alignment and preventing future dislocations: repair of the soft tissue around the patella or distal bone realignment. Treatment for a recurrent patellar dislocation or patellar instability that is not due to an industrial injury is not covered, and the department does not accept treatment for recurrent patellar instability that predates the industrial injury, unless the performance of the job is clearly contributing to recurrent dislocations. If, however, an industrial accident results in acute trauma to a knee that subsequently results in persistent patellar instability, a realignment procedure may be approved with or without a lateral retinacular release procedure. In general, it is typically recommended that nonoperative management be attempted for initial dislocations as there is a paucity of data to suggest that surgery is superior to nonoperative management.[29]

D. Meniscal Disorders

The menisci are two semilunar fibrocartilaginous pads between the femoral condyles and tibial plateau. The lateral meniscus is "C" shaped covering approximately 80% of the compartment. The medial meniscus is "U" shaped and covers approximately 60% of the compartment. The main meniscal functions are tibiofemoral load distribution, shock absorption, lubrication, and stabilizing the knee during rotation. Common mechanisms of injury include rotation of the flexed knee during sports, cutting, decelerating, or landing from a jump. Tear patterns include vertical (longitudinal and radial), oblique, complex (or degenerative), or horizontal.[30] Small meniscal tears may cause only temporary pain and dysfunction, and except in the case of severe movement limitation, non-operative treatment of at least six weeks is recommended.[31]

Studies have demonstrated a strong association between meniscal damage and knee osteoarthritis, including degenerative meniscal damage being a possible signal for early osteoarthritis.[32-34] Studies have also demonstrated that meniscal tears or destruction may be present in asymptomatic knees.[35, 36]

There is mounting evidence that surgery for meniscal tears in arthritic knees does not improve symptoms and should be avoided unless the tear results in clearly documented mechanical locking of the knee.[37, 38] Even in knees with mild or no concurrent osteoarthritis the surgical treatment of degenerative meniscal tears is not always superior to nonoperative management.[39, 40] In individuals with symptomatic knee pain, a meniscal tear, and mild knee osteoarthritis (KL score ≤ 2) arthroscopic meniscectomy and total knee arthroplasty do not have predictable results.

Meniscectomy

A meniscectomy can be a full or partial excision where a torn flap or damaged area of the meniscus is removed leaving the intact meniscus stable and smooth. The indication for a meniscectomy depends on the level of arthrosis in the knee, e.g. the degree of degenerative changes, usually indicated by KL scores. In cases of severe meniscal injury with a locked or blocked knee, surgery should be done promptly.

Repeat Meniscectomy

Repeat meniscectomy should only be done in rare instances, such as when there is locking of the knee and new MRI confirms that an additional meniscal tear is present. In a non-degenerative knee, repeat surgery should only be performed after a minimum of 12 weeks has passed since the initial surgery and a course of physical therapy has been completed. This is to allow time for the initial surgery to heal before reoperation.

Meniscal Repair

Repairing the meniscus is usually indicated for young and healthy patients, typically athletes. Rather than excising the torn tissue, the surgeon attempts to secure it arthroscopically. Repairs are only feasible when done on the outer edge of the meniscus due to the poor vasculature within the meniscus.

Meniscal Allograft Transplantation

Meniscal allograft transplantation (MAT) involves surgically replacing the meniscus with a properly sized donor graft. This is an uncommon procedure, the incidence of which did not change from 2007-2011 and is more common in men <35 years of age.[41] The articular cartilage must be free of irregularities prior to the surgery in order to create an environment suitable for the transplanted tissue.

This surgery is very technically demanding and requires an extensive rehabilitation period.[42] It should be considered only as a salvage procedure for patients who have undergone meniscal repair and meniscectomy, but who are not yet old enough for a total knee replacement. Patients should be advised that MAT is not a long term solution, and that more surgery is likely to follow.[43] Existing systematic reviews of MAT literature find failure rates of the procedure range from 10% to 29%, along with a tendency of the measured functional improvements to decline over time.[44, 45]

E. Anterior Cruciate Ligament Reconstruction (ACL)

Reconstruction of the anterior cruciate ligament (ACL) involves the use of an anatomically positioned autograft or allograft to restore function to a torn or ruptured ligament. The ACL functions to prevent the tibia from sliding forward relative to the femur. It also prevents excessive knee extension, varus & valgus movements, and tibial rotation. An intact ACL protects the menisci from sheering forces during movements such as landing from a jump, pivoting, or decelerating from a run.[46] Injuries to the ACL most often occur during twisting or pivoting in sports or high intensity activities that do not involve contact.[47]

ACL reconstruction (usually done arthroscopically) is a covered surgical procedure when all the following criteria are met:

1. Patient reports a feeling of instability or “giving way” OR
2. Pain and effusion that limits normal function AND
3. Positive Lachman’s sign OR
4. Positive pivot shift OR
5. Positive anterior drawer

Please note: pain alone is not an indication for surgery.

Treatment strategy should consider the injured worker's age, occupation, desired level of activity, and willingness to undergo an extensive rehabilitation program. Adults can often tolerate the absence of an ACL if they do not engage in pivoting, cutting or twisting activities. Non operative care is only considered in older populations with sedentary occupations and less active lifestyles.[48] This type of treatment is for people with a low risk of injury consequences to menisci, articular cartilage or re-injury of the ACL. The plan includes:

1. Physical therapy
2. Functional bracing
3. Activity modification

A torn ACL will not heal independently, leaving the patient with a permanent patholaxity. Chronic instability leads to a higher rate of late meniscal tears. Approximately half of all ACL injuries have concomitant damage to menisci or articular cartilage.[49, 50] Surgery for meniscal injury is increased with non-operative patients who choose to return to high level activity.[51] Among younger patients who were treated with non-operative care 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.[52] With appropriate indications and surgical technique, the success rate for ACL reconstruction is 90-95%.[53]

The Posterior Cruciate Ligament (PCL) functions as the primary restraint to posterior translation of the tibia relative to the femur. PCL injuries are uncommon, may be partial or complete, and rarely occur alone. Most often the treatment plan is non-operative.[53]

Medial Cruciate Ligament (MCL) injuries usually occur from valgus stress on the knee and when combined with external rotation, can cause a deep injury. This type of injury is often associated with ACL injuries. Medial collateral and anterior cruciate ligament tears are most frequently seen in very active people, with ligament injuries accounting for 40% of all knee injuries for those engaged in sports. Acute MCL injuries alone are usually treated with non-operative care.[53]

F. Osteochondral Autograft/Allograft Transplantation

Osteochondral grafting procedures are done to repair a damaged articular surface with the goal of reducing pain and improving function of the knee joint. Two techniques may be used: autograft (where the graft comes from the patient's own tissue) and allograft (where the graft is harvested from another source). Both procedures require that the knee be stable and have normal or correctable alignment (before or during surgery).[54] Osteochondral Autograft (OAT) and Allograft Transplantation are covered surgical procedures for injured workers. Studies suggest there is no significant difference in outcome improvement between autografts and allografts although the indications for the procedures differ.[55]

Osteochondral autograft transfer (OAT) and mosaicplasty

OAT is an arthroscopic surgery where cylinders or "plugs" of healthy cartilage are harvested from a non-weight bearing location in the same joint and press-fit into same length holes prepared on the damaged

cartilage lesion. When multiple plugs are transferred into the same region it is called a mosaicplasty. The goal is to restore bone contour and the articular surface. This surgery is indicated for single, full thickness articular cartilage defects.[53]

Ideal candidates for OAT therapy are young active individuals who want to delay or prevent a total knee replacement. Recovery typically consists of 6 weeks non weight bearing followed with 2-4 weeks of toe-touch weight bearing. Passive and active ranges of motion are encouraged.

Allograft Cartilage Transplantation

Allograft transplantation is an open surgical grafting procedure where cartilage and bone, procured from a cadaver, is inserted into a prepared area of drilled bone. This surgery is indicated for patients with large, full thickness chondral or osteochondral defects where other interventions like microfracture, OAT and ACI are inadequate due to lesion size.[56] This procedure is suitable for the revision of failed cartilage repair strategies.[57]

Higher rates of successful allograft transplantation are observed in younger patients, unipolar lesions, normal or corrected alignment, and defects that are treated within 12 months of symptom onset.[56] At a five year follow up, 86% of patients report a high satisfaction score and a low, 2.4% short term complication rate.[58] Studies indicate worse results in patients with increased age.[59]

Recovery typically consists of 6 weeks toe touch in a range of motion brace. A return to low impact activities is possible 4-6 months after surgery when full range of motion returns with minimal effusion.

G. Arthroplasty

Uni-compartmental Arthroplasty

Uni-compartmental Knee Arthroplasty (UKA) is a partial knee replacement. The goal is reducing pain related to end-stage osteoarthritis (OA) when it is predominantly confined to a single compartment. This procedure is generally performed in the medial compartment and less often in the lateral compartment. Literature suggests an ACL deficient knee that is unstable is a contraindication to a UKA.[60] Any existing varus or valgus deformity should be corrected as close to neutral as possible.[61] Advantages to the procedure include [62]:

- Preservation of uninvolved tissue and bone
- Reduced operative time and easier recovery than total knee replacement
- Reduced blood loss during surgery
- Improved postoperative range of motion
- Increased patient satisfaction

UKA is a covered procedure for end stage osteoarthritis in only one compartment. Subjective examination should demonstrate pain that limits activities of daily living and interferes with the ability to work, limits ambulation, or pain that interferes with sleep.

To qualify for a UKA the following must be present:

1. Angular deformity of less than 15 degrees that is passively correctable
2. Range of motion arc greater than 90 degrees with less than 5 degrees flexion contracture
3. Weight bearing x-rays showing a KL score of 3 or 4 in only one compartment
4. BMI less than 35

Evidence strongly suggests that, in general, the risk of post-op infection and surgical complications increase as BMI increases.[63-67] This guideline recommends a preoperative BMI less than 35 as an appropriate cutoff for surgical consideration. Additionally, consideration should be given to the age of the patient, as evidence suggests that an age of < 60 is a relative contraindication for a UKA.[62, 68]

Major surgical considerations for risk or harm include correction of malalignment prior to or during surgery. Without correction, abnormal wear can occur on the prosthesis or the opposite compartment, likely leading to failure.[59] This operation restores ligament tension to normal, enabling the alignment and function to be returned to pre-disease state. Therefore, the absence of the anterior cruciate ligament is a contraindication; the ACL makes the combined rolling and sliding at the meniscal femoral and meniscal tibial interfaces possible, which may yield near-normal joint kinematics and mechanics.[69]

Total Arthroplasty

Total Knee Arthroplasty (TKA) is replacement of the distal ends of the femoral condyles and proximal tibia with prosthetic components. The patellofemoral articular surface may or may not be replaced. More than 97% of TKAs are performed for osteoarthritis (OA), with over 450,000 TKAs done in the USA in 2004.[70, 71] TKA is well accepted as a reliable and suitable surgical procedure to return patients experiencing end-stage OA to a higher level of function and improved health-related quality of life.

TKA is indicated for patients who present with pain that limits their mobility, activities of daily living, work, ambulation, or sleep. The degree of disability should be evaluated using a validated functional assessment tool, along with the patient self-reporting a loss of ability to fully function. Unless highly disabling OA is evident at the time the patient first seeks medical attention, a trial of non-operative therapy is appropriate.

TKA is a covered procedure when the following objective criteria are met:

1. Physical examination demonstrates a decreased range of motion or knee effusion
2. Weight-bearing x-rays demonstrate a KL score of 3 or 4 in one or more compartments
3. BMI less than 40

There is strong evidence of an association between increased BMI and increased risk of surgical complications from TKA such as infection, need for surgical revision, and inferior long term outcomes compared to patients with a lower BMI.[72] This guideline recommends a preoperative BMI below 40 as an appropriate cutoff for surgical consideration based on the best available clinical evidence.

Replacing the entire knee joint is a major undertaking and can be a difficult experience; and despite the majority of patients reporting profound improvements in physical activity after surgery, most do not reach the same physical activity level as their peers with healthy knees. Postoperative activity level is

influenced by the level individuals had prior to surgery, so the more fit a person is before a TKA, the better their chances of having a good result afterward.[73] The Bree Collaborative (see Appendix B) has issued a set of minimal standards for evaluating an individual's "Fitness for Surgery," and it is strongly recommended that providers follow these. This can help ensure a patient's safety and commitment to actively participate in their recovery and return to function.

VI. Rehabilitation, and Return to Work

Recovery and return to work is expected after most occupational knee injuries. Length of disability or time off work depends on many factors such as the severity of the injury, type of treatment, and comorbid conditions. Ergonomic interventions such as work station and/or work flow modification appear to be helpful in sustaining return to work. In general, mild conditions such as knee sprain and bursitis may not require any time off work. Someone having an arthroscopic meniscectomy is expected to return to work in 2-6 weeks. Reconstructive surgery of the ACL requires a longer rehabilitation time, as much as 4-6 months, although return to modified duties may be possible within 6 weeks. For total knee arthroplasty, time to return to work can be as short as 6 weeks, although patients who do very heavy physical work may not be able to go back to those jobs, or at the least will require modified duties.

VII. Appendices

Appendix A - Assessment Tools

An example of a widely used knee impairment scoring tool is the Knee injury and Osteoarthritis Outcome Score (KOOS). The scale can be used for acute and long term care management. Meaningful functional improvement is an increase of 8-23 points in all subscale scores of the KOOS.[74] Detailed information about the KOOS scale is freely available https://www.sralab.org/rehabilitation-measures/knee-injury-and-osteoarthritis-outcome-score.

The KOOS was designed to measure five specific patient centered outcomes:

1. Pain frequency and severity
2. Other symptoms: edema, decreased ROM and mechanical symptoms
3. Difficulty experienced with daily activities
4. Difficulty experienced with sport or recreational activities
5. Knee related quality of life, mental and social aspects [75]

Additional functional assessment tools that are widely used and validated for the knee can be found at http://www.orthopaedicscores.com/

Validated assessment tools for measuring clinically meaningful improvement in pain and function along with responsible opioid prescribing recommendations can be accessed at www.agencymeddirectors.wa.gov

PEG Assessment Scale - A tool to assess pain intensity, interference with enjoyment of life, and interference with general activity.[76]

1. What number best describes your pain on average in the past week:

0 1 2 3 4 5 6 7 8 9 10

No pain — Pain as bad as you can imagine

2. What number best describes how, during the past week, pain has interfered with your enjoyment of life?

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

3. What number best describes how, during the past week, pain has interfered with your general activity?

0 1 2 3 4 5 6 7 8 9 10

Does not interfere — Completely interferes

Question One:

1. What number best describes your pain on average in the past week, on a scale from 0 to 10 where 0 is "no pain" and 10 is "pain as bad as you can imagine"? [0 to 10]

Questions Two and Three:

These ask you to describe how, during the past week, pain has interfered with your life on a "0 to 10" scale, where 0 is "does not interfere at all" and 10 is "completely interferes."

2. What number best describes how, during the past week, pain has interfered with your enjoyment of life? [0 to 10]

3. What number best describes how, during the past week, pain has interfered with your general activity? [0 to 10]

Scoring: The PEG score is the average of the 3 individual item scores. For clinical use, round to the nearest whole number.

Krebs EE, Lorenz KA, Bair MJ, Damush TA, Wu J, Sutherland JM, Asch SM, Kroenke K. Development and initial validation of the PEG, a 3-item scale assessing pain intensity and interference. *Journal of General Internal Medicine*. 2009 Jun;24:733-738.

Graded Chronic Pain Scale - A tool to assess pain intensity and pain interference.[77]

Graded chronic pain scale: a two-item tool to assess pain intensity and pain interference

In the last month, on average, how would you rate your pain? Use a scale from 0 to 10, where 0 is "no pain" and 10 is "pain as bad as could be"? [*That is, your usual pain at times you were in pain.*]

No pain										**Pain as bad as could be**
0	1	2	3	4	5	6	7	8	9	10

In the last month, how much has pain 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."

No interference										**Unable to carry on any activities**
0	1	2	3	4	5	6	7	8	9	10

Interpretation of the Two Item Graded Chronic Pain Scale – This two item version of the Graded Chronic Pain Scale is intended for brief and simple assessment of pain severity in primary care settings. Based on prior research, the interpretation of scores on these items is as follows:

Pain Rating Item	Mild	Moderate	Severe
Average/Usual Pain Intensity	1–4	5–6	7–10
Pain-related interference with activities	1–3	4–6	7–10

Although pain intensity and pain-related interference with activities are highly correlated and tend to change together, it is recommended that change over time be tracked for pain intensity and pain-related interference with activities separately when using these two items.

For an individual patient, a reduction in pain intensity and improvement in pain-related interference with activities of two points is considered moderate but clinically significant improvement.

Similar pain ratings have been widely used in the Brief Pain Inventory, the Multidimensional Pain Inventory, and the Pain Severity Scale of the SF-12.

There is extensive research on the reliability, validity and responsiveness to change of these pain severity ratings, which is summarized in the following reference:

Von Korff, M., *Assessment of chronic pain in epidemiological and health services research: Empirical bases and new directions*, in *Handbook of Pain Assessment Third Edition*, D.C. Turk and R. Melzack, Editors. 2011, Guilford Press: New York. p. 455-473.

Appendix B – The Bree Collaborative

In 2013, the Bree Collaborative (see sidebar) developed a set of recommendations for total knee replacement surgery that pertain to perioperative care. Their "Fitness for Surgery" recommendations are referenced in this guideline for a total knee arthroplasty because they establish minimal standards to ensure patients' safety and active participation in returning to function. This is consistent with L&I's mission to help injured workers heal and return to work.

Over time, these recommendations may be revisited and possibly revised, so be sure to visit the Bree Collaborative webpage for their most recent and complete descriptions.

What is the Bree Collaborative?

"In 2011, the Washington State Legislature established the Dr. Robert Bree Collaborative so that public and private health care stakeholders would have the opportunity to identify specific ways to improve health care quality, outcomes, and affordability in Washington State. These stakeholders are appointed by the Governor as Collaborative members and represent public health care purchasers for Washington State, private health care purchasers (employers and union trusts), health plans, physicians and other health care providers, hospitals, and quality improvement organizations." To learn more, visit http://www.breecollaborative.org/ .

Bree issues recommendations that are implemented in health plans administered by the Health Care Authority, which include those for Medicaid recipients, public employees, and others. Although Bree recommendations are not legally binding, RCW 41.05.013 requires state health care agencies to coordinate their purchasing, programs, and policies. By L&I endorsing Bree recommendations, there is greater consistency in the health care purchased for Washington citizens.

VIII. Acknowledgements

Acknowledgement and gratitude go to all those who contributed to this important guideline:

IIMAC Committee Members
Chris Howe MD – Chair, Valley Medical Center
Andrew Friedman MD, Virginia Mason Medical Center
Kirk Harmon MD, MultiCare
Dianna Chamblin MD, The Everett Clinic

Subcommittee Clinical Experts
Howard Chansky MD, University of Washington
David Belfie MD, Virginia Mason Medical Center
Christopher Standaert MD, University of Washington
Albert O. Gee MD, University of Washington

Consultants
Shari Fowler-Koorn RN, Qualis Health
Ken O'Bara MD, Qualis Health
John Sparks MD, Qualis Health
Margaret Baker MD, Qualis Health

Labor and Industries Staff
Gary M. Franklin MD MPH, Medical Director
Lee Glass MD JD, Associate Medical Director
Nicholas Reul MD MPH, Associate Medical Director
Hal Stockbridge MD MPH, Associate Medical Director
Zachary Gray BS MPH, Epidemiologist
Simone P. Javaher BSN MPA, Clinical Manager of Health Policy
Bintu Marong-Ceesay MS, Epidemiologist
Teresa Cooper BSN, Occupational Nurse Consultant
Angela Jones BSN, Occupational Nurse Consultant

IX. References

1. Kellgren, J. and J. Lawrence, *Radiological assessment of osteo-arthrosis.* Annals of the rheumatic diseases, 1957. **16**(4): p. 494.
2. Outerbridge, R., *The etiology of chondromalacia patellae.* J Bone Joint Surg Br, 1961. **43**.
3. Outerbridge, R., *Further studies on the etiology of chondromalacia patellae.* Journal of Bone & Joint Surgery, British Volume, 1964. **46**(2): p. 179-190.
4. Gage, B.E., et al., *Epidemiology of 6.6 million knee injuries presenting to United States emergency departments from 1999 through 2008.* Academic emergency medicine, 2012. **19**(4): p. 378-385.
5. Spector, J.T., M.D. Adams, and M.B. Silverstein, *Burden of work-related knee disorders in Washington State, 1999 to 2007.* Journal of occupational and environmental medicine/American College of Occupational and Environmental Medicine, 2011. **53**(5): p. 537.
6. Bureau of Labor Statistics, *Number of nonfatal occupational injuries and illnesses requiring days away from work, 2014*, U.D.o. Labor, Editor. 2015: Washington, DC.
7. Calmbach, W.L. and M. Hutchens, *Evaluation of patients presenting with knee pain: Part I. History, physical examination, radiographs, and laboratory tests.* American family physician, 2003. **68**(5): p. 907-912.
8. Woolf, A.D. and B. Pfleger, *Burden of major musculoskeletal conditions.* Bulletin of the World Health Organization, 2003. **81**(9): p. 646-656.
9. Silverwood, V., et al., *Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis.* Osteoarthritis and Cartilage, 2015. **23**(4): p. 507-515.
10. Hubertsson, J., et al., *Risk of sick leave and disability pension in working-age women and men with knee osteoarthritis.* Annals of the rheumatic diseases, 2012: p. annrheumdis-2012-201472.
11. Blagojevic, M., et al., *Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis.* Osteoarthritis and cartilage, 2010. **18**(1): p. 24-33.
12. Richmond, S.A., et al., *Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review.* journal of orthopaedic & sports physical therapy, 2013. **43**(8): p. 515-B19.
13. Toivanen, A.T., et al., *Obesity, physically demanding work and traumatic knee injury are major risk factors for knee osteoarthritis--a population-based study with a follow-up of 22 years.* Rheumatology (Oxford), 2010. **49**(2): p. 308-14.
14. Washington State Agency Medical Director's Group, *Interagency Guideline on Prescribing Opioids for Pain*. 2015: http://www.agencymeddirectors.wa.gov/Files/2015AMDGOpioidGuideline.pdf.
15. Gravlee, J.R. and D.J. Van Durme, *Braces and splints for musculoskeletal conditions.* Am Fam Physician, 2007. **75**(3): p. 342-8.
16. Jüni, P., et al., *Intra-articular corticosteroid for knee osteoarthritis.* The Cochrane database of systematic reviews, 2015. **10**: p. CD005328.
17. Møller, A.M., et al., *Effect of preoperative smoking intervention on postoperative complications: a randomised clinical trial.* The Lancet, 2002. **359**(9301): p. 114-117.
18. Møller, A.M., et al., *Effect of smoking on early complications after elective orthopaedic surgery.* Journal of Bone & Joint Surgery, British Volume, 2003. **85**(2): p. 178-181.
19. Shah, M.R., et al., *Articular cartilage restoration of the knee.* BULLETIN-HOSPITAL FOR JOINT DISEASES NEW YORK, 2007. **65**(1): p. 51.

20. Steinwachs, M., T. Guggi, and P. Kreuz, *Marrow stimulation techniques.* Injury, 2008. **39**(1): p. 26-31.
21. Kalson, N.S., P.D. Gikas, and T.W. Briggs, *Current strategies for knee cartilage repair.* International journal of clinical practice, 2010. **64**(10): p. 1444-1452.
22. Steadman, J.R., et al., *Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up.* Arthroscopy: The Journal of Arthroscopic & Related Surgery, 2003. **19**(5): p. 477-484.
23. Minas, T., et al., *Increased failure rate of autologous chondrocyte implantation after previous treatment with marrow stimulation techniques.* The American journal of sports medicine, 2009. **37**(5): p. 902-908.
24. Yen, Y.-M., et al., *Treatment of osteoarthritis of the knee with microfracture and rehabilitation.* Medicine & Science in Sports & Exercise, 2008. **40**(2): p. 200.
25. Miller, B.S., et al., *Patient satisfaction and outcome after microfracture of the degenerative knee.* The journal of knee surgery, 2004. **17**(1): p. 13-17.
26. Pestka, J.M., et al., *Clinical outcome of autologous chondrocyte implantation for failed microfracture treatment of full-thickness cartilage defects of the knee joint.* The American journal of sports medicine, 2012. **40**(2): p. 325-331.
27. Jungmann, P.M., et al., *Autologous Chondrocyte Implantation for Treatment of Cartilage Defects of the Knee What Predicts the Need for Reintervention?* The American journal of sports medicine, 2012. **40**(1): p. 58-67.
28. Mundi, R., et al., *Cartilage Restoration of the Knee A Systematic Review and Meta-Analysis of Level 1 Studies.* The American journal of sports medicine, 2015: p. 0363546515589167.
29. Smith, T.O., et al., *Surgical versus non-surgical interventions for treating patellar dislocation.* Cochrane Database Syst Rev, 2015. **2**.
30. Maffulli, N., et al., *Meniscal tears.* Open Access J Sports Med, 2010. **1**: p. 45-54.
31. Thorlund, J.B., et al., *Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms.* bmj, 2015. **350**: p. h2747.
32. Englund, M., E.M. Roos, and L. Lohmander, *Impact of type of meniscal tear on radiographic and symptomatic knee osteoarthritis: A sixteen-year followup of meniscectomy with matched controls.* Arthritis & Rheumatism, 2003. **48**(8): p. 2178-2187.
33. Bhattacharyya, T., et al., *The clinical importance of meniscal tears demonstrated by magnetic resonance imaging in osteoarthritis of the knee*.* The Journal of Bone & Joint Surgery, 2003. **85**(1): p. 4-9.
34. Hunter, D., et al., *The association of meniscal pathologic changes with cartilage loss in symptomatic knee osteoarthritis.* Arthritis & Rheumatism, 2006. **54**(3): p. 795-801.
35. Englund, M., et al., *Incidental meniscal findings on knee MRI in middle-aged and elderly persons.* N Engl J Med, 2008. **359**(11): p. 1108-15.
36. Zanetti, M., et al., *Patients with suspected meniscal tears: prevalence of abnormalities seen on MRI of 100 symptomatic and 100 contralateral asymptomatic knees.* AJR Am J Roentgenol, 2003. **181**(3): p. 635-41.
37. Moseley, J.B., et al., *A controlled trial of arthroscopic surgery for osteoarthritis of the knee.* New England Journal of Medicine, 2002. **347**(2): p. 81-88.
38. Kirkley, A., et al., *A randomized trial of arthroscopic surgery for osteoarthritis of the knee.* New England Journal of Medicine, 2008. **359**(11): p. 1097-1107.

39. Khan, M., et al., *Arthroscopic surgery for degenerative tears of the meniscus: a systematic review and meta-analysis.* Canadian Medical Association Journal, 2014. **186**(14): p. 1057-1064.
40. Sihvonen, R., et al., *Arthroscopic partial meniscectomy versus sham surgery for a degenerative meniscal tear.* N Engl J Med, 2013. **369**(26): p. 2515-24.
41. Cvetanovich, G.L., et al., *Trends in Meniscal Allograft Transplantation in the United States, 2007 to 2011.* Arthroscopy: The Journal of Arthroscopic & Related Surgery, 2015. **31**(6): p. 1123-1127.
42. Frank, R.M. and B.J. Cole, *Meniscus transplantation.* Current reviews in musculoskeletal medicine, 2015. **8**(4): p. 443-450.
43. Noyes, F.R. and S.D. Barber-Westin, *Meniscal Transplantation in Symptomatic Patients Under Fifty Years of Age.* J Bone Joint Surg Am, 2015. **97**(15): p. 1209-1219.
44. Samitier, G., et al., *Meniscal allograft transplantation. Part 2: systematic review of transplant timing, outcomes, return to competition, associated procedures, and prevention of osteoarthritis.* Knee Surgery, Sports Traumatology, Arthroscopy, 2015. **23**(1): p. 323-333.
45. Rosso, F., et al., *Meniscal Allograft Transplantation: A Systematic Review.* The American Journal of Sports Medicine, 2015. **43**(4): p. 998-1007.
46. LaBella, C.R., et al., *Anterior cruciate ligament injuries: diagnosis, treatment, and prevention.* Pediatrics, 2014. **133**(5): p. e1437-e1450.
47. Bogunovic, L. and M.J. Matava, *Operative and nonoperative treatment options for ACL tears in the adult patient: a conceptual review.* Phys Sportsmed, 2013. **41**(4): p. 33-40.
48. Fowler, P.J. and W.D. Regan, *The patient with symptomatic chronic anterior cruciate ligament insufficiency Results of minimal arthroscopic surgery and rehabilitation.* The American journal of sports medicine, 1987. **15**(4): p. 321-325.
49. Yoon, K.H., J.H. Yoo, and K.I. Kim, *Bone contusion and associated meniscal and medial collateral ligament injury in patients with anterior cruciate ligament rupture.* J Bone Joint Surg Am, 2011. **93**(16): p. 1510-8.
50. Kilcoyne, K.G., et al., *Epidemiology of meniscal injury associated with ACL tears in young athletes.* Orthopedics, 2012. **35**(3): p. 208-12.
51. Hawkins, R.J., G.W. Misamore, and T.R. Merritt, *Followup of the acute nonoperated isolated anterior cruciate ligament tear.* The American journal of sports medicine, 1986. **14**(3): p. 205-210.
52. Noyes, F., et al., *The symptomatic anterior cruciate-deficient knee. Part I: the long-term functional disability in athletically active individuals.* The Journal of bone and joint surgery. American volume, 1983. **65**(2): p. 154-162.
53. Wiesel, S.W., *Operative techniques in orthopaedic surgery*. 2012: Lippincott Williams & Wilkins.
54. Beaver, R., et al., *Fresh osteochondral allografts for post-traumatic defects in the knee. A survivorship analysis.* Journal of Bone & Joint Surgery, British Volume, 1992. **74-B**(1): p. 105-110.
55. Pearsall, A., S.G. Madanagopal, and J.T. Hughey, *Osteoarticular autograft and allograft transplantation of the knee: 3 year follow-up.* Orthopedics, 2008. **31**(1): p. 73.
56. Chui, K., L. Jeys, and M. Snow, *Knee salvage procedures: The indications, techniques and outcomes of large osteochondral allografts.* World Journal of Orthopedics, 2015. **6**(3): p. 340-350.
57. Chahal, J., et al., *Managing the patient with failed cartilage restoration.* Sports medicine and arthroscopy review, 2013. **21**(2): p. 62-68.
58. Chahal, J., et al., *Outcomes of osteochondral allograft transplantation in the knee.* Arthroscopy: The Journal of Arthroscopic & Related Surgery, 2013. **29**(3): p. 575-588.

59. Ghazavi, M., et al., *Fresh osteochondral allografts for post-traumatic osteochondral defects of the knee.* Journal of Bone & Joint Surgery, British Volume, 1997. **79**(6): p. 1008-1013.
60. Engh, G.A. and D. Ammeen, *Is an intact anterior cruciate ligament needed in order to have a well-functioning unicondylar knee replacement?* Clinical orthopaedics and related research, 2004. **428**: p. 170-173.
61. Berger, R.A. and A.J. Tria, *Minimally Invasive Surgery for Unicondylar Knee Arthroplasty: The Intramedullary Technique*, in *Minimally Invasive Surgery in Orthopedics*. 2010, Springer. p. 239-246.
62. Plate, J., et al., *Unicompartmental Knee Arthroplasty: Past, Present, Future.* Reconstructive Review, 2012. **2**(2).
63. Tjeertes, E.E., et al., *Obesity–a risk factor for postoperative complications in general surgery?* BMC anesthesiology, 2015. **15**(1): p. 1.
64. Küpper, S., et al., *Increased health services use by severely obese patients undergoing emergency surgery: a retrospective cohort study.* Canadian Journal of Surgery, 2015. **58**(1): p. 41.
65. Cantürk, Z., et al., *Nosocomial infections and obesity in surgical patients.* Obesity research, 2003. **11**(6): p. 769-775.
66. Wigfield, C.H., et al., *Is extreme obesity a risk factor for cardiac surgery? An analysis of patients with a BMI≥ 40.* European journal of cardio-thoracic surgery, 2006. **29**(4): p. 434-440.
67. Berend, K.R., et al., *Early failure of minimally invasive unicompartmental knee arthroplasty is associated with obesity.* Clinical orthopaedics and related research, 2005. **440**: p. 60-66.
68. Kozinn, S.C., C. Marx, and R.D. Scott, *Unicompartmental knee arthroplasty: a 4.5–6-year follow-up study with a metal-backed tibial component.* The Journal of arthroplasty, 1989. **4**: p. S1-S9.
69. Goodfellow, J., et al., *The Oxford Knee for unicompartmental osteoarthritis. The first 103 cases.* Journal of Bone & Joint Surgery, British Volume, 1988. **70**(5): p. 692-701.
70. Weinstein, A.M., et al., *Estimating the burden of total knee replacement in the United States.* J Bone Joint Surg Am, 2013. **95**(5): p. 385-392.
71. American Academy of Orthopaedic Surgeons, *United States Bone and Joint Decade: The burden of musculoskeletal diseases in the United States.* Rosemont, IL: , 2008.
72. Kerkhoffs, G.M., et al., *The influence of obesity on the complication rate and outcome of total knee arthroplasty.* The Journal of Bone & Joint Surgery, 2012. **94**(20): p. 1839-1844.
73. Brandes, M., et al., *Changes in physical activity and health-related quality of life during the first year after total knee arthroplasty.* Arthritis care & research, 2011. **63**(3): p. 328-334.
74. Roos, E.M. and S. Toksvig-Larsen, *Knee injury and Osteoarthritis Outcome Score (KOOS)-validation and comparison to the WOMAC in total knee replacement.* Health Qual Life Outcomes, 2003. **1**(1): p. 17.
75. Collins, N.J., et al., *Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS).* Arthritis care & research, 2011. **63**(S11): p. S208-S228.
76. Krebs, E.E., et al., *Development and initial validation of the PEG, a three-item scale assessing pain intensity and interference.* Journal of general internal medicine, 2009. **24**(6): p. 733-738.
77. Turk, D.C. and R. Melzack, *Handbook of pain assessment*. 2011: Guilford Press.