BRIGHAM AND WOMEN'S HOSPITAL

Department of Rehabilitation Services
Physical Therapy

Standard of Care: Total Knee Arthroplasty

ICD 9 Codes:

170, 171, 213, 215, 714, 715, 716, 717, 718, 719, 729, 730, 731, 732, 733, 836

Case Type / Diagnosis:

Practice Patterns:
4H: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Joint Arthroplasty
4D: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction
4E: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Localized Inflammation

This Standard of Care (SOC) serves as a guide for clinical decision making by Brigham and Women's Hospital (BWH) inpatient and outpatient physical therapy (PT) services. It applies to patients following:

- Total knee arthroplasty (TKA)
- Partial knee arthroplasty (medial, lateral, patellofemoral)
- Bicompartmental knee arthroplasty (medial and patellofemoral, lateral and patellofemoral)
- Revision TKA

The disorders under consideration for this SOC include, but are not limited to: osteoarthritis (OA), rheumatoid arthritis (RA), avascular necrosis, tumors/osteosarcoma, Ehlers-Danlos syndrome, and traumatic joint injuries.

Indications for Treatment:

TKA has become the gold standard for patients with disabling end-stage knee OA who have exhausted conservative management. It is the most frequently performed orthopedic procedure in the United States, with over 600,000 TKAs performed in 2010.[1,2] By 2030, that number is expected to rise to over 3 million.[2] In a recent meta-analysis of largely osteoarthritic patients, TKA was found to be associated with substantial functional improvements and pain relief.[3] In

patients with RA[4] and avascular necrosis[5], TKA has also resulted in recovery of function compared to the presurgical state.

TKA improves knee joint function by replacing the damaged tissues with a prosthetic implant and realigning soft tissues to correct structural and functional deficits. The basic goals of PT management following TKA are the same for all patients. These goals are:

- Alleviation of pain
- Improvement in function and quality of life
- Improvement in range of motion (ROM)
- Recovery of muscle balance and strength

The recovery time and intensity of PT treatments may be adjusted based on the severity of the underlying pathology, surgical aspects, and other patient-related factors.

Total Knee Arthroplasty Design

Numerous options for prostheses are available in the United States. Contemporary implant design options include: cruciate-retaining vs. posterior-stabilizing, mobile-bearing vs. fixed-bearing tibial components, highly cross-linked vs. traditional polyethylene inserts, and cemented vs. cementless components. At BWH, surgeons consider patient-specific needs to determine the best type of implant, however in general, most use cruciate-retaining fixed-bearing components.

At BWH, the most commonly used prostheses are of the Press-Fit Condylar (PFC) line from DePuy Orthopaedics, Inc. The first PFC Total Knee System was designed and implanted by Dr. Thomas Thornhill and Dr. Richard Scott in 1984.[6] It was developed to improve ROM and stability compared to other cruciate-retaining fixed-bearing designs.[7]

In the mid-1990s, Dr. Thornhill and Dr. Scott advanced their design as the PFC Sigma Total Knee System which included a mobile-bearing rotating platform.[7,8] In this design, posterior cruciate ligament (PCL)-preserving or -substituting tibial inserts can rotate about a central post. This allows high conformity between metal and plastic, minimizing stress and potential for wear.

In 2010, DePuy introduced the PFC Sigma CR150 High Flex Knee System which accommodates up to 150 degrees of knee flexion. Higher degrees of knee flexion are required for activities such as deep kneeling and squatting. These activities have been reported to be important functions to regain following TKA.[9] This cruciate-retaining prosthesis has extended posterior condyles to improve conformity and minimize contact stress and wear. It is offered with fixed- or mobile-bearing designs.[10] As alluded to above, surgeons have a myriad of options regarding implant brands and their components. Great debate over which options are best continues to evolve.

Surgical Approach for TKA

Standard TKA is performed with the patient supine and the knee exposed in flexion. A 13-15 cm longitudinal skin incision is made, extending from a few centimeters above the patella to just

below the tibial tubercle. Different approaches are used to perform the arthrotomy. Some common approaches are the medial parapatellar, midvastus, and subvastus arthrotomies. Once the incision into the joint has been made, the soft tissue around the joint is retracted to expose the bone. Fat pads, anterior cruciate ligament, and menisci are resected, and the bone is prepared by performing femoral, tibial, and patellar osteotomies. The implant components are then inserted into the knee joint. The surgeon checks knee stability and soft tissue balance by bringing the knee through its ROM, assessing patellar tracking and medial/lateral gaps in flexion and extension, and applying varus and valgus stress in extension. Soft tissue releases are performed as needed. The wound is then closed - capsule, subcuticular layer, and cuticular layer.

PCL Retention vs. Substitution

Different schools of thought exist regarding the benefit of PCL retention vs. substitution. Both approaches have been shown to have excellent clinical results. PCL-retaining TKA has the advantage of maintaining the proprioceptive and stabilizing function of the ligament, resulting in less force imparted on the tibial insert of the prosthesis. PCL-substituting design is proposed to be effective for patients with an ankylosed knee, severe flexion contracture, or chronic patellar dislocation.[8] Rehabilitation protocols are generally identical for both approaches.

Unicompartmental Arthroplasty

The evolution of unicompartmental knee arthroplasty (UKA) dates back to 1972 when they were used with 92% good to excellent results in 2 to 6 year follow-ups.[11] More recent studies have shown that the 10- to 15-year implant survival rate is 93-96% with good to excellent results in more than 90% of patients.[12] Proposed advantages of UKA over TKA are: preservation of bone stock, increased knee ROM, better kinematics, decreased blood loss, and faster recovery.[13] However, careful patient selection is important. Typically, UKA is not indicated for patients with: compromised ligaments, arthritic changes greater than Grade I in the opposite compartment, inflammatory synovitis, poor knee flexion, morbid obesity, varus deformity > 10 degrees, or valgus deformity > 15 degrees. Surgical approach can be a traditional medial parapatellar arthrotomy or minimally invasive.

Custom Knee Arthroplasty

During a traditional TKA, surgeons select components from the manufacturer's standard sizes which best match the patient's anatomy and alignment. TKA systems are typically available in 8 -10 femoral/tibial sizes and female and male versions. Due to advances in computer technology beginning in 1995, most major manufacturers now offer some variation of custom-fit prostheses.[14]

At BWH, Dr. Tom Minas and Dr. Wolfgang Fitz are scientific advisors and developers of the ConforMIS line of implants which includes both patient-matched implant components and a single-use instrumentation system. ConforMIS uses CT scans of the patient's lower extremity to map the topography of the knee joint and correct axial alignment to neutral as needed. Then, the imaging is used to create components which are sized and shaped to conform to the patient's

individual joint lines, biomechanical axes, and anatomical axes. The proposed benefits include: precise alignment, full coverage of weight bearing surfaces, minimized bone resection, cruciate retention, and improved operating room efficiency with minimal instrumentation.[14,15]

Surgical approach for a ConforMIS custom TKA is similar to the technique for a traditional TKA, as it includes a midline incision and parapatellar arthrotomy. This procedure tends to be less invasive because of minimized bone resection. There is only one bone resection required on the femur, the posterior condyle. Otherwise, only cartilage posterior to the sulcus terminalis is removed on the femur since the implant is designed to be positioned on subchondral bone. For the tibial plateau, cartilage is removed, but only enough bone is resected to balance the knee. ConforMIS offers the iTotal for TKA, iDuo for bicompartmental knee arthroplasty, and iUni for UKA.

Patellofemoral Knee Arthroplasty

The prevalence of isolated patellofemoral arthritis is about 10% in the population over 40 years old.[16]Although TKA has been reported as a successful treatment option for this condition, younger patients often seek more conservative alternatives. Considering life expectancy, implant survivorship, and complications of TKA revision, patellofemoral knee arthroplasty (PFA) can be a reasonable option for the younger patient. Advantages of PFA relative to TKA are bone conservation, potential for shorter postoperative rehabilitation, and limited alterations to knee kinematics since the tibiofemoral articulation, ligaments, and menisci are preserved.[17] PFA can be performed via a traditional or minimally invasive approach.

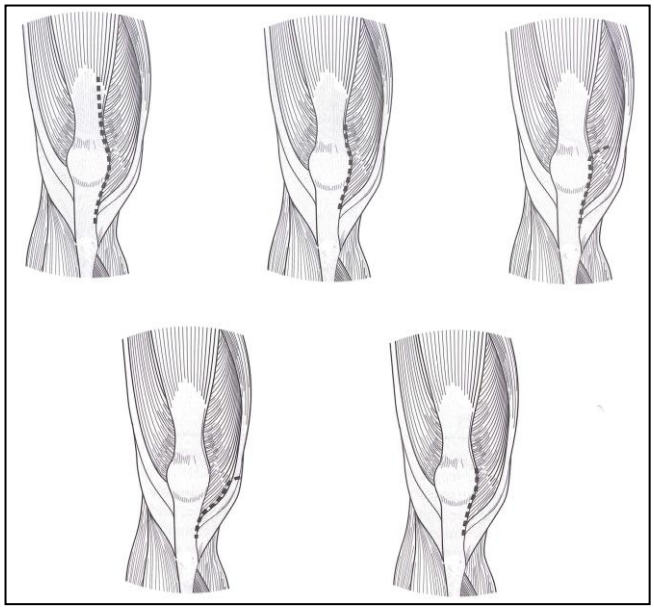
PFA was first developed over 30 years ago. Although initial failure rates were high, more careful patient selection has improved outcomes of this intervention. Indications for PFA include: younger population (<60), OA, post-traumatic arthritis, chondromalacia of the patella and/or trochlea, and patellofemoral dysplasia. The patient would have failed nonsurgical treatment or conservative procedures such as lateral release, arthroscopic debridement, or cartilage transplant. For a PFA, the patient must have intact ligaments and menisci.[16,17,18] Contraindications include: tibiofemoral arthritis, inflammatory arthropathies, obesity, patella infera, uncorrected patellofemoral instability, and fixed knee ROM loss.[18]

Improvements in PFA implant design have also contributed to better outcomes. Newer features include: onlay prosthetic design, wider trochlear surface, valgus tracking angle, and congruous articulation throughout the ROM. Broader surface and more proximal extension of the trochlear component prevents catching, snapping, and popping (i.e. - maltracking) during knee flexion.[17] In terms of early and mid-term complications, onlay style PFA has an incidence of maltracking of less than 1%. The most common reason for failure of PFA, resulting in revision to TKA, is development and progression of tibiofemoral arthritis. In general, studies report good to excellent results in most cases at short- and mid-term follow-up. However, they also report variable implant survivorship.[16,19] Walker reported that several studies have shown good to excellent survivorship of 66-100% at 3-17 years follow-up.[17]

Minimally Invasive TKA

Minimally invasive knee arthroplasty was first introduced in the early 1990s for UKA. Ten years later, surgeons began to use this technique for TKA. Typically, minimally invasive TKA is performed on patients with OA who have good bone quality, minimal varus/valgus deformities, and mild to moderate ROM limitations. It is usually not indicated in patients with: severe flexion ROM deficits, RA, osteoporosis, insulin-dependent diabetes, morbid obesity, chronic steroid use, need for increased joint exposure due to large muscle mass and/or bone dimensions, and/or severe patella baja.[12,20]

Among the minimally invasive approaches, the most commonly performed are the mini-midvastus and mini-subvastus arthrotomies (Figure 1[12]). During a minimally invasive approach, an anteromedial skin incision between 8.5 and 12 cm is made over the knee. Then, the medial arthrotomy is performed from the superior pole of the patella to the tibial tubercle. The vastus medialis oblique is identified and an oblique split of about 2 cm is made. The patella is retracted laterally to expose the joint.



An early study's results showed less intraoperative blood loss, shorter length of stay, increased ROM, and similar implant accuracy compared to standard TKA.[21] Other potential advantages include: minimal soft tissue injury with a smaller skin incision and arthrotomy, faster return of quadriceps function, preservation of most of the suprapatellar pouch, and avoidance of patellar eversion and anterior dislocation of the knee.[22]

Figure 1[12]: Arthrotomy Techniques.
Top Row Left to Right: traditional medial parapatellar, mini-parapatellar, mini-midvastus.
Bottom Row Left to Right: mini-subvastus, quadriceps-sparing.

Revision TKA

Revision TKA may be performed as a result of complications following primary TKA. The incidence of revision TKA is approximately 0.5 to 1.0% per year over the first 15 years after primary TKA.[8] Frequent causes of revision include:

- Aseptic loosening of components

- Mechanical failure (instability, malpositioning, over-/undersizing, impingement, polyethylene wear)
- Periprosthetic fracture
- Infection
- Arthrofibrosis[23,24]

Compared to primary TKA, revision TKA results in greater soft tissue injury and structural disruptions. Therefore, greater caution must be taken by physical therapists in both the evaluation and treatment of this patient population.[8]

Wound Closure

Wound closure is performed in a variety of ways depending on surgeon preference, patient age, quality of closure, and skin integrity. For all TKA wound closures, sutures are utilized for both capsular and subcuticular closure. However, for cuticular closure, surgeons may use staples, sutures, or Dermabond® tissue adhesive. Research investigating differences in cost, infection rate, length of stay, dehiscence, and drainage is inconclusive. Multiple variables in wound healing outcomes make it difficult to interpret existing research. Arguments for the use of staples include ease of application, decreased wound closure time, and lower cost. Arguments for tissue adhesives include ability to shower immediately and improved cosmesis, while the arguments for sutures include improved cosmesis. Wounds can be dressed with non-adhesive gauze, sterile pads, or Tegaderm™, and then covered with an elastic-type bandage or TED stocking from the foot up to the thigh.

Perioperative Medical Management

Anticoagulation Therapy:

Patients undergoing TKA are often started on anticoagulants (usually warfarin) the day before surgery, with an initial dose of 5 mg. After surgery, patients usually take warfarin, heparin, or aspirin with doses depending on age, weight, and medical status. Doses may be adjusted after surgery depending on the patient's hematologic values. At the time of discharge, patients will remain on anticoagulation therapy for about 4 weeks or until their postoperative appointment with their surgeon.

Pain Management:

Multimodal pain management is the use of various agents that act on different stages of the pain pathway (Figure 2[25]). This approach is utilized at BWH to control pain, minimize reliance on opioids, facilitate early mobilization, and improve patient satisfaction. Patients receive a preoperative pain medication cocktail with a single dose of medications such as acetaminophen and/or Celebrex, and gabapentin unless contraindicated.

The type of anesthesia chosen by the patient's medical team is based on the patient's current medical condition and history. Typically, the following types of anesthesia are used during TKA:

- General anesthesia with or without a continuous infusion or single-dose femoral nerve block
- Spinal anesthesia with or without a continuous infusion or single-dose femoral nerve block
- Epidural anesthesia
- Spinal anesthesia
- Intra-articular pain pump

If patients do not receive general anesthesia, they often receive a medication to induce sedation or amnesia prior to surgery, for example, Midazolam.

In addition, the patient may receive an intra-articular injection of analgesics into the tissue surrounding the incision before the wound is closed. The injection is a combination of ropivicaine, epinephrine, Ketorolac, and clonidine. Research on intra-articular injections is promising and suggests that they can be a low risk part of multimodal pain management.[26] In one study, patients who received an injection had lower visual analog scale (VAS) pain scores, higher satisfaction scores, and decreased opioid use.[25]

Compared to general anesthesia, neuraxial analgesia is associated with a decreased incidence of side effects such as pulmonary embolism, pulmonary compromise, cardiovascular accident, pneumonia, and renal failure. Proposed advantages include decreased transfusion requirements, morbidity, and mortality.[25,27] However, hypotension, urinary retention, and muscular weakness limiting immediate participation in rehabilitation are common side effects of neuraxial analgesia. Bupivacaine is the most common medication infused via the spinal, epidural, or femoral catheter.

Postoperatively, the pain medication regimen at BWH includes a variety of oral analgesics:

- *Opioids* (long-acting narcotics such as Oxycontin, short-acting narcotics such as oxycodone and Dilaudid). Multi-system side effects include: dizziness, sedation, constipation, nausea, vomiting, and respiratory depression.
- *Centrally-acting analgesics* (Tylenol)

Intravenous (IV) analgesics may also be used:

- Tramadol (*α-agonists*)
- Ketamine (*N-Methyl-D-Aspartate receptor antagonist*)
- Ketorolac (*NSAID*). This is typically used only in young healthy patients. Due to the potential for harmful gastrointestinal side effects such as peptic ulcers and bleeding, as well as decreased renal clearance, Ketorolac is contraindicated in patients over the age of 65, or those with creatinine levels > 1.5.
- If necessary, IV infusions of morphine or Dilaudid (*opioids*) are administered for additional breakthrough pain relief.

Finally, in addition to pharmaceuticals, cryotherapy is used to enhance pain management. Ice is placed on the knee and reapplied every 2 hours for the first 48-72 hours postoperatively.

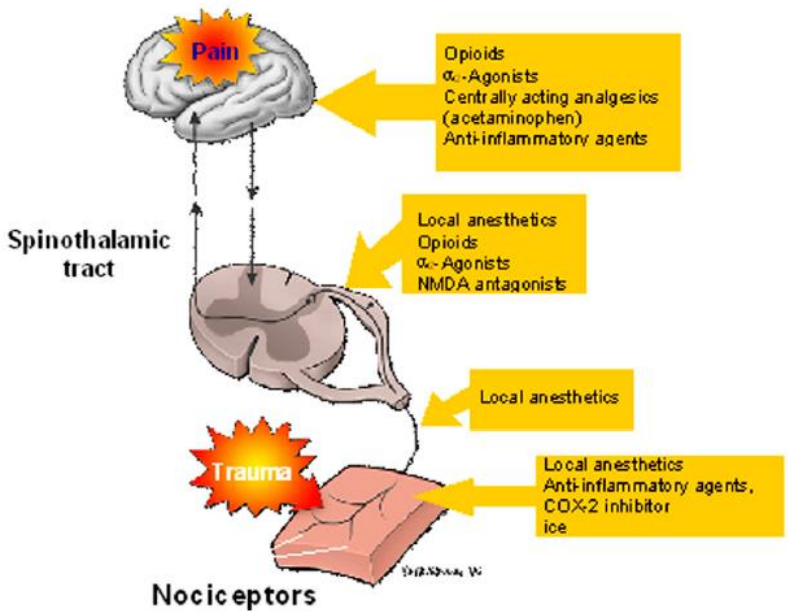


Figure 2[25]: Pain Pathways and Analgesics

Nursing Management:

Per the BWH clinical pathway, the following postoperative activity recommendations are ordered by the MD and are to be carried out by nursing staff:

- Positioning of the operative extremity: activate knee lock on bed control to be in full extension, do not place anything behind the operative knee, ankle on a rolled up towel when in bed
- Ice placed on the knee and reapplied every 2 hours for first 48-72 hours
- Patient mobilized to the edge of bed POD#0
- Foley discontinued at 6:00 am POD#1
- If used, epidural catheter or femoral nerve block catheter are discontinued at 6:00 am on POD#1 and the patients will transition to oral pain medication
- Patient out of bed three times a day beginning POD#1

Rehabilitation Management:

The typical length of stay at BWH for patients following TKA is two to three days (average 2.6 days from data collected in 2010) excluding the day of surgery.[28] The short length of stay is attributed to many factors including early mobilization and initiation of aggressive PT. The PT initial evaluation is completed on the morning of POD#1. Patients are seen two times per day while in-house to expedite their progress. The focus of PT management includes patient

education, gait and mobility training, and therapeutic exercises to increase ROM and motor control of the articular and periarticular structures. Aggressive postoperative PT has been shown to be effective in improving patient outcomes and shortening length of stay. If a patient remains in the hospital beyond the expected length of stay, frequency would be reassessed based on the patient's presentation. Knowledge of the basic concepts in TKA and the acute care hospital course will also guide clinical decision making in the outpatient PT setting.[29,30]

Contraindications / Precautions for Treatment:

Precautions typically included in the MD postoperative order set:

- WBAT to FWB
- Avoid torque or twisting forces across the knee joint
- Do not place anything behind the operative knee
- Knee control of the bed locked in full extension
- No exercises with weights or resistance
- Ankle on rolled up towel when in bed
- Ice to the knee, reapply every 2 hours for the first 48-72 hours

It is important to recognize signs and symptoms of early postoperative complications and consult with appropriate health care providers. The most common acute complications following TKA are:

- Blood loss requiring transfusion
- Deep vein thrombosis (DVT)
- Pulmonary embolism
- Excessive joint bleeding
- Superficial infection at the surgical site or joint infection
- Peroneal nerve palsy
- Compartment syndrome

During the first few days postoperatively, if a patient presents with:

- increased pain and excessive swelling,
- decreased muscle strength or sensation along a motor and/or sensory nerve distribution,
- or sudden shortness of breath, decreased oxygen saturation, and increased resting heart rate,

PT interventions must be stopped and the medical team consulted.

Late-onset complications following TKA may include:

- Periprosthetic joint infection
- Superficial wound infection/wound healing complications in the first few weeks after surgery. This typically occurs in patients who are on chronic steroids or chemotherapy,

have rheumatoid arthritis, obesity, diabetes, or are active smokers. The signs and symptoms include increased joint swelling, pain, and erythema.
- Persistent wound drainage. Most drainage will stop without intervention; however, if it persists more than 5-7 days, it may need surgical management.
- Large hematoma formation. If there is wound drainage due to the hematoma, patients may require surgical management. ROM exercises are typically stopped if wound drainage persists more than about a day and deferred until drainage resolves. Anticoagulation wound be continued, but the patient's hematologic lab values are monitored to ensure that they are within the therapeutic range.
- Patellar tendon avulsion, which is more common in younger active patients. It is recommended to stop active extension exercises and refer the patient to the surgeon.[8]

Additionally, postoperative laboratory workup, especially hematocrit and INR level, need to be monitored when evaluating the TKA patient in the acute care setting. Usually, a low hematocrit and/or a patient receiving a blood transfusion are not contraindications to PT unless the patient is hemodynamically unstable. If the patient presents with symptoms of anemia, PT treatment may be deferred or the intensity adjusted based on the physical therapist's clinical judgment. Regarding INR, levels should not exceed 3.0 as this places patients at risk for postoperative hemarthrosis. Generally, if the patient's INR is 3.0 or higher, appropriateness of treatment must be discussed with the medical team. Please refer to the General Surgery Standard of Care for further details on hematocrit and INR parameters.

Evaluation:

Medical History:

Review the pertinent past medical and surgical history documented in the medical record. Research has demonstrated age ≥70 and >1 comorbid condition affect patient outcomes following TKA. Some of the comorbid conditions that can affect outcomes are:

- Diabetes
- Hypertension
- Coronary artery disease/prior myocardial infarction
- Stroke with residual neurological deficits
- Cancer
- Chronic obstructive pulmonary disease
- Renal disease
- Obesity
- Peripheral vascular disease with claudication
- Asthma
- Parkinson's disease
- Systemic disorders
- Active psychiatric disorders

- Substance abuse
- Hemiplegia, paraplegia[31,32,33]

History of Present Illness:

Attention to preoperative ROM and strength will help the physical therapist to anticipate the patient's presentation during evaluation. Review relevant diagnostic imaging and other tests that lead to the current diagnosis and decision to pursue surgical management. Inquire about preoperative signs and symptoms like duration, severity, impact on function, and management via PT, medication, or other conservative means.

Social History:

Inquire about family/caregiver support, home environment, preoperative level of activity and function, occupation, hobbies, and use/possession of durable medical equipment (DME).

Medications:

Review pharmacological management of current medical conditions. See the Anticoagulation and Pain Management Sections above for common medications. Note the route of administration for medications (i.e. via epidural, IV, PO, etc.), as this will help guide and interpret the examination.

Examination

Observation:

On POD#1, patients will commonly have the following lines, tubes, and positioning devices:

- Nasal cannula for supplemental oxygen
- Telemetry/Cardiac and/or respiratory monitors reading continuous oxygen saturation and respiratory rate based on their comorbidities, use of narcotics, and if an epidural catheter is in place
- Thigh-high TED stockings for DVT prophylaxis
- Cryotherapy over the knee joint
- Knee-high Venodyne (compression) boots for DVT prophylaxis
- Towel roll under the ankle of the operative leg while in bed to maintain knee extension

Anthropometrics:

Body Mass Index (BMI) and/or height and weight of the patient should be included in the systems review to assist with guiding your examination.

ROM:

Obtain goniometric measurement of the operative joint and gross ROM assessment of the upper extremity and other lower extremity joints. Measurements should include active and passive

ROM of the operative knee in flexion and extension in sitting and supine. Documentation can also include description of the end-feel of the joint (i.e. firm, bony, empty/painful).

Strength:

Manual muscle testing (MMT) or gross assessment of the upper and lower extremity muscles is documented with focus on the operative extremity's quadriceps strength. The following are typically assessed:

- Ability to straight leg raise (SLR)
- Ability to perform a long arc quad
- Quality of an isometric quadriceps contraction via palpation and observation
    - Absent
    - Trace (contraction, but no movement of the joint)
    - Fair (minimal joint movement)
    - Good (able to feel pressure from the back of the knee and observable joint movement)

It is well established that quadriceps weakness and pain are among the first symptoms reported by patients with knee OA.[34] Preoperative weakness may be exacerbated in the acute postoperative period as pain and edema inhibit neuromuscular control. Preoperative reduced muscle mass and strength are not addressed by surgical interventions. Therefore, the treatment plan should address these impairments in order to achieve good outcomes.

Joint Mobility:

Assessment of tibiofemoral and patellofemoral joint play of the operative knee is often indicated in the late postoperative phase.

Posture /Alignment:

Assess and document any leg length discrepancy and posture in supine, sitting, or standing. Some examples are knee valgus or varus alignment and resting position of the lower extremities (neutral vs. rotated hip alignment).

Gait:

Gait analysis should include type of assistive device and gait pattern. Depending on the patient's presentation, other notable aspects may include: stride length, step length, cadence, speed, step width, type of initial contact (e.g. forefoot, foot flat), gross ankle/knee angles, hip rotation, and posture. Gait quality before TKA should also be documented if available from the medical record.

Pain:

Intensity and location of pain at rest, during treatment, and after treatment are documented at every inpatient encounter using the VAS or verbal report scale if possible. Mode of addressing pain such as premedication or application of cryotherapy should also be documented. Other qualitative details such as frequency, alleviating/aggravating factors, and descriptors of pain are also important.

Sensation:

Light touch sensation is assessed in bilateral lower extremities especially on POD#1-2 to ensure that there is complete resolution of any neuraxial anesthesia and no nerve damage. Noting the type of anesthesia used can help guide examination and expectations regarding potential deficits.

Proprioception:

Testing knee joint proprioception may be indicated depending on the postoperative phase, as this may impact balance. Lower extremity proprioception may also be tested at the great toe in the acute phase if you suspect impairments. For example, testing proprioception at the great toe of a patient with a history of diabetic neuropathy will help to anticipate standing balance deficits.

Balance:

Following TKA, it is important to assess and document both static and dynamic balance in the sitting and standing positions, including the use of upper extremity support. Particularly in the acute postoperative phase, standing balance will be impaired, while sitting balance may be impaired. In the subacute period, patients should be assessed for their ability to perform static and dynamic standing without assistive devices, as well as unilateral standing, as appropriate.

Vital Signs:

Blood pressure, heart rate, respiratory rate, and peripheral oxygen saturation should be assessed at rest, after position changes, and/or with activity especially if the patient is mobilizing for the first time postoperatively. Assessment and documentation of vital signs during patient encounters is based on the patient's symptomatology, particularly in the early postoperative days. As previously referenced, anemia and concomitant orthostatic hypotension are common early complications. They can cause symptoms such as lightheadedness or dizziness, shortness of breath, blurred vision, and nausea. The clinical signs include drop in blood pressure with positional changes, tachycardia, diaphoresis, and emesis. If this occurs, prompt communication with the medical team is indicated.

Endurance:

Examination of activity tolerance by utilizing the rate of perceived exertion (RPE) scale or a gross subjective and objective assessment of fatigue level should be documented. This should detail the amount of functional activities the patient was able to tolerate during the exam.

Integumentary:

Skin assessment includes the surgical incision, presence/absence of a dressing, discoloration/erythema, drainage, and ecchymosis. Soft tissue swelling of the thigh, knee, lower leg, and possibly foot/ankle commonly occurs immediately after TKA and in the subacute phase. The amount of lower extremity edema is documented by gross qualitative assessment, or via circumferential measurements of the knee as appropriate. Typical circumference measurements of the knee joint are taken at the mid patella (joint line), 15 cm above the superior border of the patella, and either at the tibial tubercle or 5 cm below the inferior border of the patella.

Communication, Affect, Mental Status/Cognition, Language, and Learning Style:

The patient's level of arousal, orientation, ability to follow commands, communicate/make needs known, and learning preferences are taken into account and documented in the examination.

Functional Outcomes:

The following functional tests and measures are used to assess functional capacity of TKA patients. They are primarily used during the home or outpatient phase of rehabilitation and rarely used in the acute care setting.

- Timed Get Up and Go (TUG)
- Six Minute Walk Test (6MWT)
- Stair Climbing Test (SCT)
- Lower Extremity Functional Scale (LEFS)
- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
- Short Form-36 (SF-36)
- Five-Repetition Sit-to-Stand Test (FRSTST)

The TUG has been found to be useful in detecting early improvements within the first three months following TKA. The 6MWT was originally conceived for a respiratory population, however has become a popular measure of lower extremity functional limitation for patients with OA progressing towards arthroplasty. The SCT has also been widely cited in the literature for patients following TKA. The LEFS may be helpful in tracking and documenting progress during the outpatient phase after TKA, as it has been shown to detect change similarly, or better, than the WOMAC in recent studies.[35] The SF-36 is a more general, but widely used, physical function scale in patients following TKA.[3] The FRSTST is practical and reliable option for measuring lower extremity strength with good to high test-retest reliability.[36]

Assessment:

Problem List

- Pain
- ROM
- Muscle performance (including strength, power, and endurance)
- Motor control
- Balance
- Gait
- Endurance
- Tissue integrity
- Edema
- Sensation

Particularly in the first few postoperative days, these impairments will result in decreased independence with bed mobility, transfers, ambulation, basic/instrumental activities of daily living (B/IADL), and participation in hobbies.

Prognosis:

Research on TKA outcomes uses various metrics for success: pain, ROM, strength, function scores, return to work/sport, and patient satisfaction. The degree to which patients reach the projected goals depends on the reason for the TKA, comorbidities, and postoperative complications. Furthermore, patients who have lower preoperative function may require more intensive PT intervention and longer recovery times as they are less likely to achieve functional outcomes similar to patients with better preoperative function.[37]

Pain
Eighty-five to 90% of patients with TKA report pain relief after surgery.[37] Callahan et al performed a systematic literature review and reported 75% of patients reported no pain and 20% of patients reported mild pain postoperatively at a mean follow-up of 4.1 years.[38]

ROM
Studies report that average knee flexion ROM after TKA ranges from 105 to 113 degrees.[39] Cho, Youm, and Park reported a mean maximal flexion of 131 degrees after a minimum of 3 year follow-up with the use of an implant designed to provide 150 degrees of flexion.[40]

Strength
Quadriceps atrophy of 5-20% at 1 month after TKA has been reported. At this time point, it has also been reported that quadriceps torque is less than 50% of its preoperative value. However, strength increases steadily until a plateau around 6-12 months postoperatively with an end result of 10-20% improvement in isometric quadriceps strength compared to preoperative levels. Although there are slight improvements in quadriceps strength post-TKA, strength is rarely comparable to age-matched healthy individuals (30-48% deficit) or the non-operative knee.[41]

Functional Outcomes
A recent literature review showed significant increases in WOMAC (from 48.3 to 76.8) and SF-36 functional scores (from 27.6 to 43.8) when comparing baseline to postoperative TKA scores at varying follow-up periods.[3] In a prospective follow-up study looking at LEFS and 6MWT scores, the greatest improvements after TKA were found within the first 12 weeks, continued more gradually up to 26 weeks, and very minimally at one year postoperatively.[42]

Return to Work
In a study by Lombardi Jr. et al, 98% of patients who were working prior to TKA returned to work after TKA. The average time for recovery before return to work was 9 weeks. Individuals returning to very heavy labor required an average of 11 weeks and those returning to sedentary labor an average of 7 weeks.[43]

Return to Sport

Research is variable, but Hopper and Leach found that 63.6% of patients returned to sport after an average time of 4 months post-TKA, but with less frequent participation.[44] Bonnin et al reported that only 10% of patients younger than 75 years old regularly participated in strenuous sports after TKA.[45]

Patient Satisfaction
Bullens et al used a satisfaction VAS system which ranged from 0 (worst, totally unsatisfied) to 100 (best, completely satisfied) points. They found that 73% of patients had a satisfactory outcome at 5 years. The average score was 80 and 68% had a VAS score greater than 80.[46]

Goals

Based on current research, the short-term goals for this patient population during the acute hospital course of 2 to 3 days are as follows:

- Independent with supine and seated therapeutic exercise program
- Independent and able to demonstrate knowledge of safety and compliance with precautions with all mobility
- Operative extremity knee flexion AA ROM >80 degrees
- Operative extremity knee extension AA ROM ≤10 degrees
- Operative extremity independent SLR
- Independent with bed mobility with the HOB flat, no use of rails (+/- use of leg lifter, non-operative lower extremity)
- Independent sit to/from stand with a walker/crutches
- Independent gait ≥75ft with a walker/crutches
- ≤Stand by assist X1 for up/down stairs with a crutch and rail +/- bilateral crutches with a non-reciprocal pattern[47,48,49]

The patient's progress and goals will be assessed at each session. The frequency and duration may be increased or tapered as treatment progresses based on the therapist's judgment of factors including, but not limited to: comorbidities, tissue healing, patient/caregiver independent self-management, ability to participate in/receive therapy due to medical stability and/or competing care priorities.

Based on the Prognosis Section above, long-term goals are:

In 1-3 weeks:
- Independent gait with unilateral upper extremity support of a crutch/cane ≥300ft
- Initiation of standing and balance therapeutic exercise program
- Initiation of stationary bicycle use if available
- Initiation of outpatient PT program (2-4 weeks)

In 3-6 weeks:
- Gait ≥500ft with the least restrictive device

- Progression to use of no assistive device by home/outpatient PT
- Participation in outpatient PT program
- Active knee flexion ROM >110 degrees
- Active knee extension ROM ≤5 degrees

8-10 weeks:

- Return to work as applicable
- Gait community distances with no device

Operative knee ROM is expected to be at least 0-115 degrees and quadriceps strength >=4+/5 MMT within 3 months following TKA. The overall long-term goal for the patient is to at least return to their preoperative level of function with less pain. However, most tend to see an overall improvement beyond their preoperative status.

Treatment Planning / Interventions

Established Pathway	___ Yes, see attached.	_X_ No
Established Protocol	_X_ Yes, see attached.	____ No

Interventions most commonly used for this case type/diagnosis.

Traditional Approach versus High-Intensity Rehabilitation with Progressive Strengthening

In the past, resistive exercises for the quadriceps and hamstrings have not been introduced in the acute phase of rehabilitation. Traditionally they have been initiated within 2 months postoperatively once pain, ROM, and edema improve, no longer restricting participation in more intense exercises.[8,50] However, in a 2012 article, Bandholm highlighted the need for proper dose of physical therapy to improve outcomes, specifically calling for increased intensity and optimal timing.[51] More recent publications also provide strong support for early initiation of high-intensity rehabilitation with progressive strength training beginning as early as a few days to 4 weeks postoperatively. [41,47,51,52] At BWH, the timing of initiating resistive exercise and the progression of the patient through our established protocol should be done on a case-by-case basis. The therapist should consider several factors including tissue healing, comorbidities, and monitoring of adverse knee joint reactions such as increased pain and swelling. The following treatments should be initiated as deemed appropriate by the evaluating PT:

Inpatient Phase

- B/IADL, bed mobility, transfer, assistive device, and often gait training are initiated on POD#1 following TKA to promote the patient's independence. Assistive equipment may also include use of a bedrail or overhead trapeze. In most cases, the goal is to wean the

patient off such assistive equipment by POD#2-3 and instruct them on mobility techniques to allow them to function safely and independently in their home environment. Proper technique for vehicle transfers is also verbally reviewed with the patient prior to discharge home.

- Prescription of DME. Patients are measured, fitted, and trained with the most appropriate assistive device to maximize safety and independence during ambulation and transfers. The most common ambulatory devices used are walkers (standard or rolling), axillary crutches, and in some cases, only a straight cane or a single crutch. Patients should be progressed to the least restrictive assistive devices as safety allows. Other DME generally used/recommended to facilitate safe and independent transfers include commodes, raised toilet seats, and tub/shower seats.
- Cryotherapy is recommended following PT treatment. It is used to control inflammation, pain, and edema in the knee joint via its physiological effects on hemodynamic, neuromuscular, and metabolic processes.[53] As outlined above, it has become part of the standard protocol at BWH to place continuous cryotherapy on the operative knee immediately after TKA.
- Stair training
- Seated and standing balance activities
- Flexion and extension A/AA/PROM of the operative knee
- Non-resistive (body weight only) strengthening therapeutic exercise with focus on isometric and functional quadriceps control
- Body mechanics and postural exercises
- Respiratory and circulatory exercises starting POD#1, such as deep breathing, coughing, and ankle pumps.

Home PT/Outpatient PT (in addition to the above)[47]

- Manual Therapy Techniques. Patellofemoral and tibiofemoral joint mobilization are most often reserved for the subacute to late phase of treatment. Soft tissue mobilization can also be performed for edema management, promoting scar remodeling, and minimizing hypersensitivity following surgery. This often becomes part of the patient's home exercise and pain management program.
- Electrotherapeutic Modalities. As appropriate, use of biofeedback and neuromuscular electrical muscle stimulation (NMES) is encouraged to improve volitional quadriceps contraction and functional outcomes following TKA.[34] Persistent residual quadriceps femoris muscle force deficits after TKA are commonly reported and can prevent patients from returning quickly and fully to functional activities. A randomized controlled trial, Stevens-Lapsley et al 2012, reported significant improvements in quadriceps and hamstring strength, functional performance, and knee extension ROM 3.5 weeks after TKA with the use of NMES initiated 48 hours after TKA.[54]
- Progressive strengthening for the lower extremity with focus on the quadriceps and hamstrings
- Weight bearing exercises
- Use of stationary bicycle to improve ROM
- Gait training on even/uneven surfaces

- Agility exercises
- Progression of balance and proprioception
- Single-limb stance progression
- Return to work/sports training

Continuous Passive Motion (CPM):
Generally, CPM machines are not part of the standard of care for patients following TKA at BWH. The use of CPM machines for this patient population is controversial. The proposed benefits of CPM are facilitation of synovial fluid movement/increased diffusion of nutrients, diffusion of metabolic waste out of the joint space, and decreased swelling due to a pumping action thought to push blood away from the joint. It is suggested that CPM enhances tissue healing, and also therefore movement. However, studies demonstrate no clinically significant difference in ROM, swelling, and pain scores.[55, 56,57] Those who used a CPM had about the same hospital length of stay as those who did not. Most studies show no long-term benefit of CPM.[55,57] At BWH, the use of CPM machines is very infrequent and considered on a case-by-case basis. Use of CPM may be appropriate with elevated risk of contracture, complicated revision surgeries, or per surgeon preference.

Frequency & Duration:

The expected number of visits per episode of care ranges from 12 to 60. The episode of care following TKA generally consist of inpatient acute care PT, short-term rehabilitation or home PT, and outpatient PT. Based on the Guide to Physical Therapist Practice, it is anticipated that 80% of patients will achieve their anticipated goals and expected outcomes during this time frame of visits.[58] During the acute care stay, patients are typically seen twice a day. Regarding home PT and outpatient PT, frequency of visits is based on the physical therapist's evaluation, but generally begins with 2-3 visits per week and tapers as the patient progresses. The duration of home PT and outpatient PT will vary. Home PT most often occurs for 2-4 weeks, while the duration of outpatient PT depends on the patient's long-term goals.

Patient / Family Education:

A preoperative joint education class is conducted at BWH for patients who are scheduled for total joint arthroplasty. Most orthopedic surgeons at BWH highly recommend that their patients attend this interdisciplinary course. Patients attend a 90 minute class taught by an experienced orthopedic nurse and physical therapist using a PowerPoint presentation. The curriculum for the class includes: basic anatomy, basic procedure of a total joint arthroplasty, precautions, preoperative preparation, step-by-step hospital course, pain control, discharge process, and patient expectations. Each patient receives a booklet based on the curriculum discussed in class. Although research on preoperative education is variable, studies do suggest that preoperative education may increase interdisciplinary communication, patients' confidence, satisfaction, decrease anxiety levels, and decrease length of stay.[59,60,61,62]

Beginning on POD#1, patients and their families/caregivers are provided education on: details of the PT intervention plan including independent exercises, safety, correct positioning of the

operative lower extremity, the importance of initiating early mobility, and the expected discharge goals and outcomes. Patients receive a patient education handout detailing the above aspects of care. They also receive the BWH TKR PT Protocol to augment knowledge of short- and long-term activity expectations and progression of activities based on time since surgery and defined clinical criteria.

Recommendations and referrals to other providers:

Care Coordination: Care coordination is consulted immediately postoperatively to assist with discharge planning.

Occupational Therapy: Patients who are in need of assistance for B/IADL are referred to occupational therapy for training using adaptive equipment.

Postoperative Pain Service: This service may be consulted if a femoral nerve block or epidural was used, if a patient's pain is not well controlled by the initial pain medication regimen, and/or a patient has a history of chronic pain on chronic pain medication.

Social Work: Social work may be consulted in complicated situations when patients have difficulty coping with recovery and have limited social supports.

Orthopedic Technician Service: This service may be consulted in rare cases if a patient requires a CPM, bed trapeze, or bracing.

Re-evaluation

Given the average inpatient length of stay following TKA is 2-3 days, patients are informally re-assessed on a daily basis with respect to their ROM, quality of movement, strength, pain intensity, gait quality, and functional independence. If the patient's hospital course is prolonged due to complications, a formal re-evaluation or re-assessment will be performed every 7-10 days, or as indicated, to assess progression towards the previously outlined goals. In the outpatient setting, the patient is to be formally re-evaluated every 30 days; however impairments such as ROM should be monitored each visit.

Discharge Planning

Commonly expected outcomes at discharge:

It is expected that most patients following TKA will be discharged home from the inpatient acute care setting. In fact, at BWH, 58-62% of patients in 2012-2013 were discharged home from the acute care setting. In a recent community-based prospective study, more than half of the patients (57%) were discharged directly home following TKA, and all patients returned to the community within 6 months postoperatively. Those who were discharged directly home tended to be younger than those who were transferred to another facility.[37] Several factors including age, comorbidities, impractical home environment, lack of assistance from family/caregivers, and

functional status, may all contribute to the patient's discharge to a short-term rehabilitation setting instead of directly home. The functional status expected for discharge home is: ability to perform bed mobility and transfers independently, safely ambulate distances of 50-100 feet with an assistive device, and increased knee ROM and strength, as previously identified in the goals outlined above.

Transfer of Care:

Collaboration with Care Coordination for discharge planning is initiated at the time of initial evaluation. This collaboration is documented in the PT initial evaluation note and in any other encounter note as appropriate. This will facilitate appropriate discharge to home with services or transfer to an extended care facility. Communication with members of the clinical team such as the surgeon, surgical residents, and nursing staff is also documented.

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