Hip and Knee Arthroplasty (non-live)
Goals and Objectives

Course Description
"Hip and Knee Arthroplasty" is a continuing education program for athletic trainers that examines surgical management of osteoarthritis through total joint arthroplasty. This course includes a review of current literature relating to pathophysiology of osteoarthritis, specific arthroplasty procedures, post-surgical medical management, and anticipated rehabilitation outcomes.

Course Rationale
The purpose of this course is to provide participants with a comparative analysis of surgical techniques and post-surgical management to minimize complications, assess rehabilitation potential, and maximize outcomes based on current research.

Course Goals and Objectives
Upon completion of this course, participants will be able to:

1. Describe the current trends in osteoarthritis conservative and surgical management techniques.
2. Define prolotherapy and its indications for management of osteoarthritis.
3. Compare prosthetic knee components which substitute or salvage cruciate ligaments.
4. Describe total hip arthroplasty surgical procedures.
5. Compare outcomes for various total hip arthroplasty surgical techniques.
6. Identify factors contributing to increased risk of post-surgical complications.
7. Differentiate surgical anesthetic and pharmacologic strategies to manage post-surgical pain after total joint replacement.
8. Detail factors associated with improved outcomes following total joint replacement.
9. Identify components of pre-operative patient education programs.
10. Recognize the benefits of early post-surgical mobilization.

Course Provider – Innovative Educational Services

Provider Conflict of Interest - None

Course Instructor - Jodi Gootkin, PT, Med

Instructor Conflict of Interest - None

Target Audience – Athletic Trainers

Athletic Training Practice Domains - Clinical Evaluation & Diagnosis (0201, 0202, 0203, 0204, 0205); Treatment and Rehabilitation (0401, 0404, 0405)

Level of Difficulty – Essential

Course Prerequisites – None

Method of Instruction/Availability – Recorded video available on-demand online

Criteria for Issuance of CE Credits –Viewing of recorded video and at least 70% correct on the course post-test.

Continuing Education Credits – Three (3) hours of continuing education credit.

Fees - $34.95

Refund Policy - Unrestricted 100% refund upon request. The request for a refund by the learner shall be honored in full without penalty or other consideration of any kind. The request for a refund may be made by the learner at any time without limitations before, during, or after course participation.

Course Schedule

Pathophysiology of Osteoarthritis	0:00-0:10
Conservative Management	0:11-0:30
Surgical Management	0:31-0:35
Total Knee Arthroplasty	0:36-0:50
Clinical Applications	0:51-1:00
Total Hip Arthroplasty	1:01-1:30
Post-Operative Complications	1:31-1:50
Clinical Applications	1:51-2:00
Post -Surgical Pain	2:01-2:15
Clinical Outcomes	2:16-2:35
Pre-Operative education	2:36-2:40
Early Mobilization	2:41-2:50
Clinical Discussion	2:51-3:00

Approval -

Innovative Educational Services is approved by the Board of Certification, Inc. to offer continuing education for Certified Athletic Trainers.

Hip and Knee Arthroplasty

1

Live Interactive Webinar Presented By:
Jodi Gootkin, PT, MEd, CEAS
jodiemail@comcast.net

Course Rationale

3

- The purpose of this course is to provide a comparative analysis of surgical techniques and post-surgical management to minimize complications, assess rehabilitation potential, and maximize outcomes based on current research.

Goals and Objectives

4

1. Describe the current trends in osteoarthritis conservative and surgical management techniques.
2. Define prolotherapy and its indications for management of osteoarthritis.
3. Compare prosthetic knee components which substitute or salvage cruciate ligaments.
4. Describe total hip arthroplasty surgical procedures.
5. Compare outcomes for various total hip arthroplasty surgical techniques.
6. Identify factors contributing to increased risk of post-surgical complications.
7. Differentiate surgical anesthetic and pharmacologic strategies to manage post-surgical pain after total joint replacement.
8. Detail factors associated with improved outcomes following total joint replacement.
9. Identify components of pre-operative patient education programs.
10. Recognize the benefits of early post-surgical mobilization.

Disclaimer

5

- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations.

National Arthritis Prevalence

8

23%

Adults over 18 diagnosed with arthritis as of 2016

44%

Adults with Arthritis Attributable Limitation (AAL)

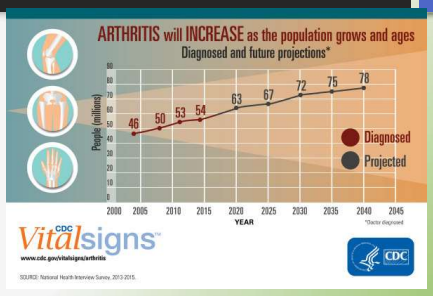
- Grasping small objects
- Reaching overhead
- Sitting > 2 hours
- Climbing flight of stairs
- Walking ¼ mile
- Standing > 2 hours

Copyright J. Gootkin 2019

https://www.cdc.gov/arthritis/data_statistics/disabilities-limitations.htm

Future Burden: 78 Million

9



Copyright J. Gootkin 2019

https://www.cdc.gov/arthritis/data_statistics/national-statistics.html

Impact of Arthritis

10

15 years — Most Common cause of disability in US

1 in 25 — Adults with Arthritis Attributable Limitations

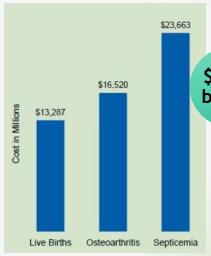
2.5X — More likely to have fall with injury

https://www.cdc.gov/arthritis/data_statistics/arthritis-related-stats.htm

Copyright J. Gootkin 2019

Osteoarthritis Cost

11



$16.5 billion

2nd most expensive condition treated in hospitals

$6.2 billion

Most expensive cause of hospitalization for private insurance patients

Copyright J. Gootkin 2019

https://www.cdc.gov/chronicdisease/resources/publications/aag/arthritis.htm

Pathophysiology of Osteoarthritis - OA

12

- Progressive cartilage damage in response to mechanical loading during weight bearing.

Copyright J. Gootkin 2019

OA Progression

13

- **Stage 1**
  - Proteolytic breakdown of cartilage matrix
  - Chondrocyte metabolism altered
  - Increased metalloproteinase enzymes destroy cartilage matrix
- **Stage 2**
  - Fibrillation of surface layers of cartilage
  - Proteoglycan and collagen fragments released into synovium
- **Stage 3**
  - Reactive synovial chronic inflammatory response
  - Macrophages produce metalloproteinases and cytokines.
- **Progression**
  - Subchondral thickening, marginal osteophytes

Radiologic Examination

Radiographic features confirming OA include:

- Bony sclerosis
- Marginal osteophytes
- Joint space narrowing
- Subchondral cysts
- malalignment

14

Kellgren-Lawrence Grading

15

- Universally accepted method of classifying OA base on radiographic features

Grade 1	Grade 2	Grade 3	Grade 4
Possible narrowing of joint space and possible osteophytes	Definite osteophytes, definite narrowing of joint space, and slight sclerosis	Marked narrowing of joint space, multiple osteophytes, definite narrowing of joint space, some sclerosis, deformity, cysts	• Gross loss of joint space, large osteophytes, severe sclerosis with cysts, and marked deformity of bone contour.

Outerbridge Classification

16

- Classification of cartilage damage based on arthroscopy.

Grade 0	Grade 1	Grade 2	Grade 3	Grade 4
• Normal	• Cartilage with softening and swelling	• Partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter	• Fissuring to the level of subchondral bone in an area with a diameter more than 1.5 cm	• Exposed subchondral bone

OA Clinical Presentation

17

- Joint pain, swelling, and decreased range of motion.
- Morning stiffness ≥30 min
- Inactivity stiffness
- Crepitus with motion

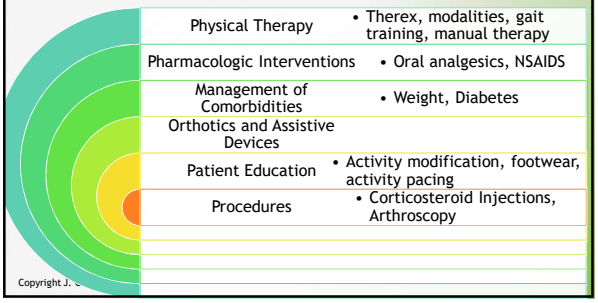
OA Clinical Indicators

18

Knee	Hip
Knee flexion capsular pattern greater than extension.	Pain in groin, buttock, or anteromedial thigh to knee
Lateral compartment knee OA produces genu valgum and medial compartment produces genu varum	Hip extension and internal rotation restrictions, and positive Scour test

Conservative Management

19



OA Rehabilitation

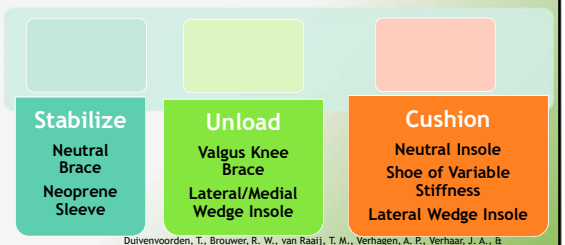
20

- Goals:
  - Decrease pain
  - Increase ROM and strength
  - Maximize gait quality and quantity
  - Improve balance and proprioception
  - Maximize functional task performance
  - Independent in home exercise program

Knee OA Orthotics

21

"The optimal choice for an orthosis remains unclear"



Duivenvoorden, T., Brouwer, R. W., van Raaij, T. M., Verhagen, A. P., Verhaar, J. A., & Bierma-Zeinstra, S. (2015). Braces and orthoses for treating osteoarthritis of the knee. *The Cochrane Library*.

OA Clinical Guidelines

22

- Based on current evidence from AAOS, NICE, and ESCEO, the following management strategies are NOT recommend:
  - Neutraceuticals –Glucosamine and Chondroitin
  - Acupuncture
  - Intra-articular hyaluronan

Prolotherapy

23

- Injection of an irritating dextrose solution to stimulate body's natural repair and healing mechanisms potentially reducing degenerative changes in ligament, tendon, and cartilage.
- Intra and extra articular injections into multiple points at site of pain/pathology occur every 3-6 weeks.
- Typically results evident after 3 treatments.

Consider This

Prolotherapy Intervention

24

- Mechanism of action theorized to include:
  - Stimulation of intra- and extra- articular tissue healing
  - Stimulation of collagen cell proliferation
- During the course of treatment AVOID:
  - Anti-inflammatory medication
  - Cryotherapy
  - Aggressive exercise and stretching
  - Inactivity
  - Smoking

Prolotherapy Evidence

25

- Evidence is evolving indicating progressively improved pain and function.

Interventions	Outcome
Prolotherpay vs. Home Exercise	WOMAC composite, pain, and function scores improved

- Additional research needed to determine optimal strategy for prolotherapy.
  - Dextrose concentration and volume
  - Treatment frequency and duration
  - Specificity of injection sites

Sit, Regina WS, et al. "Hypertonic dextrose injections (prolotherapy) in the treatment of symptomatic knee osteoarthritis: a systematic review and meta-analysis." *Scientific reports* 6 (2016).

Anatomy Review

26

- Hip Joint
  - Triaxial ball and socket articulation of femoral head and acetabulum.
- Knee Joint
  - Hinge articulation of femoral condyles and tibial plateau.

Role of Knee Ligaments

27

- Anterior cruciate ACL resists anterior tibial translation from 0-30 degrees of flexion when peak quad force creates anterior translation of tibia on femur.
- Posterior cruciate PCL resists hamstring force generating posterior translation of tibia on femur during knee flexion.

Total Knee Arthroplasty - TKA

28

- Distal end of the femur and proximal end of the tibia are excised.
- Tibial and femoral guides are inserted to determine appropriate fit to restore mechanical alignment and a level joint line.
- Prosthetic implants are placed on femur, tibia, and patella.
- ROM, ligamentous stability, and patellar tracking are assessed.

Total Knee Arthroplasty Surgery

29

Implant Design	Tibial Component	Fixation	Surgical Approach
Unicomparmental	Fixed Bearing	Cemented	Medial Patellar
Bilateral Cruciate Retaining	Mobile Bearing	Uncemented	Lateral Patellar
PCL Stabilizing		Hybrid	Midvastus
PCL Retaining			Subvastus
			Minimally Invasive

Implant Materials

30

- Metal components are cobalt chrome or titanium.
- Plastic is high molecular weight polyethylene.
- Implant selection considers patient size, weight, and gender.

Implant Design Unicompartmental

31

- Also referred to as partial knee replacement.
- Only one femoral condyle and articulating tibial surface are replaced.
- All ligaments are preserved allowing greater stability and proprioception.

Implant Design Bilateral Cruciate Retaining

32

- Both anterior and posterior cruciate ligaments are left intact maintaining anatomical kinematics.
- Femoral bone box component allows preservation of natural tibial bone island.
- Early loosening and failure contribute to limited use, but newer designs emerging.

Implant Design Posterior Cruciate Stabilizing

33

- Also referred to as:
  - Posterior Cruciate Sacrificing
  - Posterior Cruciate Substituting
- Both anterior and posterior cruciate ligaments removed during surgery.
- This is a total condylar prosthesis that closely replicates anatomy and function of natural knee.

Consider This

PCL Stabilizing Prosthesis

34

- Easier balancing when contractures and deformity are present
- Greater ROM

- Cam jump
- Tibial post polyethylene wear
- Patellar Clunk Syndrome
- Less reliable Femoral Rollback

Patellar Clunk Syndrome

35

- Following TKA patient may develop scar tissue in the quad tendon at the superior pole of the patella.
- The fibrous nodule causes mechanical catching of the patella during active knee extension.
- A painful, palpable “clunk” occurs.

Femoral Roll Back

36

- Normal kinematics of anterior to posterior translation of the femur on the tibia must be recreated by the prosthesis to achieve full knee flexion ROM.

Implant Design Posterior Cruciate Retaining

37

- Also referred to as:
  - Posterior Cruciate Retention
  - Posterior Cruciate Sparing
  - Cruciate Retaining
- Only the anterior cruciate ligament is removed during surgery.
- The natural posterior cruciate ligament provides stability to the joint.

PCL Retaining

38

- Resembles normal knee kinematics - Enhanced stability - Improved proprioception and kinesthesia	- Knee pain, restricted ROM, and instability if ligament balancing is insufficient

PCL Retention vs. Stabilizing Outcomes

39

- Clinical and functional outcome measures demonstrated no clinically relevant difference.
  - WOMAC, KSS Pain, HSS, SF-12
  - Radiographic evaluation
  - Complication rate
- Slightly more favorable results in favor of PCL stabilizing where PCL is removed.
  - **2 degree increase in post-operative knee flexion**
  - 2.4 point higher KSS functional score.

Verra, Wiebe C., et al. "Similar outcome after retention or sacrifice of the posterior cruciate ligament in total knee arthroplasty: A systematic review and meta-analysis." *Acta orthopaedica* 86.2 (2015): 195-201.

Tibial Compnents

40

- Fixed bearing implant incorporates metal tibial component witha polyethylene tray locked on top.
- Mobile bearing implant utilizes a rotating polyethylene insert on a metal tibial platform.

Fixed Bearing Design

41

Reduced polyethylene wear	Single point of contact may increase wear

Mobile Bearing Design

42

Reduced polyethylene wear Improved kinematics	Requires PCL removal

Mobile vs. Fixed Bearing Outcomes

43

- No statistical differences on multiple outcome measures.

Outcome	Assessment Tool
Pain	KSS Knee Society Score VAS Visual Analogue Scale
Function	KSS HSS Hospital for Special Surgery WOMAC
Health Related Quality of Life	SF12 Short Form Health Summary
Revision Rate	3 more knees per 1000 in mobile bearing

Hofstede, Stefanie N., et al. "Mobile bearing vs fixed bearing prostheses for posterior cruciate retaining total knee arthroplasty for postoperative functional status in patients with osteoarthritis and rheumatoid arthritis." *The Cochrane Library* (2015).

Fixation

44

- A hybrid design is typically utilized.
- The femoral stem is a trabecular metal surface for new bone growth.
- The tibial component is secured using a fast curing bone cement for strong fixation to bone.

Patellar Prosthesis

45

- Evidence demonstrates no difference in pain or function with or without patellar resurfacing.
- Resurfacing may decrease the need for revision after 5 years when compared to no patellar resurfacing.

American Academy of Orthopedic Surgeons (2017). Surgical Management of Osteoarthritis of the Knee Evidence Based Clinical Practice Guideline. http://www.orthoguidelines.org/topic?id=101

Surgical Approach

46

- **Medial Parapatellar**
  - Midline incision with patella flipped
  - Potential lateral patellar subluxation
- **Lateral Parapatellar**
  - Used for valgus deformity and lateral contractures
- **Midvastus**
  - Incision mid-muscle belly
  - Spares VMO insertion for accelerated rehab and improved patellar tracking
- **Subvastus**
  - VMO is lifted without flipping the patella
- **Minimally Invasive**
  - Small incision site for robotic assisted surgery
  - Potentially more rapid recovery

Infrapatellar Fat Pad Resection

47

- Beyond 6 months post-op, patients with resection demonstrate increased incidence of knee pain.

White, L., Holyoak, R., Sant, J., Hartnell, N., & Mullan, J. (2016). The effect of infrapatellar fat pad resection on outcomes post-total knee arthroplasty: a systematic review. *Archives of Orthopaedic and Trauma Surgery*, *136*(5), 701-708.

Longevity

48

- Long term wear and loosening lead to late implant failure.
- Typical survivorship of TKA is between 20-30 years

Total Hip Arthroplasty - THA

49

Surgical Procedure	Prosthesis	Fixation	Surgical Approach
Hip Resurfacing	Femoral Component	Cemented	Direct Anterior
Total Hip Arthroplasty	Acetabular Component	Uncemented	Direct Lateral
		Hybrid	Direct Posterior

Hip Resurfacing

50

- The procedure involves sculpting of the deteriorated femoral head for placement of a metal cap with a short stem.
- It then articulates with a shallow cup inserted into acetabulum.
- This technique preserves biomechanics for greater stability in younger active patients.

Hip Resurfacing Outcomes

51

- According to the Food and Drug Administration (FDA):

  "Metal ions from a metal-on-metal implant will enter the bloodstream."
- The long term safety of metal on metal components requires further analysis.
- An increased incidence of revisions compared to total hip arthroplasty has been demonstrated.

https://www.fda.gov/medicaldevices/productsandmedicalprocedures/implantsandprosthetics/metalonmetalhipimplants/ucm241766.htm

FDA Recommendations for Patients with Metal on Metal Implants

52

- Patients must be monitored for adverse tissue reactions of increased pain, swelling, numbness, noise, and gait alterations.
- Potential systemic adverse reactions:
  - General hypersensitivity reaction
  - Cardiomyopathy
  - Neurological changes including sensory changes
  - Psychological status change
  - Renal function impairment
  - Thyroid dysfunction
- Greater risk for patients with renal insufficiency, immunocompromise, obesity, receiving high doses of steroids, females, and bilateral implants.

https://www.fda.gov/medicaldevices/productsandmedicalprocedures/implantsandprosthetics/metalonmetalhipimplants/ucm241766.htm

Total Hip Arthroplasty Prosthesis

53

- A titanium or ceramic stemmed device with a prosthetic head replaces the femoral head and neck.
- A hemispherical shaped cup with a polyethylene or ceramic liner replaces acetabulum.
- Leg length must be assessed to avoid discrepancy.
- Newer components account for anatomical gender differences.

FDA Recalls

54

July 2016
- **Standard Offset Cup Impactor by Greatbatch**
- **Class I Recall - Inadequate Sterilization**

https://www.fda.gov/safety/medwatch/safetyinformation/safetyalertsforhumanmedicalproducts/ucm533967.htm

August 2015
- **PROFEMUR Neck Varus/Valgus by MicroPort Orthopedics**
- **Class I Recall - Unexpected Rate of Post-op Fractures**

https://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm465529.htm

June 2015
- **M/L Taper Kinectiv Technology Prosthesis by Zimmer**
- **Class I Recall - Higher than Expected Levels of Manufacturing Residues**

https://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm452012.htm

Fixation

55

- Acetabular component
  - Porous coated press fit and stabilized with screws
  - Cemented
- Femoral component
  - Cemented
  - Uncemented has porous trabecular surface for bone growth

Fixation Outcomes

56

"Although cementless femoral fixation for THA has evolved to the "new standard", it has not been proven to be the "gold standard" for all patients."

Moskal, Joseph T., Susan G. Capps, and John A. Scanelli. "Still no single gold standard for using cementless femoral stems routinely in total hip arthroplasty." *Arthroplasty Today* 2.4 (2016): 211-218.

- Cemented femoral stems beneficial for patients with poor bone integrity and demonstrate good long term survivorship.
- Loosening failure risk is lower in younger patients under 55 years old.

Consider This

Posterior Approach

57

- Incision is along and posterior to the greater trochanter.
- Glut max split with tendon intact.
- Piriformis and Gemelli muscles are detached.

Better visualization of entire hip	Potentially more expensive due to pharmacy needs of patient, operating room time, and longer length of stay.
	Disruption of hip abductor muscles.

Anterior Approach

58

- Incision from ASIS distal toward ipsilateral knee
- Entering in between Sartorius and Tensor Fascia Lata requires no muscle detachment.

Less disruptive to hip musculature	Custom operating table and fluoroscopy required
Less post-operative pain	Increased risk associated with surgeon learning curve
Improved function in early post-operative phase	Potential damage to lateral femoral cutaneous nerve
ADLs less disrupted by dislocation precautions	

Consider This

Anterior vs. Posterior Approach Outcomes

59

- AAOS guidelines find no clinically significant differences in outcomes.
- Potential benefit of shorter length of stay and improved function for anterior approach.
  - Earlier mobilization is permitted due to less muscular trauma.

Improved function on HHS at 12 months noted for anterior approach

Balasubramaniam, Umatheepan, et al. "Functional and clinical outcomes following anterior hip replacement: a 5-year comparative study versus posterior approach." *ANZ journal of surgery* 86.7-8 (2016): 589-593.

Consider This

Current Trends

60

- Minimally Invasive
  - Surgeons use this term to reference incision length, speed of recovery, or level of surgical dissection of tissues.
- Robotic Assisted
  - Surgeon uses robotic arms to plan procedure and control tools during surgical operation.

Robot Assisted Arthroplasty

61

- Two primary systems are MAKO Robot (Stryker®) and the NAVIO Robot (Smith & Nephew®)

Improved alignment and stability

Prolonged surgical time

Possible higher hip dislocation rate

Robot 217 Shenoy, R., & Nathwani, D. (2017). Evidence for robots. *SICOT-J, 3*, 38.

THA Dislocation

62

Anterior Avoid
- Hip Extension
- Hip External Rotation
- Hip ADDuction past neutral

Posterior Avoid
- Hip Flexion >90
- Hip Internal Rotation past neutral
- Hip ADDuction past neutral

- Risk factors include greater age, prior surgery, cognitive and neuromuscular comorbidities.
- There appears to be no difference in the rate of dislocation between anterior and posterior approach.

Consider This

Observing Anterior Precautions

63

Precaution	Patient Instruction
Avoid closed chain external rotation.	Do not turn away from your operative side when turning or performing ADLs.
Limit operative limb hip extension at toe off.	Take a short step with your NON-operative limb.
Avoid hip extension beyond neutral in supine and hook lying.	Be cautious when using bed pan and avoid bridging up your bottom with feet planted.

Observing Posterior Precautions

64

Precaution	Patient Instruction
Avoid closed chain internal rotation.	Do not turn toward your operative side when turning or performing ADLs.
Avoid hip flexion greater than 90 degrees.	Do not bend forward to pick up objects. Do not sit in a low chair or couch.
Avoid hip ADDuction past neutral.	Do not cross legs in sitting or when lying down.

Total Joint Arthroplasty Post-Operative Complications

65

- Preventing hospital re-admissions and reducing complications contributes to improved patient outcomes and manages the cost of care.
- Centers for Medicare and Medicaid Services implemented the Comprehensive Care for Joint Replacement Model in April 2016 to provide more coordinated patient care from surgery through recovery.

https://innovation.cms.gov/initiatives/cjr

Comprehensive Care for Joint Replacement Model - CJR

66

- The hospital where the surgery was performed is responsible for the full cost of the episode of care which is defined from time of surgery through 90 days post hospital discharge.
- Bundling payments is intended to foster coordination among hospitals, physicians, and other providers for effective and efficient care.

Hospital-Level Risk-Standardized Complication Rate - RSCR

67

This THA/TKA complications measure tracks:

During the admission or within 7 days
acute myocardial infarction, pneumonia, and sepsis/septicemia/shock

During admission or within 30 days
death, surgical site bleeding, and pulmonary embolism

During the admission or within 90 days
mechanical complications and periprosthetic joint infection/wound infection

https://www.qualitymeasures.ahrq.gov/summaries/summary/49201/total-hip-arthroplasty-tha-andor-total-knee-arthroplasty-tka-hospitallevel-riskstandardized-complication-rate-rscr-following-elective-primary-tha-andor-tka

Infection

68

- Wound site and periprosthetic joint infections can occur.
- According to the Centers for Disease Control, infection is the most common indication for revision in total knee arthroplasty and the third most common indication in total hip arthroplasty.
- Lifelong antibiotic prophylaxis prior to dental care or other surgical procedures can help reduce transient bacteremia.

Minimizing Risk

69

- Implementation of a pre-operative staphylococcal decolonization protocol decreases incidence of surgical site infections.

Hadley, Scott, et al. "Staphylococcus aureus decolonization protocol decreases surgical site infections for total joint replacement." *Arthritis* 2010 (2010).

Surgical Site Infection

70

- Infection risk is greater with BMI >30, active smoking, and staphylococcus aureus colonization.
- Several factors related to obesity increase infection risk:
  - Longer surgical time
  - Difficult surgical exposure
  - Decreased vascularization of adipose tissue
  - Weakened immune responses

Venous Thromboembolism - VTE

71

- Deep vein thrombosis (DVT) is the formation of a clot within the lumen of a deep vein in the lower extremity.
- Pulmonary embolism (PE) occurs when the clot dislodges traveling through the circulatory system into the heart and lodging in the lungs obstructing blood flow.

VTE Prevalence

72

- Despite prophylaxis, patients are still at risk for DVT and PE.

Diagnosed before discharge	TKA	THA
VTE - Pooled DVT and PE	1.09%	0.53%
DVT	0.63	0.26
PE	0.27	0.14
Within 3 months post discharge	2-3%	2-5%

- There is limited evidence that the complication rate increases with age, but comorbidities have been shown to increase risk.

Consider This

Januel J, Chen G, Ruffieux C, Quan H, Douketis JD, Crowther MA, Colin C, Ghali WA, Burnand B, IMECCHI Group FT. Symptomatic In-Hospital Deep Vein Thrombosis and Pulmonary Embolism Following Hip and Knee Arthroplasty Among Patients Receiving Recommended ProphylaxisA Systematic Review. *JAMA*. 2012;307(3):294-303. doi:10.1001/jama.2011.2029

DVT Differential Diagnosis

73

- Signs and symptoms of DVT include localized calf pain, tenderness, swelling, warmth, but are not conclusive of diagnosis.
- Other possible etiologies include:
  - Sciatica
  - Gastroc spasm or tendonitis
  - Intermittent claudication
  - Baker's cyst
  - Cellulitis

Homan's Sign

74

"The clinical signs cannot be trusted"

Positive in only 33% cases and false positive in 21%

"Unreliable, insensitive, and nonspecific"

Positive in 8-56% cases and false positive in 50% cases

"Essentially no diagnostic value"

Low sensitivity of 50.0% and specificity of 51.875%

Haeger K. Problems of acute deep venous thrombosis. The interpretation of signs and symptoms. Angiology 1969;20:219-23.
Urbano, FL. Homans' sign in the diagnosis of deep vein thrombosis. Hospital Physician. March 2001, pp. 22-24
Patnaik, Pritam Pritish, et al. "A Study Of Deep Vein Thrombosis In Surgical Practice." *Age* 8.648X100 (2016): 1-23.

Wells Rule for DVT

75

- Predicts DVT presence of prior to imaging studies.
- Scoring 3 High Probability
  1-2 Moderate Probability
  0 Low Probability

Assessment Criteria	Points
Active Cancer (treatment ongoing or within previous 6 months)	+ 1
Paralysis, paresis or recent plaster immobilization of the LE	+ 1
Recently bedridden for 3 days or more, or major surgery within the previous 12 weeks requiring anesthesia	+ 1
Localized tenderness along the distribution of the deep venous system	+ 1
Entire leg swelling	+ 1
Calf Swelling at least 3cm larger than asymptomatic leg (measured 10cm below tibial tub)	+ 1
Pitting Edema confined in symptomatic leg	+ 1
Collateral superficial veins (nonvaricose)	+ 1
Previous DVT	+ 1
Alternative diagnosis at least as likely as a DVT	- 2

DVT Management

76

- General recommendation is to refer symptomatic patients for diagnostic testing.
- Continuous Passive Motion (CPM) device does NOT prevent VTE.
- Enhanced peri-operative management and prophylaxis can decrease risk.
  - Anticoagulant medications
  - Compression stockings
  - Mechanical compression devices

Consider This

Mechanical Compression Devices

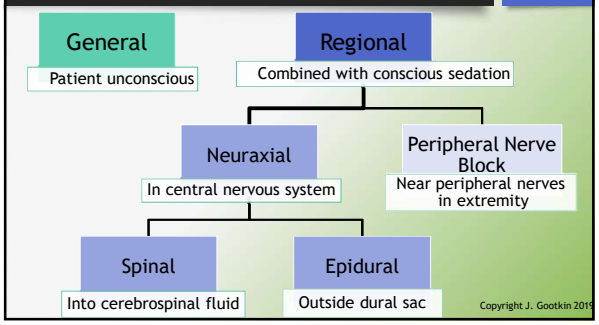
77

Above-Knee Sequential Compression Devices	Not recommended over other devices for THA
Below-Knee Sequential Compression Device	Good efficacy for THA and TKA
Rapid Asymmetrical Inflation Device	Promising but future research needed
Foot Pump	Potential benefit when combined with pharmacoprophylaxis

Pierce, Todd P., et al. "A current review of mechanical compression and its role in venous thromboembolic prophylaxis in total knee and total hip arthroplasty." *The Journal of arthroplasty* 30.12 (2015): 2279-2284.

Surgical Anesthesia

78



Anesthesia Complications

79

	Benefits	Complications
Regional Anesthesia	• Decreased one month mortality • Decreased post-op confusion • Potential decreased risk of DVT	• Increased minor complications of wound dehiscence and superficial infection

Whiting, Paul S., et al. "Regional anaesthesia for hip fracture surgery is associated with significantly more peri-operative complications compared with general anaesthesia." *International orthopaedics* 39.7 (2015): 1321-1327.

Anesthesia Functional Outcomes

80

- Regional anesthesia appears to decrease length of stay, improve joint ROM, strength, gait, and stair negotiation post-operatively but long-term functional impact beyond 3 months cannot be confirmed.

Atchabahian, A., Schwartz, G., Hall, C. B., Lajam, C. M., & Andreae, M. H. (2015). Regional analgesia for improvement of long-term functional outcome after elective large joint replacement. *The Cochrane Library*. Johnson, R. L., Kopp, S. L., Burkle, C. M., Duncan, C. M., Jacob, A. K., Erwin, P. J., ... & Mantilla, C. B. (2016). Neuraxial vs general anaesthesia for total hip and total knee arthroplasty: a systematic review of comparative-effectiveness research. *British journal of anaesthesia*, *116*(2), 163-176.

Acute Post-Surgical Pain

81

- Effective preemptive multimodal management of post-operative pain supplies several benefits.
  - Facilitates earlier mobilization
  - Diminishes opioid related side effects
  - Improves patient satisfaction
  - Contributes to shorter hospital length of stay

Acute Post Surgical Pain Pre-operative Considerations

82

No Pre-operative Education

- Poorer functional outcomes at 6 months

Effective Pre-operative Education

- Decreased pain levels at 2 weeks
- Greater use of non-medication interventions
- Less pain interference with ADLs

Surgical Anesthetic Techniques

83

- During joint replacement surgery, the physician may combine general anesthesia with a regional method including epidural or peripheral nerve block.

Patient Controlled Epidural Analgesia - PCEA

84

- Self administered IV pain medication through epidural catheter placed during surgery.
- Close medication delivery to opioid receptors in dorsal horn increases potency.
- Pump design prevents overdosing by blocking self administration if too early based on medication prescription parameters.

Only the patient should push the button!!

Peripheral Nerve Block

85

- Reliability and duration of the pain relief can be problematic.
- While pain analgesia is achieved, the side effect of muscle weakness can contribute to decrease motor control increasing risk of falls.
  - Femoral Nerve Block common
- Assess patients sensory and motor status to ensure adequate quad strength for out of bed activities.

Local Infiltration Analgesia

86

- Also referred to as periarticular local anesthetic infusion or high volume local infiltration analgesia.
- The surgeon injects anesthetic into the joint region throughout the surgery and prior to wound closure.
- Medication combinations may vary, but the most common is:
  - Ropivacaine
  - Adrenaline
  - Ketorolac

Local Infiltration Analgesia Outcomes

87

- Lower VAS pain ratings, decreased narcotic medication use, and improved motor function contribute to enhanced early therapy participation.

Gibbins, M. L., Kane, C., Smit, R. W., & Rodseth, R. N. (2016). Periarticular local anaesthetic in knee arthroplasty: A systematic review and meta-analysis of randomised trials. *SA Orthopaedic Journal*, *15*(3), 49-56
Horn, B. J., Cien, A., Reeves, N. P., Pathak, P., & Taunt Jr, C. J. (2015). Femoral Nerve Block vs Periarticular Bupivacaine Liposome Injection After Primary Total Knee Arthroplasty: Effect on Patient Outcomes. *The Journal of the American Osteopathic Association*, *115*(12), 714-719.

Consider This

Cryotherapy

88

- Research reflects only small improvements in pain and ROM when cryotherapy is utilized during the immediate post-operative phase.

Potential Benefit TKA	Research Outcome
Decreased blood loss	225 ml less blood loss
Decreased pain	Post-op day 2 less reported pain POD 1 and 3 equivalent
Increased ROM	11 degrees greater knee flexion at time of hospital discharge

Adie S, Kwan A, Naylor JM, Harris IA, Mittal R. Cryotherapy following total knee replacement. Cochrane Database of Systematic Reviews 2012, Issue 9

Continuous Passive Motion - CPM

89

- A CPM machine is applied after TKA to passively move joint through specified ROM.
- Evidence does NOT support the widely accepted rationales for the use of the CPM.
  - Improving knee flexion ROM
  - Pain management
  - Enhanced functional mobility
  - Improved quality of life
  - Decreased risk of DVT
- Use may reduce future risk of manipulation under anesthesia

Harvey, L. A. (2014). Continuous passive motion following total knee arthroplasty in people with arthritis. *Cochrane Database Of Systematic Reviews*, (3),

Arthroplasty Clinical Outcomes

90

- Function and Outcomes Research for Comparative Effectiveness in Orthopedics – FORCE Ortho
- This is a current registry gathering data to guide practice, reimbursement, and improve patient outcomes.

https://forceortho.org/

Factors Associated with Improved Outcomes from TKA

91

- Geriatric population does NOT demonstrate reduced functional outcomes or pain management compared to the younger population undergoing TKA.

Factors Associated with Improved Outcomes from THA

92

- Stronger pre-operative strength of knee extensors on involved side
- Greater walking distance pre-operatively.
- Lower post-operative HHS can be predictor of revision risk.

HHS	
<55 at 2 or 5 years	Predictive of revision
16-18 point change	Minimal clinically important improvement
40 point change	Moderate clinical improvement

Singh, Jasvinder A., et al. "Clinically important improvement thresholds for Harris Hip Score and its ability to predict revision risk after primary total hip arthroplasty." *BMC musculoskeletal disorders* 17.1 (2016): 256.

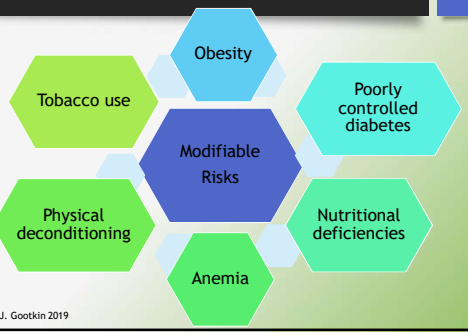
Factors Associated with Poor Outcomes from THA and TKA

93

- Research appears to be consistent that having poorer psychological health, more compromised function, and greater pain levels prior to surgery diminish long-term outcomes.

Pre-operative Modifiable Risk Factors

94



Obesity

95

- Increased Body Mass Index (BMI) >30-40 contributes to greater risk of post-surgical complications.
  - Aseptic loosening
  - Superficial and deep infections
- Obese patients following total joint replacement report higher pain scores, experience slower recovery from pain, and have greater difficulty restoring functional mobility.

Musculoskeletal Comorbidities

96

- Pre-operative arthritic pain elsewhere in the body is associated with poorer physical function.
- TKA patients present with additional arthritic pain in the contralateral knee and low back.
- THA patients present with additional arthritic pain in the ipsilateral knee and low back.

Rehabilitation Measures

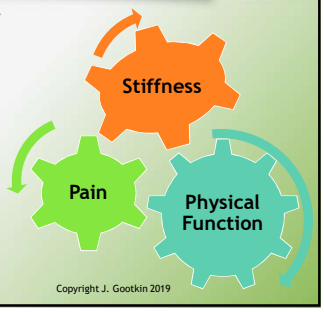
97

- Clinicians use a combination or patient reported outcome measures and performance measures to assess progress.

Western Ontario and McMaster Universities Arthritis Index - WOMAC

98

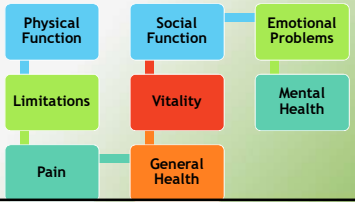
- Patient self-assessment tool using 0-5 Likert scale.
- Originally designed specific for OA disability.
- Higher scores indicate greater pain, stiffness, and functional limitation.



Short Form Health Summary - SF-12

99

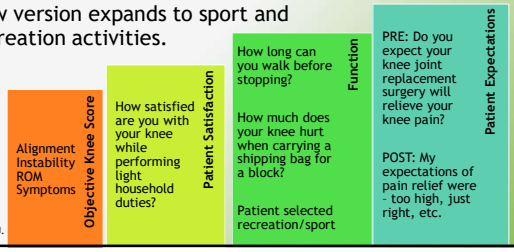
- Patient self-assessment of physical and mental well being.
- Scores >50 reflect better physical or mental health than the mean normative data.



Knee Society Score - KSS

100

- Physician and patient pre/post-operative information.
- Assesses expectation, satisfaction, and physical function
- New version expands to sport and recreation activities.



Knee Injury and Osteoarthritis Outcome Score - KOOS

101

- Patient self-assessment questionnaire regarding their knee and associated problems in the past week.
- Specifically considers stiffness, pain, function in sport/recreation, activities of daily living, and quality of life.
- Score of 100 indicates no symptoms and score of 0 reflects extreme symptoms.
- Minimal Important Change is suggested to be 8-10.

Consider This

Hip Dysfunction and Osteoarthritis Outcome Score - HOOS

102

- Patient self-assessment questionnaire regarding their hip and associated problems in the past week.
- Specifically considers stiffness, pain, function in sport/recreation, activities of daily living, and quality of life.
- Score of 100 indicates no symptoms and score of 0 reflects extreme symptoms for each subscale.

Harris Hip Score - HHS

103

- Clinician based tool considered Gold Standard for assessing hip surgical outcomes.
- Rates patient's pain, function, and joint mobility.
- Scores range from 0-100 with a higher score indicating less dysfunction.

Poor	Fair	Good	Excellent
<70	70 - 79	80-89	90 -100

Consider This

Patient Satisfaction

104

- The majority of patients appear to be satisfied with their post-operative achievements.
- Dissatisfaction tends to bbe related to pain and limited ability to kneel and descend stairs.

Chronic Post-Surgical Pain

105

- Multifactorial symptom with anatomical and psychological components to address.
- Greater post surgical pain, poor mental health, and presence of musculoskeletal comorbidities may contribute to the risk of developing chronic postsurgical pain.
- Consider central-sensitization of pain and fear avoidance during the early post-operative phase.

Iliopsoas Impingement

106

- Prominence of the anteroinferior rim of the THA acetabular cup causes mechanical irritation to the iliopsoas tendon.
- Symptoms are consistent with tendonitis.
- Imaging studies confirm the diagnosis.
- Management options include physical therapy, corticosteroid injections, arthroscopic tenotomy, or acetabular revision.

Pre-operative Patient Education

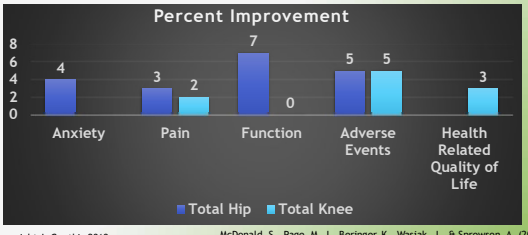
107

- Traditional "Prehab" content is function based with patient education emphasizing:
  - Exercise programs
  - Mobility training
  - Adaptive equipment
  - Home environment safety
  - post-operative precautions

Pre-operative Education Outcomes

108

"Unsure if it offers benefits over usual care"



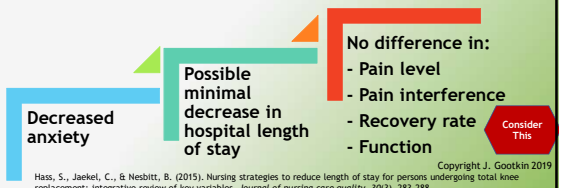
McDonald, S., Page, M. J., Beringer, K., Wasiak, J., & Sprowson, A. (2014). Preoperative education for hip or knee replacement. *The Cochrane Library*.

Pre-Operative Education Outcomes continued

109

"Invite the patient to be an active participant"

- Primary benefit is to improve patient awareness and expectations.

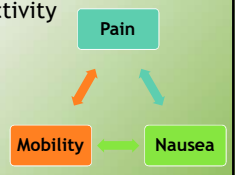


Hass, S., Jaekel, C., & Nesbitt, B. (2015). Nursing strategies to reduce length of stay for persons undergoing total knee replacement: integrative review of key variables. *Journal of nursing care quality*, *30*(3), 283-288.
Wilson, R. A., Watt-Watson, J., Hodnett, E., & Tranmer, J. (2016). A Randomized Controlled Trial of an Individualized Preoperative Education Intervention for Symptom Management After Total Knee Arthroplasty. *Orthopaedic Nursing*, 35(1), 20-29

Symptom Management Education

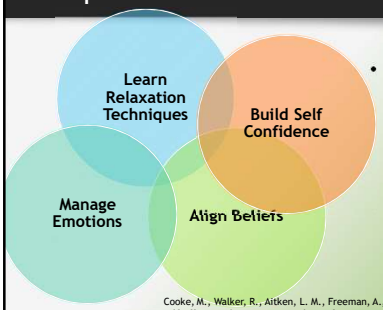
110

- To maximize benefits, inform the patient of the peri-operative pathway focusing on symptom management strategies.
  - Importance pain relief for activity
  - Communicating pain level
  - Requesting analgesics and antiemetics
  - Preventing dehydration



Pre-operative Patient Empowerment

111

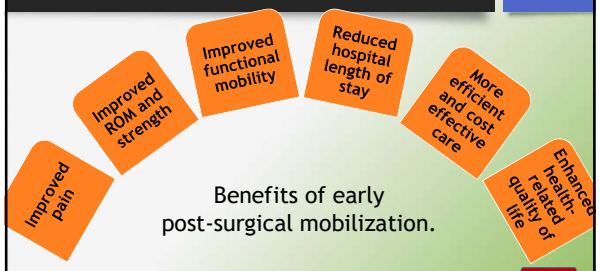


- Self-efficacy training may yield physical and psychological benefits to enhance outcomes.

Cooke, M., Walker, R., Aitken, L. M., Freeman, A., Pavey, S., & Cantrill, R. (2016). Pre-operative self-efficacy education vs. usual care for patients undergoing joint replacement surgery: a pilot randomised controlled trial. *Scandinavian journal of caring sciences*, *30*(1), 74-82.

Early Post-Operative Mobilization

112



Benefits of early post-surgical mobilization.

Consider This

Physical Therapy Day of Surgery

113

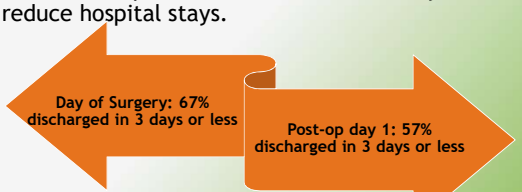
- At minimum within 24 hours of surgery, sitting upright and an attempt at ambulation should occur.

Hass, S., Jaekel, C., & Nesbitt, B. (2015). Nursing strategies to reduce length of stay for persons undergoing total knee replacement: integrative review of key variables. *Journal of nursing care quality*, *30*(3), 283-288.
Guerra, M. L., Singh, P. J., & Taylor, N. F. (2015). Early mobilization of patients who have had a hip or knee joint replacement reduces length of stay in hospital: a systematic review. *Clinical rehabilitation*, *29*(9), 844-854.

Physical Therapy Day of Surgery

114

- As early as 4 to 6 hours post surgery has been shown to help achieve functional recovery and reduce hospital stays.



Hass, S., Jaekel, C., & Nesbitt, B. (2015). Nursing strategies to reduce length of stay for persons undergoing total knee replacement: integrative review of key variables. *Journal of nursing care quality*, *30*(3), 283-288.
Guerra, M. L., Singh, P. J., & Taylor, N. F. (2015). Early mobilization of patients who have had a hip or knee joint replacement reduces length of stay in hospital: a systematic review. *Clinical rehabilitation*, *29*(9), 844-854.

Early Mobilization Considerations

115

- Weight bearing status varies among physicians.
  - Cemented tends to permit earlier weight bearing as tolerated.
- Coordinate therapy with pain medication administration to allow easier participation in rehabilitation interventions.
- Femoral nerve block decreases quad strength potentially increasing risk of falls.

TKA Acute Care Phase

116

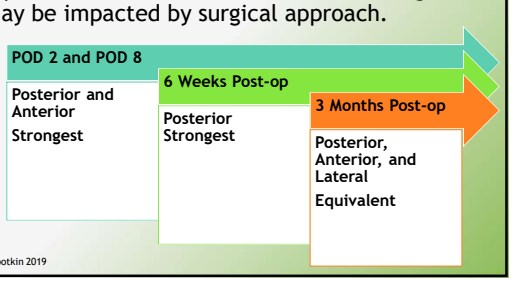
- Rehab goals directed at decreasing swelling, increasing range of motion, enhancing lower extremity strength, and maximizing mobility.
- Encourage knee extension with trochanter roll and towel roll at ankle.

Knee Flexion ROM	Post-op Week Achieved At
90 degrees	1-2
100 degrees	3-4
120 degrees	5-8 weeks

Surgical Approach Impact on THA Strength

117

- Hip Abduction and Extension muscle strength may be impacted by surgical approach.



Aquatic Therapy

118

- Buoyancy reduces the relative body weight and diminishes compressive forces on the lower extremities allowing earlier ambulation and progressive resistance exercise.

Outcome	Compared to land based therapy
Wound Infection	No increased risk
ADL's	Improved function
Muscle Strength	Increase knee extension and hip abduction
ROM	Increased knee flexion
Pain, Edema, Quality of Life	No statistical difference

Villalta, E. M., & Peiris, C. L. (2013). Early aquatic physical therapy improves function and does not increase risk of wound-related adverse events for adults after orthopedic surgery: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, *94*(1), 138-148.

Effectiveness of Therapy

119

- Physical therapy improves function at 3-4 months post-op TKA compared to no therapy.
- Outpatient and home care therapy demonstrate equivalent improvement in pain and function.
- Supervised use of THA adaptive equipment by occupational therapist can reduce disability.

Artz, N., Elvers, K. T., Lowe, C. M., Sackley, C., Jepson, P., & Beswick, A. D. (2015). Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis. *BMC musculoskeletal disorders*, *16*(1), 15.
Florez-Garcia, M., Garcia-Pérez, F., Curbelo, R., Pérez-Porta, I., Nishishinya, B., Lozano, M. P. R., & Carmona, L. (2016). Efficacy and safety of home-based exercises versus individualized supervised outpatient physical therapy programs after total knee arthroplasty: a systematic review and meta-analysis. *Knee Surgery, Sports Traumatology, Arthroscopy*, 1-14.
Bozorgi, J., Asghar, A., Ghamkhar, L., Kahlaee, A. H., & Sabouri, H. (2016). The Effectiveness of Occupational Therapy Supervised Usage of Adaptive Devices on Functional Outcomes and Independence after Total Hip Replacement in Iranian Elderly: A Randomized Controlled Trial. *Occupational therapy international*, *23*(2), 143-153.

Conclusion

120

- The continued evolution of surgical techniques and components combined with a broader perspective on the role of rehabilitation professionals throughout the continuum of care will foster enhanced patient outcomes from total joint arthroplasty.

References

Achten, J., Parsons, N. R., Edlin, R. P., Griffin, D. R., & Costa, M. L. (2010). A randomised controlled trial of total hip arthroplasty versus resurfacing arthroplasty in the treatment of young patients with arthritis of the hip joint. *BMC musculoskeletal disorders*, *11*(1), 1.

Adie, S., Kwan, A., Naylor, J. M., Harris, I. A., & Mittal, R. (2012). Cryotherapy following total knee replacement. *The Cochrane Library*.

Aglietti, P., Baldini, A., Buzzi, R., Lup, D., & De Luca, L. (2005). Comparison of mobile-bearing and fixed-bearing total knee arthroplasty: a prospective randomized study. *The Journal of arthroplasty*, *20*(2), 145-153.

Aigner, T., & Schmitz, N. (2011). Pathogenesis and pathology of osteoarthritis. *Rheumatology*, *414*, 1741-1759.

American Academy of Orthopedic Surgeons (2013). AAOS Clinical Practice Guideline: Treatment of Osteoarthritis of the Knee: Evidence-Based Guideline, 2nd Edition. http://www.orthoguidelines.org/topic?id=1005

American Academy of Orthopedic Surgeons (2017). Surgical Management of Osteoarthritis of the Knee Evidence Based Clinical Practice Guideline. http://www.orthoguidelines.org/topic?id=1019

American Academy of Orthopedic Surgeons (2017). AAOS Clinical Practice Guideline: Management of Osteoarthritis of the Hip: Evidence-Based Guideline. http://www.orthoguidelines.org/topic?id=1021

American Academy of Orthopedic Surgeons. (2011). Preventing venous thromboembolic disease in patients undergoing elective hip and knee arthroplasty evidence based guideline and evidence report. http://www.orthoguidelines.org/topic?id=1006

American College of Rheumatology. (May 2017) "Herbal Remedies, Supplements & Acupuncture For Arthritis". *Rheumatology.org*. Web. 4 June 2017.

American Society of Regional Anesthesia and Pain Medicine. (2017) "Regional Anesthesia for Surgery." https://www.asra.com/page/41/regional-anesthesia-for-surgery

Artz, N., Elvers, K. T., Lowe, C. M., Sackley, C., Jepson, P., & Beswick, A. D. (2015). Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis. *BMC Musculoskeletal Disorders*, *16*(1), 15.

Atchabahian, A., Schwartz, G., Hall, C. B., Lajam, C. M., & Andreae, M. H. (2015). Regional analgesia for improvement of long-term functional outcome after elective large joint replacement. *The Cochrane Library*.

Ayers DC, Harrold L, Li W, Snyder B, Allison JJ, Lewis C. Greater musculoskeletal pain in TKR and THR patients correlates with poorer function in a national consortium. 2013 Orthopaedic Research Society Annual Meeting, San Antonio, TX.

Balasubramaniam, U., Dowsey, M., Ma, F., Dunin, A., & Choong, P. (2016). Functional and clinical outcomes following anterior hip replacement: a 5-year comparative study versus posterior approach. *ANZ Journal of Surgery*.

Bergin, P. F., Doppelt, J. D., Kephart, C. J., Benke, M. T., Graeter, J. H., Holmes, A. S., ... & Unger, A. S. (2011). Comparison of minimally invasive direct anterior versus posterior total hip arthroplasty based on inflammation and muscle damage markers. *J Bone Joint Surg Am*, *93*(15), 1392-1398.

Beswick, A. D., Wylde, V., & Gooberman-Hill, R. (2015). Interventions for the prediction and management of chronic postsurgical pain after total knee replacement: systematic review of randomised controlled trials. *BMJ open*, *5*(5), e007387.

References continued

Bozorgi, J., Asghar, A., Ghamkhar, L., Kahlaee, A. H., & Sabouri, H. (2016). The effectiveness of occupational therapy supervised usage of adaptive devices on functional outcomes and independence after total hip replacement in iranian elderly: A randomized controlled trial. *Occupational Therapy International*, *23*(2), 143-153.

Brokelman, R. B., Haverkamp, D., van Loon, C., Hol, A., van Kampen, A., & Veth, R. (2012). The validation of the visual analogue scale for patient satisfaction after total hip arthroplasty. *European orthopaedics and traumatology*, *3*(2), 101-105.

Bruyère, O., Cooper, C., Pelletier, J. P., Branco, J., Brandi, M. L., Guillemin, F., ... & Rizzoli, R. (2014, December). An algorithm recommendation for the management of knee osteoarthritis in Europe and internationally: a report from a task force of the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO). In *Seminars in Arthritis and Rheumatism* (Vol. 44, No. 3, pp. 253-263). WB Saunders.

Centers for Medicare and Medicaid Services. (2017). Comprehensive Care for Joint Replacement Model. *Innovation.cms.gov*. Retrieved 20 May 2017, from https://innovation.cms.gov/initiatives/cjr

Chalmers, B. P., Sculco, P. K., Sierra, R. J., Trousdale, R. T., & Berry, D. J. (2017). Iliopsoas impingement after primary total hip arthroplasty: Operative and nonoperative treatment outcomes. *JBJS*, *99*(7), 557-564.

Cibulka, M. T., White, D. M., Woehrle, J., Harris-Hayes, M., Enseki, K., Fagerson, T. L., ... & Godges, J. J. (2009). Hip pain and mobility deficits—Hip osteoarthritis: Clinical practice guidelines linked to the international classification of functioning, disability, and health from the Orthopaedic Section of the American Physical Therapy Association. *Journal of Orthopaedic & Sports Physical Therapy*, *39*(4), A1-A25.

Cooke, M., Walker, R., Aitken, L. M., Freeman, A., Pavey, S., & Cantrill, R. (2016). Pre-operative self-efficacy education vs. usual care for patients undergoing joint replacement surgery: a pilot randomised controlled trial. *Scandinavian Journal of Caring Sciences*, *30*(1), 74-82.

Cromie, M. J., Siston, R. A., Giori, N. J., & Delp, S. L. (2008). Posterior cruciate ligament removal contributes to abnormal knee motion during posterior stabilized total knee arthroplasty. *Journal of Orthopaedic Research*, *26*(11), 1494-1499.

D'Anchise, R., Andreata, M., Balbino, C., & Manta, N. (2013). Posterior cruciate ligament-retaining and posterior-stabilized total knee arthroplasty: differences in surgical technique. *Joints*, *1*(1), 5-9.

Duivenvoorden, T., Brouwer, R. W., van Raaij, T. M., Verhagen, A. P., Verhaar, J. A., & Bierma-Zeinstra, S. (2015). Braces and orthoses for treating osteoarthritis of the knee. *The Cochrane Library*.

Edwards, P., Hadden, K., Connelly, J. O., & Barnes, C. L. (2016). Effect of total joint arthroplasty surgical day of the week on length of stay and readmissions: A clinical pathway approach. *The Journal of Arthroplasty*.

Eka, A., & Chen, A. F. (2015). Patient-related medical risk factors for periprosthetic joint infection of the hip and knee. *Annals of Translational Medicine*, *3*(16), 233.

Fallahiarezoodar, A., Kadir, M. R. A., Alizadeh, M., Naveen, S. V., & Kamarul, T. (2014). Geometric variable designs of cam/post mechanisms influence the kinematics of knee implants. *Knee Surgery, Sports Traumatology, Arthroscopy*, *22*(12), 3019-3027.

Flanagan, S. R., Ragnarsson, K. T., Ross, M. K., & Wong, D. K. (1995). Rehabilitation of the geriatric orthopaedic patient. *Clinical orthopaedics and related research*, *316*, 80-92.

References continued

Florez-Garcia, M., Garcia-Pérez, F., Curbelo, R., Pérez-Porta, I., Nishishinya, B., Lozano, M. P. R., & Carmona, L. (2016). Efficacy and safety of home-based exercises versus individualized supervised outpatient physical therapy programs after total knee arthroplasty: a systematic review and meta-analysis. *Knee Surgery, Sports Traumatology, Arthroscopy*, 1-14.

Fowler, S. J., & Christelis, N. (2013). High volume local infiltration analgesia compared to peripheral nerve block for hip and knee arthroplasty-what is the evidence?. *Anaesthesia and intensive care*, *41*(4), 458.

Franklin, P. D., Lewallen, D., Bozic, K., Hallstrom, B., Jiranek, W., & Ayers, D. C. (2014). Implementation of patient-reported outcome measures in US Total joint replacement registries: rationale, status, and plans. *J Bone Joint Surg Am*, *96*(Supplement 1), 104-109.

Fu, D., Zhao, Y., Shen, J., Cai, Z., & Hua, Y. (2016). Comparison of Venous Thromboembolism after Total Artificial Joint Replacement between Musculoskeletal Tumors and Osteoarthritis of the Knee by a Single Surgeon. *PloS one*, *11*(6), e0158215.

Gibbins, M. L., Kane, C., Smit, R. W., & Rodseth, R. N. (2016). Periarticular local anaesthetic in knee arthroplasty: A systematic review and meta-analysis of randomised trials. *SA Orthopaedic Journal*, *15*(3), 49-56.

Guerra, M. L., Singh, P. J., & Taylor, N. F. (2014). Early mobilization of patients who have had a hip or knee joint replacement reduces length of stay in hospital: a systematic review. *Clinical rehabilitation*, 0269215514558641.

Haeger K. Problems of acute deep venous thrombosis. The interpretation of signs and symptoms. Angiology 1969;20:219-23.

Hall, M., Dixon, S., Bracey, M., MacIntyre, P., Powell, R., & Toms, A. (2015). A randomized controlled trial of postoperative analgesia following total knee replacement: transdermal Fentanyl patches versus patient controlled analgesia (PCA). *European Journal Of Orthopaedic Surgery & Traumatology*, *25*(6), 1073-1079.

Harvey, L. A. (2014). Continuous passive motion following total knee arthroplasty in people with arthritis. *Cochrane Database Of Systematic Reviews*, (3),

Hass, S., Jaekel, C., & Nesbitt, B. (2015). Nursing Strategies to Reduce Length of Stay for Persons Undergoing Total Knee Replacement: Integrative Review of Key Variables. *Journal of Nursing Care Quality*, *30*(3), 283-288.

He, M. L., Xiao, Z. M., Lei, M., Li, T. S., Wu, H., & Liao, J. (2014). Continuous passive motion for preventing venous thromboembolism after total knee arthroplasty. *The Cochrane Library*.

Hofstede, S. N., Nouta, K. A., Jacobs, W., van Hooff, M. L., Wymenga, A. B., Pijls, B. G., ... & Marang-van de Mheen, P. J. (2015). Mobile bearing vs fixed bearing prostheses for posterior cruciate retaining total knee arthroplasty for postoperative functional status in patients with osteoarthritis and rheumatoid arthritis. *The Cochrane Library*.

Horn, B. J., Cien, A., Reeves, N. P., Pathak, P., & Taunt Jr, C. J. (2015). Femoral nerve block vs periarticular bupivacaine liposome injection after primary total knee arthroplasty: Effect on patient outcomes. *The Journal of the American Osteopathic Association*, *115*(12), 714-719.

Iorio, R., Clair, A. J., Inneh, I. A., Slover, J. D., Bosco, J. A., & Zuckerman, J. D. (2016). Early results of Medicare's bundled payment initiative for a 90-day total joint arthroplasty episode of care. *The Journal of Arthroplasty*, *31*(2), 343-350.

Jiang, C., Liu, Z., Wang, Y., Bian, Y., Feng, B., & Weng, X. (2016). Posterior cruciate ligament retention versus posterior stabilization for total knee arthroplasty: a meta-analysis. *PloS one*, *11*(1), e0147865.

Johnson, R. L., Kopp, S. L., Burkle, C. M., Duncan, C. M., Jacob, A. K., Erwin, P. J., ... & Mantilla, C. B. (2016). Neuraxial vs general anaesthesia for total hip and total knee arthroplasty: a systematic review of comparative-effectiveness research. *British Journal of Anaesthesia*, *116*(2), 163-176.

References continued

Joseph, N. M., Roberts, J., & Mulligan, M. T. (2016). Financial impact of total hip arthroplasty: a comparison of anterior versus posterior surgical approaches. *Arthroplasty Today*.

Kearney, M., Jennrich, M. K., Lyons, S., Robinson, R., & Berger, B. (2011). Effects of preoperative education on patient outcomes after joint replacement surgery. *Orthopaedic Nursing*, *30*(6), 391-396.

Keijsers, R., van Delft, R., van den Bekerom, M. P., de Vries, D. C., Brohet, R. M., & Nolte, P. A. (2015). Local infiltration analgesia following total knee arthroplasty: effect on post-operative pain and opioid consumption--a meta-analysis. *Knee Surgery, Sports Traumatology, Arthroscopy*, *23*(7), 1956-1963.

Keswani, A., Beck, C., Meier, K. M., Fields, A., Bronson, M. J., & Moucha, C. S. (2016). Day of surgery and surgical start time affect hospital length of stay after total hip arthroplasty. *The Journal of Arthroplasty*, *31*(11), 2426-2431.

Kianmajd, B., & Soshi, M. (2017). A new methodology of finding optimal toolpath and tooling strategies for robotic-assisted arthroplasty. *Journal of Medical Devices*, *11*(1), 011006.

Kim, H., Pelker, R. R., Gibson, D. H., Irving, J. F., & Lynch, J. K. (1997). Rollback in posterior cruciate ligament--retaining total knee arthroplasty: A radiographic analysis. *The Journal of Arthroplasty*, *12*(5), 553-561.

Klassbo M, Larsson E, Mannevik E. Hip disability and osteoarthritis outcome score. An extension of the Western Ontario and McMaster Universities Osteoarthritis Index. Scand J Rheumatol. 2003;32(1):46-51.

Kuperman, E. F., Schweizer, M., Joy, P., Gu, X., & Fang, M. M. (2016). The effects of advanced age on primary total knee arthroplasty: a meta-analysis and systematic review. *BMC geriatrics*, *16*(1), 1.

Kwak HS, Cho JH, Kim JT, Yoo JJ, Kim HJ. (2017) Intermittent pneumatic compression for the prevention of venous thromboembolism after total hip arthroplasty. *Clin Orthop Surg.* 9(1):37-42.

Lee, J. S., Hobden, E., Stiell, I. G., & Wells, G. A. (2003). Clinically important change in the visual analog scale after adequate pain control. *Academic Emergency Medicine*, *10*(10), 1128-1130.

Lemay, C. A., Lewis, C. G., Singh, J. A., & Franklin, P. D. (2017). Receipt of pain management information preoperatively is associated with improved functional gain after elective total joint arthroplasty. *The Journal of Arthroplasty*, *32*(6), 1763-1768.

Lozada, C. (2017). Progression of osteoarthritis: Stages of osteoarthritis, subsets of primary osteoarthritis, radiologic classification of osteoarthritis. *Emedicine.medscape.com*. Retrieved 20 April 2017, from http://emedicine.medscape.com/article/1930582-overview#a2

Maratt, J. D., Gagnier, J. J., Butler, P. D., Hallstrom, B. R., Urquhart, A. G., & Roberts, K. C. (2016). No Difference in Dislocation Seen in Anterior Vs Posterior Approach Total Hip Arthroplasty. *The Journal of Arthroplasty*.

McConnell, S., Kolopack, P., & Davis, A. M. (2001). The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): A review of its utility and measurement properties. *Arthritis Care & Research*, *45*(5), 453-461.

Merrill A, Millham F. (2012). Increased risk of postoperative deep vein thrombosis and pulmonary embolism in patients with inflammatory bowel disease a study of national surgical quality improvement program patients. *Arch Surg.* 147(2):120-124. doi:10.1001/archsurg.2011.297

Moskal, J. T., Capps, S. G., & Scanelli, J. A. (2016). Still no single gold standard for using cementless femoral stems routinely in total hip arthroplasty. *Arthroplasty Today*.

References continued

Murgier, J., Cailliez, J., Wargny, M., Chiron, P., Cavaignac, E., & Laffosse, J. M. (2017). Cryotherapy with dynamic intermittent compression improves recovery from revision total knee arthroplasty. *The Journal of Arthroplasty*.

Nagra, N. S., Hamilton, T. W., Ganatra, S., Murray, D. W., & Pandit, H. (2015). One-stage versus two-stage exchange arthroplasty for infected total knee arthroplasty: a systematic review. *Knee Surgery, Sports Traumatology, Arthroscopy*, 1-9.

Nankaku, M., Tsuboyama, T., Akiyama, H., Kakinoki, R., Fujita, Y., Nishimura, J., ... & Matsuda, S. (2013). Preoperative prediction of ambulatory status at 6 months after total hip arthroplasty. *Physical Therapy*, *93*(1), 88.

National Institute for Health and Care Excellence. (2014). Osteoarthritis: Care and management. *Nice.org.uk*. Retrieved 20 April 2017, from https://www.nice.org.uk/guidance/cg177

Nilsdotter, A., & Bremander, A. (2011). Measures of hip function and symptoms: Harris hip score (HHS), hip disability and osteoarthritis outcome score (HOOS), Oxford hip score (OHS), Lequesne index of severity for osteoarthritis of the hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) hip and knee questionnaire. *Arthritis care & Research*, *63*(S11), S200-S207.

O'Reilly, Richard F., Ian A. Burgess, and Bernard Zicat. (2005) "The prevalence of venous thromboembolism after hip and knee replacement surgery." *Med J Aust* 182.4:154-9.

Panni, A. S., Corona, K., Giulianelli, M., Mazzitelli, G., Del Regno, C., & Vasso, M. (2016). Antibiotic-loaded bone cement reduces risk of infections in primary total knee arthroplasty? A systematic review. *Knee Surgery, Sports Traumatology, Arthroscopy*, *24*(10), 3168-3174.

Parcells, B. W., & Tria Jr, A. J. (2016). The cruciate ligaments in total knee arthroplasty. *American Journal of Orthopedics (Belle Mead, NJ)*, *45*(4), E153.

Patnaik, P. P., Das, B. B., Sahoo, N., Das, S. K., Panda, C., & Ahmed, M. A. (2016). A study of deep vein thrombosis in surgical practice. *Age*, *8*(648X100), 1-23.

Petis, S., Howard, J. L., Lanting, B. L., & Vasarhelyi, E. M. (2015). Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes. *Canadian Journal of Surgery*, *58*(2), 128.

Pierce, T. P., Cherian, J. J., Jauregui, J. J., Elmallah, R. K., Lieberman, J. R., & Mont, M. A. (2015). A current review of mechanical compression and its role in venous thromboembolic prophylaxis in total knee and total hip arthroplasty. *The Journal of Arthroplasty*, *30*(12), 2279-2284.

Pope, D., El-Othmani, M. M., Manning, B. T., Sepula, M., Markwell, S. J., & Saleh, K. J. (2015). Impact of Age, Gender and Anesthesia Modality on Post-Operative Pain in Total Knee Arthroplasty Patients. *The Iowa Orthopaedic Journal*, *35*, 92.

Rabago, D., Mundt, M., Zgierska, A., & Grettie, J. (2015). Hypertonic dextrose injection (prolotherapy) for knee osteoarthritis: Long term outcomes. *Complementary Therapies in Medicine*, *23*(3), 388-395.

Ratto, N., Arrigoni, C., Rosso, F., Bruzzone, M., Dettoni, F., Bonasia, D. E., & Rossi, R. (2016). Total knee arthroplasty and infection: how surgeons can reduce the risks. *EFORT Open Reviews*, *1*(9), 339-344.

Scuderi, G. R., Bourne, R. B., Noble, P. C., Benjamin, J. B., Lonner, J. H., & Scott, W. N. (2012). The new knee society knee scoring system. *Clinical Orthopaedics and Related Research*, *470*(1), 3-19.

Shenoy, R., & Nathwani, D. (2017). Evidence for robots. *SICOT-J*, *3*, 38. http://doi.org/10.1051/sicotj/2017020

References continued

Shepherd, A. (Ed.). (2009, February 12). Heparin vs LMWHs vs Fondaparinux: What's the difference? *Pharmacy and Therapeutics Committee Formulary Flash*.

Siston, R. A., Giori, N. J., Goodman, S. B., & Delp, S. L. (2006). Intraoperative passive kinematics of osteoarthritic knees before and after total knee arthroplasty. *Journal of Orthopaedic Research*, *24*(8), 1607-1614

Sit, R. W., Chung, V. C., Reeves, K. D., Rabago, D., Chan, K. K., Chan, D. C., ... & Wong, S. Y. (2016). Hypertonic dextrose injections (prolotherapy) in the treatment of symptomatic knee osteoarthritis: A systematic review and meta-analysis. *Scientific Reports*, *6*.

Slaven, E. J. (2012). Prediction of functional outcome at six months following total hip arthroplasty. *Physical Therapy*, *92*(11), 1386.

Smith, G. H., Johnson, S., Ballantyne, J. A., Dunstan, E., & Brenkel, I. J. (2012). Predictors of excellent early outcome after total hip arthroplasty. *Journal of Orthopaedic Surgery and Research*, *7*(1), 1.

Snir, N., Schwarzkopf, R., Diskin, B., Takemoto, R., Hamula, M., & Meere, P. A. (2014). Incidence of patellar clunk syndrome in fixed versus high-flex mobile bearing posterior-stabilized total knee arthroplasty. *The Journal of Arthroplasty*, *29*(10), 2021-2024.

Söderman, P., & Malchau, H. (2001). Is the Harris hip score system useful to study the outcome of total hip replacement?. *Clinical orthopaedics and related research*, *384*, 189-197.

Sutlive, T. G., Lopez, H. P., Schnitker, D. E., Yawn, S. E., Halle, R. J., Mansfield, L. T., ... & Childs, J. D. (2008). Development of a clinical prediction rule for diagnosing hip osteoarthritis in individuals with unilateral hip pain. *Journal of Orthopaedic & Sports Physical Therapy*, *38*(9), 542-550.

Tayrose, G., Newman, D., Slover, J., Jaffe, F., Hunter, T., & Bosco 3rd, J. (2013). Rapid mobilization decreases length-of-stay in joint replacement patients. *Bull Hosp Jt Dis*, *71*(3), 222.

Thornley, P., Evaniew, N., Riediger, M., Winemaker, M., Bhandari, M., & Ghert, M. (2015). Postoperative antibiotic prophylaxis in total hip and knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *CMAJ open*, *3*(3), E338.

Urbano, FL. (2001). Homans' sign in the diagnosis of deep vein thrombosis. *Hospital Physician*. March, pp. 22-24

Verra, W. C., Boom, L. G. V. D., Jacobs, W. C., Schoones, J. W., Wymenga, A. B., & Nelissen, R. G. (2015). Similar outcome after retention or sacrifice of the posterior cruciate ligament in total knee arthroplasty: A systematic review and meta-analysis. *Acta Orthopaedica*, *86*(2), 195-201.

Villalta, E. M., & Peiris, C. L. (2013). Early aquatic physical therapy improves function and does not increase risk of wound-related adverse events for adults after orthopedic surgery: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, *94*(1), 138-148.

Wells PS, Anderson DR, Bormanis J, et al. Value of assessment of pretest probability of deep-vein thrombosis in clinical management. *Lancet*. 1997;350:1795-1798.

White, L., Holyoak, R., Sant, J., Hartnell, N., & Mullan, J. (2016). The effect of infrapatellar fat pad resection on outcomes post-total knee arthroplasty: a systematic review. *Archives of Orthopaedic and Trauma Surgery*, *136*(5), 701-708.

References continued

Whiting, P. S., Molina, C. S., Greenberg, S. E., Thakore, R. V., Obremskey, W. T., & Sethi, M. K. (2015). Regional anaesthesia for hip fracture surgery is associated with significantly more peri-operative complications compared with general anaesthesia. *International Orthopaedics*, *39*(7), 1321-1327.

Wilson, R. A., Watt-Watson, J., Hodnett, E., & Tranmer, J. (2016). A randomized controlled trial of an individualized preoperative education intervention for symptom management after total knee arthroplasty. *Orthopaedic Nursing*, *35*(1), 20-29.

Winther, S. B., Husby, V. S., Foss, O. A., Wik, T. S., Svenningsen, S., Engdal, M., & ... Husby, O. S. (2016). Muscular strength after total hip arthroplasty. *Acta Orthopaedica*, *87*(1), 22-28.

Yu, S., Garvin, K. L., Healy, W. L., Pellegrini Jr, V. D., & Iorio, R. (2015). Preventing hospital readmissions and limiting the complications associated with total joint arthroplasty. *Journal of the American Academy of Orthopaedic Surgeons*, *23*(11), e60-e71.

Zheng, H., Li, W., Harrold, L., Ayers, D. C., & Franklin, P. D. (2014). Web-based comparative patient-reported outcome feedback to support quality improvement and comparative effectiveness research in total joint replacement. *EGEMS*, *2*(1), 1130.

Hip and Knee Arthroplasty
Resource Links

Centers for Disease Control (CDC) Arthritis Data
https://www.cdc.gov/chronicdisease/resources/publications/aag/pdf/2016/aag-arthritis.pdf

Food and Drug Administration (FDA) Advice for Patients with Metal on Metal Implants
https://www.fda.gov/medicaldevices/productsandmedicalprocedures/implantsandprosthetics/metalonmetalhipimplants/ucm241766.htm

American Academy of Orthopedic Surgeons Clinical Practice Guidelines - AAOS
https://www.aaos.org/guidelines/

Medicare Comprehensive Care for Joint Replacement Model - CJR
Website https://innovation.cms.gov/initiatives/cjr
Provider Fact Sheet https://innovation.cms.gov/Files/fact-sheet/cjr-providerfs-finalrule.pdf

Assessment Tools
Body Mass Index Online Calculator - BMI
https://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmicalc.htm

Wells Rule Online Calculator
https://www.mdcalc.com/wells-criteria-dvt

Short Form Health Summary - SF-12v2
Copyright: https://campaign.optum.com/content/optum/en/optum-outcomes/what-we-do/health-surveys/sf-12v2-health-survey.html
Sample Form: http://www.cscc.unc.edu/codi/forms/UNLICOMMSFHSF12ShortFormHealthSurvey03192010.pdf

Western Ontario and McMaster Universities Arthritis Index - WOMAC
Copyright: http://www.womac.org/womac/index.htm
Sample Form: https://www.hss.edu/files/New_patient_Hip_WOMAC.PDF
Electronic Version:
http://www.orthopaedicscore.com/scorepages/hip_disability_osteoarthritis_outcome_score_womac.html

Harris Hip Score - HHS
Electronic Version: http://www.orthopaedicscore.com/scorepages/harris_hip_score.html

Knee Society Score - KSS
Copyright: http://www.kneesociety.org/web/outcomes.html
New Version: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3237971/pdf/11999_2011_Article_2135.pdf
Electronic Original Version: http://www.orthopaedicscore.com/scorepages/knee_society_score.html

Knee Injury and Osteoarthritis Outcome Score - KOOS
Adult and Pediatric Paper Versions: http://www.koos.nu/
Adult Electronic Version: http://www.orthopaedicscore.com/scorepages/knee_injury_osteopaedic_outcome_score.html

Hip Dysfunction and Osteoarthritis Outcome Score – HOOS
Paper Version: http://www.koos.nu/
Electronic Version: www.orthopaedicscore.com/scorepages/hip_disability_osteoarthritis_outcome_score_hoos.html