Innovations in Knee Arthroplasty: State of the art in Surgery and Rehabilitation

Dr. Jason Jennings, MD, PT – Colorado Joint Replacement
Dr. Andrew Kittelson, PT, PhD – University of Colorado Anschutz Medical Campus
Dr. Jennifer Stevens-Lapsley, PT, PhD – University of Colorado Anschutz Medical Campus
Dr. Michael Bade, PT, PhD – University of Colorado Anschutz Medical Campus

Combined Sections Meeting 2019 Washington, DC, January 23-26, 2019
Learning Objectives

• Identify best practice and evidence to support the management of patients after total joint replacement.
• Understand key surgical factors that influence post-operative rehabilitation and how to effectively communicate with your patient’s surgical team.
• Leverage health systems data to anticipate patient trajectories of recovery and resource utilization.
• Incorporate clinically effective treatments for some of the most common post-operative complications, including persistent muscle weakness, movement asymmetries, and lower extremity edema.
Disclosure

• Dr. Jennings has the following disclosures:
  – Consultation
    • Total Joint Orthopedics
    • Xenex
  – Research support
    • Porter Adventist Hospital
    • DePuy
    • Zimmer

• Drs. Kittelson, Stevens-Lapsley, and Bade have nothing to disclose
What You Need to Know About TKA

Jason M. Jennings, MD, DPT
Colorado Joint Replacement
Porter Adventist Hospital
Denver, Colorado

Adjunct Professor
University of Denver
Biomedical Department of Engineering
DISCLOSURES

- Consultation
  - Total Joint Orthopedics
  - Xenex
- Research support
  - Porter Adventist Hospital
  - DePuy
  - Zimmer
MY BACKGROUND

• Undergraduate - University of Florida

• MPT, DPT – University of St. Augustine

• ATC – Internship route

• MD – University of South Florida

• Residency – Duke University Medical Center

• Fellowship – Colorado Joint Replacement
MY PHYSICAL THERAPY MENTORS
MY PHYSICAL THERAPY MENTORS
MY PRACTICE

• Colorado Joint Replacement – Denver
  • Hip and knee – primary and revision surgery
  • Academic – 10-20 publications/year
  • Fellowship – 2 per year
  • Mission work – Operation Walk (Denver Chapter)
• Arthritis is the second most common chronic condition in the US

• Healthcare cost - ~82 billion/year
EXPECTED TO INCREASE

WHAT ARE WE GOING TO TALK ABOUT?

• Preoperative

• Intraoperative

• Postoperative

• Generalizations regarding PT
### Table 3. Comparison of published satisfaction percentages after primary total knee replacement

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>Followup (years)</th>
<th>Satisfied (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al. [2]</td>
<td>74</td>
<td>1–5.5</td>
<td>89</td>
</tr>
<tr>
<td>Noble et al. [22]</td>
<td>253</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>Robertsson et al. [23]</td>
<td>27,372</td>
<td>2–17</td>
<td>82</td>
</tr>
<tr>
<td>Wylde et al. [26]</td>
<td>228</td>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>Hawker et al. [12]</td>
<td>1193</td>
<td>2–7</td>
<td>85</td>
</tr>
<tr>
<td>Heck et al. [14]</td>
<td>291</td>
<td>2</td>
<td>88</td>
</tr>
<tr>
<td>Current study</td>
<td>1703</td>
<td>1</td>
<td>81</td>
</tr>
</tbody>
</table>

Bourne et al. CORR 2010
PATIENT EXPECTATIONS AFFECT SATISFACTION

- Satisfaction correlated with
  - Age < 60
  - Absence of residual symptoms
  - Absence of functional impairment
  - Fulfillment of expectations
    - WE CAN CONTROL!
- Noble et al. CORR, 2006 (John Insall Award)
PREOPERATIVE EDUCATION

• We currently require all patients to attend a preoperative “joints” class

• We believe patients with very short hospital length of stay may benefit greatly from the education

• There is less one-on-one hospital time with these “fast-track” patients
PREOPERATIVE REHABILITATION

• Systematic Review and Meta-analysis of RCTs
  • Slightly reduces pain in the first 4 weeks (no differences beyond)
  • Slightly improves WOMAC function and 6-8 and 12 weeks
  • Chair, toilet and stair climbing – slightly improved early
  • NO difference in length of hospital stay, cost or quality of life
  • Conclusions: effects remain too small and short term to be considered clinically-important
SURGICAL TECHNIQUE
SURGICAL TECHNIQUE
SURGICAL TECHNIQUE
SURGICAL TECHNIQUE
Ten-year Results Comparing Posterior Cruciate-retaining Versus Posterior Cruciate-substituting Total Knee Arthroplasty

Takashi Sando, MD, PhD, Richard W. McInlde, MD, FRCSC, Robert B. Bourne, MD, FRCSC, Steven J. MacDonald, MD, FRCSC, Lyndsay E. Somerville, PhD

Division of Orthopaedic Surgery, London Health Science Centre, University Campus, London, Ontario, Canada
University Hospital, University of Western Ontario, London, Ontario, Canada
TOURNIQUET USE

- Dennis et al. CORR, 2016.
**ANESTHESIA**

Table 1: Recommendations for enhanced recovery after total knee arthroplasty

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preoperative education</strong></td>
<td>Patient expectations are managed by providing preoperative and postoperative education to patients.</td>
</tr>
<tr>
<td><strong>Intraoperative factors</strong></td>
<td>Use of TKA reduces blood loss and transfusions after TKA.</td>
</tr>
<tr>
<td><strong>Rehabilitation</strong></td>
<td>Physical therapy is provided to patients.</td>
</tr>
<tr>
<td><strong>Anesthetic methods</strong></td>
<td>Neuropathic anesthesia is preferred over general anesthesia in TKA.</td>
</tr>
<tr>
<td><strong>Regional and local anesthesia</strong></td>
<td>Motor function-sparing adjacent methods such as ACIBs and PAIs can enhance perioperative pain control</td>
</tr>
<tr>
<td><strong>Analgesia</strong></td>
<td>Multimodal pain protocols incorporating acetaminophen, nonsteroidal anti-inflammatory drugs, and corticosteroids are recommended.</td>
</tr>
</tbody>
</table>

**References**

- Rutherford R, Jennings JM, Dennis DA. Orthop Clin N Am. 2017
Tranexamic Acid Reduces Blood Loss and Blood Transfusion after TKA

A Prospective Randomized Controlled Trial

Keerati Charoencholvanich MD, Pichet Siriwattanasakul MD
DRAIN USE

- Unpublished data (submitted Bone Joint)

- No differences
  - Quadriceps strength
  - Quadriceps activation
  - Swelling
  - Effusion
  - Pain
  - Complications
POSTOPERATIVE CONSIDERATIONS

Table 1: Recommendations for enhanced recovery after total knee arthroplasty

<table>
<thead>
<tr>
<th>Patient optimization</th>
<th>Psychological: Provide additional educational resources and support to patients with depression and anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anemia: Screen for preoperative anemia and correct before elective TKA, if possible</td>
</tr>
<tr>
<td></td>
<td>Diabetes: Monitor HgbA1c with a goal of &lt;8, perioperative blood glucose should ideally be kept between 110 and 140 g/dl</td>
</tr>
<tr>
<td></td>
<td>Tobacco use: Smoking cessation 4-6 wk before surgery with behavioral support</td>
</tr>
<tr>
<td></td>
<td>Malnutrition: Correct malnutrition before surgery; markers indicating malnutrition are total lymphocyte count (TLC) &lt;1500 cells/mm³, albumin &lt;3.5 g/dL, and transferrin &lt;200 mg/dL</td>
</tr>
<tr>
<td>Preoperative education</td>
<td>Patient expectations: Managing patient expectations with preoperative and postoperative education has potential benefits with conflicting data in the literature</td>
</tr>
<tr>
<td></td>
<td>Intraoperative factors: The authors recommend limiting tourniquet use to decrease quadriceps inhibition after TKA</td>
</tr>
<tr>
<td></td>
<td>Blood management: Use of TXA (either intravenous, topical, or oral) reduces blood loss and transfusions after TKA</td>
</tr>
<tr>
<td>Perioperative factors</td>
<td>Anesthetic methods: Neuraxial anesthesia appears to be safer and more effective than general anesthesia in TKA</td>
</tr>
<tr>
<td></td>
<td>Regional and local anesthesia: Motor function-sparing adjunctive methods such as ACSI and PAMS can enhance perioperative pain control</td>
</tr>
<tr>
<td></td>
<td>Analgesia: Multimodal pain protocols incorporating acetaminophen, nonsteroidal anti-inflammatory drugs, gabapentinoids, short-acting corticosteroids with supplemental opioids rather than opioid monotherapy are recommended</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>Physical therapy (PT): Although there is no consensus on length, duration, or intensity of PT after TKA, the authors’ practice is 2-3 outpatient visits per week for 4-6 wk</td>
</tr>
<tr>
<td></td>
<td>Preoperative rehabilitation: The authors favor a single preoperative PT visit, especially in those with significant preoperative disability</td>
</tr>
<tr>
<td></td>
<td>Cyrotherapy: Traditional ice or gel packs for 20-30 min per session are recommended over cryotherapy devices due to the cost and risk of thermal injury</td>
</tr>
<tr>
<td></td>
<td>CPM: Use of CPM is reserved for patients who have had a closed manipulation and is not used after primary TKA</td>
</tr>
<tr>
<td></td>
<td>Bracing: Dynamic extension bracing is reserved for severe cases of postoperative complications</td>
</tr>
<tr>
<td></td>
<td>Discharge disposition: Use of clinical care coordinators and discussing disposition in advance of surgery are recommended with strong encouragement for discharge to home</td>
</tr>
</tbody>
</table>

• Rutherford R, Jennings JM, Dennis DA. Orthop Clin N Am. 2017
• Discharge destination comparisons
  • (A) – rate of 30 day adverse reactions vs. number of risk factors
  • (B) – rate of 30 day unplanned readmissions vs. number or risk factors

• Keswani et al. JOA 2016
HIP ABDUCTION STRENGTH

DEFORMITY CORRECTION
DEFORMITY CORRECTION
DEFORMITY CORRECTION
### Table 3

Univariate Analysis of Change in Normalized Quadriceps Strength From Baseline to 1 and 6 mo Regressed on Known Covariates and Radiographic Measures.

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Change in Normalized Quadriceps Strength at 1 mo (Nm/kg)</th>
<th>Change in Normalized Quadriceps Strength at 6 mo (Nm/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>Beta Coefficient</td>
<td>P Value</td>
</tr>
<tr>
<td>Age</td>
<td>0.014</td>
<td>.0034&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.07</td>
<td>.43</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.03</td>
<td>.0007&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Quadriceps activation</td>
<td>0.01</td>
<td>&lt;0.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Radiographic measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>0.09</td>
<td>.19</td>
</tr>
<tr>
<td>DFA</td>
<td>-0.25</td>
<td>.0009&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>PFA</td>
<td>-0.03</td>
<td>.67</td>
</tr>
<tr>
<td>PTA</td>
<td>-0.06</td>
<td>.41</td>
</tr>
</tbody>
</table>

BMI, body mass index; DFA, distal femoral angle; MA, mechanical axis; PFA, patellofemoral angle; PTA, proximal tibial angle.

<sup>a</sup> Meaningful contributing variables (P <.10) retained for multivariable analysis.
Preoperative Range = Postoperative Range of Motion

(At least for flexion)
EFFUSION
Does an Elastic Compression Bandage Provide Any Benefit After Primary TKA?

Christopher N. Matthews BS, Antonia F. Chen MD, MBA, Tanine Daryoush BA, Richard H. Rothman MD, PhD, Mitchell G. Maltenfort PhD, William J. Hozack MD

Conclusions  Applying a compression bandage after TKA did not result in any clinical improvement in limb circumference, ROM, or pain. Based on this study, we believe that applying a compression bandage after TKA neither benefits nor harms the patient. Thus, we no longer use compression dressings for routine primary TKA.

Level of Evidence  Level I, therapeutic study.
Device or Ice: The Effect of Consistent Cooling Using a Device Compared with Intermittent Cooling Using an Ice Bag after Total Knee Arthroplasty

Michelle Bech, BScN, MN, ACNP, NP(A); Joanne Moorhen, BScPT; Mary Cho, BScOT; M. Ruth Lavergne, MSc; Keith Stothers, MD, FRCS(C); Alison M. Hoens, MSc, BScPT, PG Sports PT

<table>
<thead>
<tr>
<th>Table 3: Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcomes</strong></td>
</tr>
<tr>
<td>Primary outcome</td>
</tr>
<tr>
<td>Pain, NRS (24–48 h post-op)</td>
</tr>
<tr>
<td>Secondary clinical outcomes</td>
</tr>
<tr>
<td>PROM, degrees (48 h postop)</td>
</tr>
<tr>
<td>Nausea or vomiting, % yes (24–48 h postop)</td>
</tr>
<tr>
<td>Opioid use, mg (24–48 h postop)</td>
</tr>
<tr>
<td>Change in Hb, g/dL (24–48 h postop)</td>
</tr>
<tr>
<td>Change in VAS pain</td>
</tr>
<tr>
<td>Change in WOMAC stiffness</td>
</tr>
<tr>
<td>Change in WOMAC function</td>
</tr>
<tr>
<td>Length of stay, d</td>
</tr>
<tr>
<td>Length of stay, d</td>
</tr>
<tr>
<td>Patient satisfaction, cm</td>
</tr>
<tr>
<td>Patients who recommended “yes,” %</td>
</tr>
<tr>
<td>Consistency of use</td>
</tr>
<tr>
<td>Average time used during the day, % of participants</td>
</tr>
<tr>
<td>None of the time (97%)</td>
</tr>
<tr>
<td>Little bit of the time (22%)</td>
</tr>
<tr>
<td>Half the time (50%)</td>
</tr>
<tr>
<td>Almost always (75%)</td>
</tr>
<tr>
<td>Always (100%)</td>
</tr>
<tr>
<td>Average time used at night, % of participants</td>
</tr>
<tr>
<td>None of the time (97%)</td>
</tr>
<tr>
<td>Little bit of the time (22%)</td>
</tr>
<tr>
<td>Half the time (50%)</td>
</tr>
<tr>
<td>Almost always (75%)</td>
</tr>
<tr>
<td>Always (100%)</td>
</tr>
</tbody>
</table>

*Unless otherwise indicated.
NRS = Numeric Rating Scale; PROM = passive range of motion; Hb = hemoglobin; WOMAC = Western Ontario and McMaster University Osteoarthritis Index.
CRYOTHERAPY

Preoperative Morbidity

Mariano E. Meneghini
Brian T. Biletnikoff
Brent J. Morris, MD
Hassan R. Mir, MD

Narcotic Use: A Modifiable Risk Factor for Hip and Knee Arthroplasty

Robert M. O’Neal, BS; Kipp A. Cryer, MD; Paul K. Edwards, MD; C. Lowry Barnes, MD; and Simon C. Mears, MD, PhD
MINIMAL OPIOID PATHWAY

• Pre-operative
  • Tylenol
  • Meloxicam (NSAID)
  • Neurontin (Gabapentin)
  • Decadron (Steroid)

• Post-operative
  • Tylenol
  • Decadron
  • Toradol (NSAID)
  • Neurontin
  • 1st line opioid
    • Tramadol
The 2018 Chitrnanjan S. Ranawat, MD Award: Developing and Implementing a Novel Institutional Guideline Strategy Reduced Postoperative Opioid Prescribing After TKA and THA

Cody C. Wyles MD, Mario Hevesi MD, Eleanor R. Trousdale MD, Daniel S. Ubl MPH, Halena M. Gazelka MD, Elizabeth B. Habermann MPH, PhD, Robert T. Trousdale MD, Mark W. Pagnano MD, Tad M. Mabry MD

Table 1. Summary of new departmental guidelines for maximum opioid prescriptions in opioid-naïve patients

<table>
<thead>
<tr>
<th>Level</th>
<th>Representative conditions</th>
<th>Maximum OME (mg)</th>
<th>Tramadol (50 mg)</th>
<th>Hydrocodone (5 mg)</th>
<th>Oxycodeine (5 mg)</th>
<th>Hydromorphone (2 mg)</th>
<th>Oxycodeine (5 mg) + Tramadol (50 mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Acute Fracture</td>
<td>Radiculopathy Carpal tunnel</td>
<td>100</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>Oxycodeine 8 Tramadol 8</td>
</tr>
<tr>
<td>2 Knee scope</td>
<td>ACL reconstruction</td>
<td>200</td>
<td>40</td>
<td>40</td>
<td>25</td>
<td>25</td>
<td>Tramadol 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Ankle ORIF</td>
<td>Shoulder scope</td>
<td>300</td>
<td>60</td>
<td>60</td>
<td>40</td>
<td>40</td>
<td>Oxycodeine 20 Tramadol 10</td>
</tr>
<tr>
<td></td>
<td>Wrist fracture ORIF</td>
<td>Minor spine surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 THA</td>
<td>TKA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oxycodeine 25 Tramadol 40</td>
</tr>
<tr>
<td></td>
<td>TSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*OME conversion factors: tramadol: 0.1 = 50-mg tablet tramadol = 5 OME; hydrocodone: 1.0 = 5-mg tablet hydrocodone = 5 OME; oxycodeine: 1.5 = 5 mg tablet oxycodeine = 7.5 OME; hydromorphone: 4.0 = 2-mg tablet hydromorphone = 8 OME; OME = oral morphine equivalent (mg); ACL = anterior cruciate ligament; MTP = metatarsal phalangeal; ORIF = open reduction and internal fixation; TSA = total shoulder arthroplasty.
MINIMAL OPIOID PATHWAY

• Home medications
  • Tylenol
  • NSAIDs
  • Neurontin
  • Tramadol 1st line opioid
    • If needed switch to oxycodone or norco

• GOAL = Pain 5 or below at rest

• What about marijuana........
Has Self-reported Marijuana Use Changed in Patients Undergoing Total Joint Arthroplasty After the Legalization of Marijuana?

Jason M. Jennings MD, DPT, Michael A. Williams MD, Daniel L. Levy BS, Roseann M. Johnson BA, Catherine L. Eschen BS, Douglas A. Dennis MD

- Pre-legalization: 0.8% (4/500)
- Post-legalization: 11% (55/500)
- Risk factors for use (self-reporting)
  - Younger age
  - Male gender
  - Current smokers or those who did not report a smoking status
  - History of current substance abuse
  - Medicaid insurance
  - Preoperative narcotic use
OUTCOMES – MJ & TJA

- Primary unilateral TJA
- Retrospective
- Minimum 1 year follow-up
- Exclusion: alcohol, opioid or illicit drug use, tobacco use
- Match
  - Age
  - Gender
  - BMI
  - Insurance type
OUTCOMES TKA

- 71 patients in each cohort (user:nonuser)
- ROM – no difference
- KSS – no difference
  - Follow-up or overall change
- VR-12 – no difference
  - Physical
  - Mental
- No differences in readmissions/reoperations

Marijuana use does not appear to influence (adverse or beneficial) outcomes in patients undergoing a primary TKA

- Jennings et al, AAOS Poster 2019
# DOES IT WORK?

## 2 Week Follow UP (Knee Patient)

<table>
<thead>
<tr>
<th></th>
<th>User (Average ± SD) N = 25*</th>
<th>Non-User (Average ± SD) N = 25*</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain - Week 1 Average</td>
<td>4.6 ± 1.8</td>
<td>4.0 ± 1.9</td>
<td>p = 0.255</td>
</tr>
<tr>
<td>Pain - Week 2 Average</td>
<td>4.2 ± 1.9</td>
<td>3.7 ± 1.4</td>
<td>p = 0.314</td>
</tr>
<tr>
<td>Pain @ 2 Week Follow Up</td>
<td>3.1 ± 1.9</td>
<td>2.5 ± 1.5</td>
<td>p = 0.258</td>
</tr>
<tr>
<td>Narcotic Usage (Morphine Equivilence) – Week 1 Average</td>
<td>55.9 ± 31.8</td>
<td>55.2 ± 42.4</td>
<td>p = 0.946</td>
</tr>
<tr>
<td>Narcotic Usage (Morphine Equivilence) – Week 2 Average</td>
<td>40.7 ± 26.3</td>
<td>32.9 ± 28.4</td>
<td>p = 0.313</td>
</tr>
</tbody>
</table>
### DOES IT WORK?

#### 6 Week Follow Up (Knee Patient)

<table>
<thead>
<tr>
<th>Measure</th>
<th>User (Average ± SD) N = 25*</th>
<th>Non-User (Average ± SD) N = 25*</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain (Self-Reported at Visit)</td>
<td>1.7 ± 1.6</td>
<td>1.56 ± 1.9</td>
<td>p = 0.747</td>
</tr>
<tr>
<td>Pain on Knee Score</td>
<td>37.6 ± 12.3</td>
<td>37 ± 11.1</td>
<td>p = 0.857</td>
</tr>
<tr>
<td>Function</td>
<td>73 ± 19.3</td>
<td>79.0 ± 17.3</td>
<td>p = 0.253</td>
</tr>
<tr>
<td>ROM (Ext/Flex)</td>
<td>122.4 ± 10.2</td>
<td>121.9 ± 9.2</td>
<td>p = 0.862</td>
</tr>
<tr>
<td>KSS</td>
<td>157.3 ± 28.0</td>
<td>164.6 ± 21.1</td>
<td>p = 0.305</td>
</tr>
<tr>
<td>VR-12 (MCS)</td>
<td>52.1 ± 9.6</td>
<td>56.5 ± 9.4</td>
<td>p = 0.110</td>
</tr>
<tr>
<td>VR-12 (PCS)</td>
<td>37.2 ± 8.3</td>
<td>34.4 ± 9.7</td>
<td>p = 0.273</td>
</tr>
</tbody>
</table>
ONLY PROSPECTIVE STUDY

• No differences that we have found in our prospective analysis. Only attempt to study to date in TJA patients

• What is next?
  • Prospective randomized blinded
  • Marinol
WHAT SHOULD YOU DO WITH ABNORMAL FINDINGS?

• Do not ever hesitate to call the surgeon or their team

• Always do the right thing for the patient
WOUND ISSUES
ERYTHEMA
ECCHYMOSIS
ECCHYMOSIS
ADHESIVE REACTION
WHAT IS HAPPENING WITH PT

- Reimbursement most likely to decrease
- You need more evidence based outcomes
PHYSICAL THERAPY: FREQUENCY & DURATION

- No evidence based guidelines

- Functional testing and ideal target for rehabilitation needs to be established

- We typically suggest 3x/week for 4-6 weeks

- Educate patients to “not depend on your therapist”
  - Patient must work on therapy program t.i.d. on their own
BUNDLED CARE – IT IS HERE

Bundled Payment Initiatives for Medicare and Non-Medicare Total Joint Arthroplasty Patients at a Community Hospital: Bundles in the Real World
James P. Doran, BS a, Stephen J. Zabinski, MD b
a NYU Langone Medical Center, NYU Hospital for Joint Diseases, Department of Orthopaedic Surgery, New York, New York
b Division of Orthopaedic Surgery, Shore Orthopaedic University Associates, Somers Point, New Jersey

Strategies and Tactics for Successful Implementation of Bundled Payments: Bundled Payment for Care Improvement at a Large, Urban, Academic Medical Center
Richard Iorio, MD
Orthopaedic Surgery, Department of Orthopaedic Surgery, NYU Langone Medical Center, Hospital for Joint Diseases, New York, NY
TABLE 3
Guidelines for Postoperative Physical Therapy Management

<table>
<thead>
<tr>
<th>Activity</th>
<th>Geomedic</th>
<th>Walldius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of immobilization</td>
<td>1 week</td>
<td>4-6 weeks</td>
</tr>
<tr>
<td>Begin knee range of motion</td>
<td>Week 1 (average 5-7 days)</td>
<td>Week 4-6</td>
</tr>
<tr>
<td>Training in activities of daily living</td>
<td>Week 1 (in cast)</td>
<td>Week 1 (in cast)</td>
</tr>
<tr>
<td></td>
<td>Week 2 (cast removed)</td>
<td>Week 4-6 (cast removed)</td>
</tr>
<tr>
<td>Strengthening exercises to knee</td>
<td>Week 2-4</td>
<td>Week 5-7</td>
</tr>
<tr>
<td>Begin ambulation, weight bearing to tolerance</td>
<td>Week 2-3</td>
<td>Week 2 (in cylinder cast)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week 6-8 (cast removed)</td>
</tr>
</tbody>
</table>

Waters. Physical Therapy 1974
# Shift in Rehabilitation Protocol “Accelerated Rehabilitation”

## Table 1: Protocols for Standard and Accelerated Interventions for Eighty-seven Patients Treated with Total Hip or Knee Arthroplasty in Denmark from 2005 to 2006

<table>
<thead>
<tr>
<th>Standard-Protocol Group</th>
<th>Accelerated-Protocol Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information given separately to each individual patient on the day of admission</td>
<td>Patients receive information in groups at an outpatient clinic visit prior to hospitalization</td>
</tr>
<tr>
<td>Hospitalization on the day before surgery</td>
<td>Hospitalization on the day of surgery</td>
</tr>
<tr>
<td>Patients treated with arthroplasty placed randomly among other patients</td>
<td>All patients treated with arthroplasty placed together in one separate part of the ward</td>
</tr>
<tr>
<td>Various nurses in charge of care, and various occupational therapists and physiotherapists responsible for mobilization</td>
<td>One nurse in charge of a multidisciplinary team of nurses, occupational therapists, and physiotherapists</td>
</tr>
<tr>
<td>Nutrition screening</td>
<td>Nutrition screening and special focus on daily consumption of 1.5 L of fluid, including two protein beverages</td>
</tr>
<tr>
<td>Mobilization and exercise started on the first postoperative day</td>
<td>Mobilization and exercise started on the day of surgery</td>
</tr>
<tr>
<td>Individual and gradual mobilization according to the patient’s tolerance</td>
<td>Intensive mobilization of patients in teams after preset daily goals</td>
</tr>
<tr>
<td>Four hours of mobilization daily</td>
<td>Eight hours of mobilization daily</td>
</tr>
<tr>
<td></td>
<td>No difference in operating theater</td>
</tr>
<tr>
<td></td>
<td>No difference in pain relief, nausea control, or bowel regulation</td>
</tr>
</tbody>
</table>
2018 John N. Insall Award: Recovery of Knee Flexion With Unsupervised Home Exercise Is Not Inferior to Outpatient Physical Therapy After TKA: A Randomized Trial

Andrew N. Fleischman MD, Meredith P. Crizer BS, Majd Tarabichi MD, Shelby Smith BS, Richard H. Rothman MD, PhD, Jess H. Lonner MD, Antonia F. Chen MD, MBA

Fig. 2  This histogram demonstrates the change in knee flexion from preoperative baseline at 4 to 6 weeks to 6 months.
In-Home Telerehabilitation Compared with Face-to-Face Rehabilitation After Total Knee Arthroplasty

A Noninferiority Randomized Controlled Trial

Hélène Moffet, PT, PhD, Michel Tousignant, PT, PhD, Sylvie Nadeau, PT, PhD, Chantal Mérette, PhD, Patrick Boissy, PhD, Hélène Corriveau, PT, PhD, François Marquis, MD, François Cabana, MD, Pierre Ranger, MD, Etienne L. Bélisle, MD, and Ronald Dimenberg, MD

Investigation performed at the Center for Interdisciplinary Research in Rehabilitation and Social Integration, Québec; the Research Centre on Aging, Sherbrooke; and the Center for Interdisciplinary Research in Rehabilitation of Greater Montréal, Montréal, Québec, Canada
Home-Health-Care Physical Therapy Improves Early Functional Recovery of Medicare Beneficiaries After Total Knee Arthroplasty

Jason R. Falvey, DPT, Michael J. Bade, PhD, Jeri E. Forster, PhD, Robert E. Burke, MD, MS, Jason M. Jennings, MD, Eugene Nucio, PhD, and Jennifer E. Stevens-Lapsley, PhD

Investigation performed at the University of Colorado, Anschutz Medical Campus, Aurora, Colorado

<table>
<thead>
<tr>
<th>TABLE II Improvement in ADL Function by PT Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Improvement in ADL Score (95% CI (points))</td>
</tr>
<tr>
<td>PT Utilization</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>≤5 visits</td>
</tr>
<tr>
<td>6-9 visits</td>
</tr>
<tr>
<td>10-13 visits</td>
</tr>
<tr>
<td>≥14 visits</td>
</tr>
</tbody>
</table>

*Adjusted for age, sex, baseline ADL function, non-elective admission, duration of home health care, living alone, CCI, baseline dyspnea, and presence of severe pain. †P < 0.0001 compared with low PT utilization.
JOINTS WITH ALTITUDE
OPERATION WALK
OPERATION WALK
Leveraging Health Systems Data to Anticipate Patient Recovery Trajectories and Shape Resource Utilization

Andrew Kittelson, PT, PhD
Assistant Professor
University of Colorado Denver
Physical Therapy Program
Rehabilitation Science PhD Program
Provider Challenges
Provider Challenges

How to help patients understand TKA and recovery
Provider Challenges

How to help patients understand TKA and recovery

Demonstrating resource-responsible care
Provider Challenges

How to help patients understand TKA and recovery

Demonstrating resource-responsible care

Standardizing person-centered care
Patient Challenges
Patient Challenges

Burden to understand surgery and recovery
Patient Challenges

Information based on the “average patient”

Burden to understand surgery and recovery
Patient Challenges

Information based on the “average patient”

No framework for person-centered discussions

Burden to understand surgery and recovery
Patient Challenges

Information based on the “average patient”

No framework for person-centered discussions

Burden to understand surgery and recovery

Benchmarking recovery: “Am I recovering as I should be?”
“Most people do well with intensive physical therapy, but for me it backfired and set up a vicious cycle of inflammation. I needed a different protocol than the standard one that works for the majority. I needed a protocol for patients with histories and conditions like mine.”
“Most people do well with intensive physical therapy, but for me it backfired and set up a vicious cycle of inflammation. I needed a different protocol than the standard one that works for the majority. I needed a protocol for patients with histories and conditions like mine.”
“Personalized Outcome Forecasts”

The Role of Outcome Forecasts in Patients’ Treatment Decisions—Evidence from a Survey Experiment on Knee Replacement Surgery

Iris Kesternich, Francis G. Caro, Alison S. Gottlieb, Susanne Hoffmann, and Joachim K. Winter
• Age
• Gender
• BMI
- Age
- Gender
- BMI
Compared to similar patients, the patient is currently in the 63rd percentile.
- Age
- Gender
- BMI
- Age
- Gender
- BMI
Compared to similar patients, the patient is currently in the 35th percentile.
Compared to similar patients, the patient's knee flexion AROM is currently in the 65 percentile.

Compared to all patients with TKA, the patient's knee flexion AROM is currently in the 96 percentile.
Compared to similar patients, the patient's flexion AROM is currently in the 38th percentile.

Based on the recovery of previous similar patients, we have 90% confidence the patient's 3mo flexion AROM will be greater than 110 degrees.

This is typically sufficient for:
- Level walking
- Walking up or down a slope
- Ascending and descending stairs
- Sit to stand from a low chair
- Sit to stand from a standard chair

The patient may have difficulty with:
- Getting in and out of a bath
- Cycling (bicycle ergometer)
It starts with a conversation...

“When you don’t know what is going on or what is causing the pain or what to expect...you don’t know if your experience is typical or something is wrong...either I’m not on track or something is wrong”

“AVERAGE PATIENT LIKE ME HAS NO IDEA WHAT IS COMING”

“The patient wants to know, well where do I fall in? I would have loved that”
It starts with a conversation...

• Data should support clinical interactions (feedback and feedforward)
It starts with a conversation...

- Data should support clinical interactions (feedback and feedforward)

The most clinical important outcomes
It starts with a conversation...

• Data should support clinical interactions (feedback and feedforward)

The most clinical important outcomes

Responsive

Low measurement error
It starts with a conversation...

• Data should support clinical interactions (feedback and feedforward)
• Address the key “pain points” of patients and providers
It starts with a conversation...

- Data should support clinical interactions (feedback and feedforward)
- Address the key “pain points” of patients and providers
- The importance of user-centered design
A collaborative team committed to optimizing movement and quality-of-life in older adults through innovative research and educational excellence

www.movement4everyone.com
Lower Extremity Weakness after TKA

Jennifer Stevens-Lapsley, PT, PhD
Professor
Director, Rehabilitation Science PhD Program
University of Colorado
Eastern Colorado Geriatrics Research Education and Clinical Center
90% of patients have a substantial reduction in their knee pain

Pain reduction = #1 Benefit of TKA

TKA Outcomes

- Range of motion (ROM) at 1 year
  - Flexion: 110-124°
  - Extension: -1-0°


- Knee ROM limits function only when ROM limited acutely
Outcomes with TKA

Long-term deficits in strength and function compared to healthy adults:

- 40% deficits in quadriceps strength
- 30% deficits in walking distance
- 105% deficit in stair climbing speed
Quadriceps Strength Loss After TKA

* Significantly different from healthy adults (p<0.05)

Bade et al JOSPT, 2010
Stair Climbing Performance After TKA

* Significantly different from healthy adults (p<0.05)
What should be the focus to improve outcomes?

- Quadriceps strength is directly related to functional performance.
  - Brown et al 1995
  - Connelly et al 1997

- Therefore, quadriceps strength is the focus of much ongoing research.
Clinical Implications

- Activation deficits account for a greater proportion of the post-operative weakness than muscle atrophy. (Mizner 2005)

- Patients with large muscle activation deficits have negligible improvements in force even after intensive rehabilitation. (Hurley 1993)
Clinical Implications

- Muscle activation deficits moderate the relationship between quadriceps strength and physical function with OA.

- Physical function loss
  - Weakness with activation failure
  - Weakness without activation failure

  Fitzgerald et al. Arthritis Rheum 2004
Strength loss

Activation deficits

Muscle size
Mechanisms for Quadriceps Strength Loss

- Pre-existing Quadriceps Strength Deficits
- Acute Strength Loss
  - Activation Deficit
- Long Term Strength Loss
  - Atrophy
Muscle Force and Activation

Activation Deficit

Complete Activation

Torque (N·m) vs. Time (ms)
Activation Deficit

Torque (N·m) vs. Time (ms)

- Diagram showing a graph with time on the x-axis and torque on the y-axis, indicating a peak in torque around 3000 ms.
- Image of a patient seated in a chair with medical equipment around, possibly related to the measurement or analysis of torque.

University of Colorado
Anschutz Medical Campus
Complete Activation
Clinical Activation Battery

3 Tasks (Total Possible Score = 6 points):

QUAD SET
0: Unable to initiate contraction
1: Poor contraction no superior patellar movement
2: Strong contraction, visible superior movement of patella

STRAIGHT LEG RAISE
0: Unable to perform
1: Performed with Flexed Knee
2: Good form (lift leg >2 feet)

EXTENSION LAG TEST
0: Unable to hold against gravity
1: Able to maintain <1 s, slows leg
2: Able to maintain >1 s.
Inpatient PT
3 days
6 sessions

Home PT
2 weeks
6 sessions

Outpatient PT
6 weeks
10-12 sessions

TKA surgery

Pre-Op Testing Session

Post-op Day 1

3.5 wk Testing Session

Post-op Day 2

6.5 wk Testing Session

Neuromuscular Electrical Stimulation

NMES Home Treatment
6 weeks (2x/day)
<table>
<thead>
<tr>
<th>Time Point</th>
<th>Activation (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-op</td>
<td>65</td>
</tr>
<tr>
<td>3.5 wks</td>
<td>70</td>
</tr>
<tr>
<td>6.5 wks</td>
<td>75</td>
</tr>
<tr>
<td>13 wks</td>
<td>80</td>
</tr>
<tr>
<td>26 wks</td>
<td>85</td>
</tr>
<tr>
<td>52 wks</td>
<td>90</td>
</tr>
</tbody>
</table>

**Quadriceps Activation**

Stevens-Lapsley et al. *PTJ* 2012
**Quadriceps Normalized Strength**

- **Time Point**
  - Pre-op
  - 3.5 wks
  - 6.5 wks
  - 13 wks
  - 26 wks
  - 52 wks

- **Normalized Torque (N-m/kg)**
  - 0.4
  - 0.6
  - 0.8
  - 1.0
  - 1.2
  - 1.4
  - 1.6
  - 1.8
  - 2.0

- * NMES
- * Control

**Hamstrings Normalized Strength**

- **Time Point**
  - Pre-op
  - 3.5 wks
  - 6.5 wks
  - 13 wks
  - 26 wks
  - 52 wks

- **Normalized Torque (N-m/kg)**
  - 0.3
  - 0.4
  - 0.5
  - 0.6
  - 0.7
  - 0.8
  - 0.9
  - 1.0

- * NMES
- * Control
**Timed Up and Go Test**

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Pre-op</th>
<th>3.5 wks</th>
<th>6.5 wks</th>
<th>13 wks</th>
<th>26 wks</th>
<th>52 wks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (sec)</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

**Stair Climbing Test**

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Pre-op</th>
<th>3.5 wks</th>
<th>6.5 wks</th>
<th>13 wks</th>
<th>26 wks</th>
<th>52 wks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (sec)</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

**Diagram**

- **Stair Climbing Test**
  - NMES
  - Control

- **Timed Up and Go Test**
  - NMES
  - Control

*Significant difference at specific time points.*
Clinical Application

- Two-phase algorithm for patient selection and treatment intended to improve clinical decisions regarding
  - 1) the appropriateness of NMES therapy
  - 2) monitoring of patient progress
  - 3) the timing and rationale for NMES therapy modifications or cessation

Spector et al. JBJS 2016
Algorithm

Patient Education

NMES Familiarization (1-2 wks)

KNEE SURGERY

Treatment Phase 1: High-Intensity High-Volume NMES (~3wks)

Evaluation Session 1

Fitzgerald Criteria

YES

NO

Exclusion

Evaluation Session 2

Activation Failure

YES

NO

Treatment Phase 2: High-Intensity Low-Volume NMES (~3wks)

Voluntary Strengthening

3 wks

>12 Sessions

Spector et al. JBJS 2016
## Recommendations for Quadriceps NMES Therapy

### Current Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment Phase 1</th>
<th>Treatment Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulse waveform</strong></td>
<td>Symmetrical biphasic rectangular or sinusoidal</td>
<td></td>
</tr>
<tr>
<td><strong>Pulse Duration</strong></td>
<td>200-300 µs</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>~50 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td>Highest tolerable</td>
<td></td>
</tr>
<tr>
<td><strong>On:off time</strong></td>
<td>~10:30 s³</td>
<td></td>
</tr>
</tbody>
</table>

### Treatment session characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment Phase 1</th>
<th>Treatment Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>~10 min/session</td>
<td>~15 min/session</td>
</tr>
<tr>
<td><strong>Number of contractions</strong></td>
<td>~15/session</td>
<td>~22/session</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>2-3 session/day</td>
<td>4-6 sessions/week</td>
</tr>
</tbody>
</table>

### General Settings (see also Fig 2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrode number and size</strong></td>
<td>Two rectangular electrodes (e.g. 3x5 inches)</td>
</tr>
<tr>
<td><strong>Electrode position</strong></td>
<td>Over vastus medialis (distal electrode) and vastus lateralis (proximal electrode)</td>
</tr>
<tr>
<td><strong>Knee angle</strong></td>
<td>60-75° of flexion</td>
</tr>
</tbody>
</table>

Spector et al. *JBJS* 2016
Algorithm

Patient Education → NMES Familiarization (1-2 wks) → KNEE SURGERY → Evaluation Session 1

Evaluation Session 2 → Activation Failure

Treatment Phase 1: High-Intensity High-Volume NMES (~3wks) → YES → Fitzgerald Criteria → Evaluation Session 1

NO → Exclusion

YES → 1 wk → Treatment Phase 2: High-Intensity Low-Volume NMES (~3wks) → >12 Sessions → Voluntary Strengthening

3 wks → YES → 3 wks → NO → 3 wks

Spector et al. JBJS 2016
Fitzgerald Criteria

NMES should evoke a full, sustained, tetanic contraction of the quadriceps with visual or palpable evidence of superior patellar glide.
Algorithm

Patient Education

NMES Familiarization (1-2 wks)

KNEE SURGERY

Evaluation Session 1

Fitzgerald Criteria

Exclusion

Evaluation Session 2

Activation Failure

Treatment Phase 1: High-Intensity High-Volume NMES (~3wks)

Treatment Phase 2: High-Intensity Low-Volume NMES (~3wks)

Voluntary Strengthening

YES

NO

YES

NO

1 wk

3 wks

>12 Sessions

Spector et al. JBJS 2016
Clinical Activation Battery

3 Tasks (Total Possible Score = 6 points):

**QUAD SET**
- 0: Unable to initiate contraction
- 1: Poor contraction no superior patellar movement
- 2: Strong contraction, visible superior movement of patella

**STRAIGHT LEG RAISE**
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**EXTENSION LAG TEST**
- 0: Unable to hold against gravity
- 1: Able to maintain <1 s, slows leg
- 2: Able to maintain >1 s.
Algorithm

Patient Education

NMES Familiarization (1-2 wks)

KNEE SURGERY

Evaluation Session 1

Fitzgerald Criteria

YES

NO

Evaluation Session 2

YES

NO

Activation Failure

Treatment Phase 1: High-Intensity High-Volume NMES (~3wks)

1 wk

>12 Sessions

Voluntary Strengthening

Treatment Phase 2: High-Intensity Low-Volume NMES (~3wks)

3 wks

3 wks

Spector et al. JBJS 2016
Portable NMES Units

Flex-MT Plus

Designed to help with muscle re-education, reduction of atrophy, muscle spasm, and pain, the Flex-MT Plus is now a more powerful, yet still portable device to help patients recover.
Systematic Review of Three Electrical Stimulation Techniques for Rehabilitation After Total Knee Arthroplasty.

Yue C¹, Zheng X¹, Zhu Y¹, Jia Y¹, Wang H¹, Liu Y¹.


Does electric stimulation of the vastus medialis muscle influence rehabilitation after total knee replacement?

Avramidis K¹, Karachalios T, Popoteasios K, SACORFAES D, Papathanasiades AA, Malizos KN.


Comparison of the Effect of Sensory-Level and Conventional Motor-Level Neuromuscular Electrical Stimulation on Quadriceps Strength After Total Knee Arthroplasty: A Prospective Randomized Single-Blind Trial.

Yoshida Y¹, Ikuno K², Shumoto K³.
Repetitive Facilitated Long Arc Quad
Concerns

- Increased swelling
- Risk for injury

Increased pain

Decreased ROM

Prosthesis

Musculoskeletal

Alternative to NMES: Intensive Rehabilitation
RCT of 162 subjects after TKA
  - high-intensity progressive rehabilitation protocol (HI)
  - lower-intensity rehabilitation protocol (LI)
High-Intensity Group
Early initiation of an intensive rehabilitation program targeting:
• Lower extremity strength
• Balance
• Agility
• Faster progression to weight-bearing strengthening

Progression: pain, ROM, swelling, & function

Low-Intensity Group
Standard rehabilitation targeting:
• ROM
• Stretching
• Moderate resistance bands
• Moderate-demand functional exercises

Progression: time-based

Participants
N = 162 (89 females)
63 ± 7 years of age

Methods

Higher level of exercise progression

Outcome Measures
pre-op, 1, 2, 3, 6, 12 mos post-op
1. Stair climbing test
2. Timed-up-and-go
3. Five-times sit-to-stand
4. 6-minute walk
5. Quadriceps/Hamstrings strength & activation
6. Surgical limb ROM
7. WOMAC Index of OA

2-3x/wk for 12 weeks
25 total visits

University of Colorado
Denver | Anschutz Medical Campus
## Key Differences Between Interventions

<table>
<thead>
<tr>
<th>Element</th>
<th>High-Intensity Intervention</th>
<th>Low-Intensity Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise Difficulty &amp; Complexity</td>
<td>Quick Progression to WB Exercise Utilization of Weights (8RM) Higher Level WB Exercises</td>
<td>Initial focus on NWB exercises Slower progression through WB exercises</td>
</tr>
<tr>
<td>Progression</td>
<td>Ability-Based (Progression Criteria)</td>
<td>Time-Based (Tissue-Based)</td>
</tr>
<tr>
<td>Education</td>
<td>Focused on detrimental effects of surgery and that knee replacements are strong and safe to use</td>
<td>Focused on the need to protect the new joint in the early postoperative period to facilitate healing</td>
</tr>
<tr>
<td>Activities</td>
<td>Early prescription of a home walking program with progression to higher level activities</td>
<td>Instructed to minimize activity in the 1st month to ADLs only with gradual progression in walking program by 3 months</td>
</tr>
</tbody>
</table>
Progression Criteria:

- Decrease in ability to rise from a chair or walking endurance?
- Any soreness >2 hours following last tx?
- Decrease in AROM by 5°?
- Increase in swelling > 2cm?
- Increase in resting VPRS by 2 points?

- **If one criteria is positive maintain current level of provocative exercise/s and advance all others as tolerated...**

- **If two or more criteria are “yes” decrease tx intensity**
High Intensity Exercise Progression (performance-based)

<table>
<thead>
<tr>
<th>Warm-up</th>
<th>PRE</th>
<th>Function</th>
<th>Balance</th>
<th>Agility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Gym AAROM or Assisted Heel Slides</td>
<td>Assisted LAQ</td>
<td>Mini-Squats</td>
<td>Weight shifting</td>
<td>Side Stepping</td>
</tr>
<tr>
<td>Stationary Biking - Partial Circles or Total Gym AROM</td>
<td>LAQ</td>
<td>Sit to Stands</td>
<td>Marching (Decrease UE Support)</td>
<td>Marching</td>
</tr>
<tr>
<td>Stationary Biking - Full Circles with Decreasing Seat Height</td>
<td>LAQ with Ankle Weight</td>
<td>Ball Wall Slides</td>
<td>Balance Board Stance/Squats</td>
<td>SLS – Eyes Closed, Restart SLS Progression</td>
</tr>
<tr>
<td>Stationary Biking at Normal Seat Height – Increase Resistance 10% Every 2 Weeks</td>
<td>Machine Leg Extension (8 RM Goal of 10% Increase Every 2 weeks)</td>
<td>Wall Slide Endurance Holds</td>
<td>Star Excursion Foot Reach ± Weight (Can count as a balance exercise)</td>
<td>Side Shuffles, Grape Vine, Figure 8 Walking, Backward Shuffle (Progress Volume and Speed)</td>
</tr>
</tbody>
</table>

- **Quadriceps**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip 4-way (With UE support)**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**
- **Machine Calf Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**

- **Hamstrings**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
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- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**
- **Machine Calf Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**

- **Hip**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**
- **Machine Calf Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**

- **Gluts**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
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- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**
- **Machine Calf Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**

- **Calf**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
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- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**
- **Machine Calf Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**

- **Quadriceps**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**

- **Hamstrings**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**

- **Hip**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**

- **Gluts**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
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- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
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- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**

- **Calf**
- **SAQ**
- **Heel Slides**
- **Standing Curls**
- **Standing Hip Adduction**
- **Glute Squeezes**
- **Standing Hip Adduction**
- **Total Gym Squats (Increase % Body Weight) progress bilat to unilat**
- **Bilateral Calf Raise (Decrease UE support)**
- **Machine Leg Press (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Machine Leg Curls (8 RM Goal of 10% Increase every 2 weeks) progress bilat to unilateral**
- **Supine Stability Ball Bridge Progression**
- **Resisted Hip 4-way (Decrease UE Support)**
- **Resisted Hip 4-way No Support (8 RM Goal of 10% Increase every 2 weeks)**

- **Bilateral**
- **Mini-Squats**
- **Step Ups, Side Step Ups, Step Downs (Progress Height, Decrease UE support)**
- **Forward Lunge (Progress Depth, Decrease UE Support)**

- **Unilateral**
- **Multi-directional Stepping**
- **Wall Slide Endurance Holds**

- **Supine Stability Ball Bridge Progression ± Weight (Can count as a balance exercise)**
- **Star Excursion Foot Reach ± Weight (Can count as a balance exercise)**
- **Multi-Directional Lunge ± Weight (Can count as a balance exercise)**
## Low-Intensity Exercise Progression (time-based)

<table>
<thead>
<tr>
<th>Time</th>
<th>CLINICAL TREATMENT</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manual techniques</td>
<td>Surgery – Week 2</td>
<td>Week 3 – Week 4</td>
<td>Week 5 – Week 6</td>
<td>Week 7 – Week 9</td>
<td>Week 10 – End</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Patellar mobilization</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Patellar mobilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Distraction</td>
<td>• Functional training (stair)</td>
<td>• AD progression</td>
<td>• Gait training</td>
<td>• Distraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Proximal tib/fib as needed</td>
<td>• Gait training</td>
<td>• AD progression</td>
<td>• AD progression</td>
<td>• Proximal tib/fib as needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PROM (knee/hip)</td>
<td>• Heel slides</td>
<td>• AD progression</td>
<td>• Seated theraband hamstring curls (min resistance)</td>
<td>• PROM (knee/hip)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Soft tissue mobilization</td>
<td>• Glut sets</td>
<td>• Short arc quads</td>
<td>• Stool scoots fwd/bkwd</td>
<td>• Soft tissue mobilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Incision massage (if healed)</td>
<td>• Quad sets</td>
<td>• Straight leg raises</td>
<td>• Single leg stance</td>
<td>• Incision massage (if healed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ankle Pumps</td>
<td>• Ankle Pumps</td>
<td>• Standing hamstring curls</td>
<td>• Balance board stance</td>
<td>• Manual stretching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mini-squats</td>
<td>• Standing hamstring curls</td>
<td>• Standing weight shifts</td>
<td>• Closed chain TKE (min resistance)</td>
<td>• Manual stretching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mini-squats</td>
<td>• Mini-squats</td>
<td>• Mini-squats</td>
<td>• Sit to stands</td>
<td>• Manual stretching</td>
</tr>
<tr>
<td></td>
<td>Ther Ex</td>
<td>• Functional training (bed, transfers, stairs)</td>
<td>• Techiques</td>
<td>• Techiques</td>
<td>• Techiques</td>
<td>• Techiques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Gait training</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Gait training</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• AD progression</td>
<td>• Functional training (stair)</td>
<td>• AD progression</td>
<td>• AD progression</td>
<td>• Gait training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heel slides</td>
<td>• Gait training</td>
<td>• AD progression</td>
<td>• Seated theraband hamstring curls (min resistance)</td>
<td>• AD progression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Glut sets</td>
<td>• Heel slides</td>
<td>• AD progression</td>
<td>• Stool scoots f/wd/bkwd</td>
<td>• AD progression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Quad sets</td>
<td>• Glut sets</td>
<td>• Short arc quads</td>
<td>• Single leg stance</td>
<td>• Gait training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ankle Pumps</td>
<td>• Quad sets</td>
<td>• Straight leg raises</td>
<td>• Balance board stance</td>
<td>• AD progression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Standing hamstring curls</td>
<td>• Ankle Pumps</td>
<td>• Standing hamstring curls</td>
<td>• Closed chain TKE (min resistance)</td>
<td>• Seated theraband hamstring curls (mod/heavy resistance)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Standing weight shifts</td>
<td>• Standing weight shifts</td>
<td>• Standing weight shifts</td>
<td>• Sit to stands</td>
<td>• Stool scoots f/wd/bkwd</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mini-squats</td>
<td>• Mini-squats</td>
<td>• Mini-squats</td>
<td>• Bilateral calf raises</td>
<td>• Single leg stance</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>• Pain management</td>
<td>• Techiques</td>
<td>• Techiques</td>
<td>• Techiques</td>
<td>• Techiques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Swelling control</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
<td>• Warm up on bike with no resistance (5 min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Wound healing</td>
<td>• Functional training (stair)</td>
<td>• AD progression</td>
<td>• AD progression</td>
<td>• AD progression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Educate on overdoing it in the early phase of rehab and need to decrease swelling first</td>
<td>• Gait training</td>
<td>• Seated theraband hamstring curls (min resistance)</td>
<td>• Stool scoots f/wd/bkwd</td>
<td>• Activity counseling</td>
</tr>
<tr>
<td></td>
<td>Modalities</td>
<td>None</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ice after therapy (10-15 min)</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ice after therapy (10-15 min)</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
<td>• Activity counseling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heat before therapy or ice after therapy (10-15 min)</td>
<td>• Heat before therapy or ice after therapy (10-15 min)</td>
<td>• Heat before therapy or ice after therapy (10-15 min)</td>
<td>• Heat before therapy or ice after therapy (10-15 min)</td>
<td>• Heat before therapy or ice after therapy (10-15 min)</td>
</tr>
</tbody>
</table>
# Low-Intensity Exercise Progression (time-based)

<table>
<thead>
<tr>
<th>HOME EXERCISE PLAN</th>
<th>Time</th>
<th>PHASE 1</th>
<th>PHASE 2</th>
<th>PHASE 3</th>
<th>PHASE 4</th>
<th>PHASE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td></td>
<td>Surgery – Week 2</td>
<td>Week 3 – Week 4</td>
<td>Week 5– Week 6</td>
<td>Week 7– Week 9</td>
<td>Week 10 – End</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 x 10 reps 2x daily on non-therapy days: • Heel slides • Glut squeezes • Ankle pumps • Quad sets</td>
<td>2 x 10 reps 2x daily on non-therapy days: • Short arc quads • Straight leg raises • Ankle pumps • Clams • Standing hamstring curls • Standing weight shifts</td>
<td>2 x 10 reps 1x daily on non-therapy days: • Long arc quads • Straight leg raises • Standing hamstring curls • Marching • Bilateral calf raises</td>
<td>2 x 10 reps 3x/week on non-therapy days: • Seated hamstring curls (min/mod resistance TB) • Closed chain TKE (mod resistance TB) • Bilateral calf raises • Single leg stance</td>
<td>2 x 10 reps 3x/week on non-therapy days: • Seated hamstring curls (mod/heavy resistance TB) • Single leg stance - foam • TKE (mod/heavy resistance TB) • Bilateral calf raises</td>
</tr>
<tr>
<td><strong>Stretching</strong></td>
<td></td>
<td>AROM/AAROM warm-up • 30-60 min/day flexion/extension static stretching • Self patellar mobilization</td>
<td>AROM/AAROM warm-up • 30-60 min/day flexion/extension static stretching • Self patellar mobilization</td>
<td>If needed; discontinued if ROM 0-120 degrees • AROM/AAROM warm-up • 30-60 min/day flexion/extension static stretching • Self patellar mobilization • Daily quad, hamstrings, calf, hip stretching as appropriate</td>
<td>If needed; discontinued if ROM 0-120 degrees • AROM/AAROM warm-up • 30-60 min/day flexion/extension static stretching • Self patellar mobilization • Daily quad, hamstrings, calf, hip stretching as appropriate</td>
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</tr>
<tr>
<td><strong>Activity</strong></td>
<td></td>
<td>ADLs only, including: • Errands • Social outings • Limited community ambulation</td>
<td>ADLs only, including: • Errands • Social outings • Limited community ambulation</td>
<td>Up to 10 min of stationary biking (min resistance) or walking if patient does not spend a large amount of time standing during the day</td>
<td>Up to 20 min of stationary biking (min resistance) or walking if patient does not spend a large amount of time standing during the day</td>
<td>Up to 30 min of stationary biking (min resistance) or walking if patient does not spend a large amount of time standing during the day</td>
</tr>
<tr>
<td><strong>Modalities</strong></td>
<td></td>
<td>Ice 3-5x/day with emphasis on elevation</td>
<td>Ice after HEP</td>
<td>Ice after HEP and as needed</td>
<td>Ice after HEP and as needed</td>
<td>Ice after HEP and as needed</td>
</tr>
</tbody>
</table>

- **HOME EXERCISE PLAN**
- **Time**
- **PHASE 1**
  - Surgery – Week 2
  - Week 3 – Week 4
- **PHASE 2**
- **PHASE 3**
  - Week 5– Week 6
- **PHASE 4**
  - Week 7– Week 9
- **PHASE 5**
  - Week 10 – End

- **Strength**
  - 2 x 10 reps 2x daily on non-therapy days:
    - Heel slides
    - Glut squeezes
    - Ankle pumps
    - Quad sets
- **Stretching**
  - AROM/AAROM warm-up
  - 30-60 min/day flexion/extension static stretching
  - Self patellar mobilization
- **Activity**
  - ADLs only, including:
    - Errands
    - Social outings
    - Limited community ambulation
- **Modalities**
  - Ice 3-5x/day with emphasis on elevation

- **ADLs only, including:**
  - Errands
  - Social outings
  - Limited community ambulation
- **Ice after HEP**
- **Ice after HEP and as needed**
Results - Safety

- No significant differences in ROM between groups (p>0.05)
- No significant differences in adverse events between groups (p>0.05)
Results - Efficacy

- No significant difference between groups at any time point in functional performance, strength, activation, or WOMAC score (p>0.05).
- Notable variability in both interventions
Comparison with Prior Study Results

Stair Climbing Test

Time Point
Preop 1month 3 months 12 months
Seconds
0 5 10 15 20 25 30 35 40 45 50
Control (2012a)
Control (2012b) 2

Stevens-Lapsley 2012, Stevens-Lapsley 2012

- Poorer Performance
- Better Performance
Secondary Analyses

Home exercise compliance differed by group
- HI: 76% compliance
- LI: 83% compliance

Activity compliance
- PASE score did not differ by group over time
- PASE scores should have been different at all time points during the intervention
Early Activation and Recovery

Stair Climbing Test Time

Time (s)

Time Point (Months)

High Activation - LI
Low Activation - LI
High Activation - HI
Low Activation - HI

Poorer Performance
Better Performance
Conclusions

• High-intensity rehabilitation after TKA:
  • Is safe to utilize and does not compromise ROM or safety
  • Decision to utilize this approach should be based on several factors (e.g. patient preference, activation deficits)
  • Both high-intensity and lower-intensity programs were effective in improving functional performance after TKA
  • Neither program was more effective in helping individuals with activation deficits recovery as quickly as those without activation deficits
Additional Studies

The Effect of Early Progressive Resistive Exercise Therapy on Balance Control of Patients With Total Knee Arthroplasty
A Randomized Controlled Trial

Randomized controlled trial of maximal strength training vs. standard rehabilitation following total knee arthroplasty

Vigdis S. HUSBY, Olav A. FOSS, Otto S. HUSBY, Sivi B. WINther
A collaborative team committed to optimizing movement and quality-of-life in older adults through innovative research and educational excellence

www.movement4everyone.com
Movement Pattern Training after Total Knee Arthroplasty

Michael Bade, PT, PhD, OCS, FAAOMPT
Movement Pattern Asymmetry After TKA
Movement Pattern Asymmetry
Transitions from Sitting to Standing

Use of Hands and Poor Eccentric Control
Quadriceps Avoidance

Increased Hip Flexion
Hip Extensor Substitution

Affected Limb
Asymmetrical Foot Placement
Quadriceps Avoidance

Weight Shift Towards Non-Surgical Limb
Unloading Substitution

Asymmetry Increases with:
• Constrained Foot Position
• Depth
• Speed
Why is Asymmetry Important?

- Movement asymmetry persists in the long-term
- Asymmetry is related to recovery of strength and function

TIME POINT | PAIN | STRENGTH RATIO | 6MWT | SCT
---|---|---|---|---
PRE TKA | -0.34* | 0.37* | 0.29* | -0.39*
TKA 1M | -0.18 | 0.20 | -0.05 | -0.39*
TKA 3M | -0.19 | 0.46* | 0.35* | -0.37*
TKA 6M | 0.07 | 0.40* | 0.38* | -0.39*

Pearson Correlations with Weight Bearing Ratio
* p<0.05

Christiansen 2011
Potential Long-Term Implications

• The “good leg” becomes the “bad leg”
  • Contralateral strength decreases and pain increases
  • Contralateral strength and pain are the main contributors to function at 3 years

• 46% of patients will require a contralateral TKA in 3 years after their initial procedure

• Rates of Contralateral TKA by OA Severity at initial procedure
  • None – 5%
  • Mild – 20%
  • Moderate – 54%
  • Severe -93%

Shao 2013, Mont 1995, Farquhar 2010, Mizner 2005
Predicting Weight Bearing Asymmetry 1 month After TKA

Potential Predictors:
- Strength
- Strength Ratios
- ROM
- Pain
- Age
- Sex
- BMI
- Preoperative Weight Bearing

\[ WBA_1 = WBA_0 + \text{Quadriceps Ratio} + \text{Hamstring Ratio} \]

- **Preoperative** weight bearing asymmetry is a strong predictor of **postoperative** weight bearing asymmetry!
- Postoperative strength loss may also be related to learned disuse

Christiansen 2013
Effects of Weight-Bearing Biofeedback Training on Functional Movement Patterns Following Total Knee Arthroplasty: A Randomized Controlled Trial

TABLE 1

<table>
<thead>
<tr>
<th>Activity*</th>
<th>Weight-Bearing Biofeedback Progression Tasks (Games)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral stance</td>
<td>Static bilateral stance (ultimate balance challenge)</td>
</tr>
<tr>
<td></td>
<td>Mediolateral weight shift, basic (penguin slide)</td>
</tr>
<tr>
<td></td>
<td>Mediolateral weight shift, medium (skiing)</td>
</tr>
<tr>
<td></td>
<td>Multidirectional weight shift, basic (table tilt)</td>
</tr>
<tr>
<td></td>
<td>Above progression with foam placed on balance board</td>
</tr>
<tr>
<td>Unilateral stance</td>
<td>Unilateral stance (yoga: standing knee bend or tree pose)</td>
</tr>
<tr>
<td></td>
<td>Unilateral stance on foam (yoga: standing knee bend or tree pose)</td>
</tr>
<tr>
<td>Sit-to-stand</td>
<td>Self-paced squat (ultimate balance challenge)</td>
</tr>
<tr>
<td></td>
<td>Static squat (yoga: chair pose)</td>
</tr>
<tr>
<td></td>
<td>Dynamic squat (strengthening: rowing squat)</td>
</tr>
<tr>
<td></td>
<td>Above progression with a chair target and gradually increased depth</td>
</tr>
<tr>
<td>Lunging</td>
<td>Static lunge (yoga: warrior pose)</td>
</tr>
<tr>
<td></td>
<td>Dynamic lunge (strengthening: lunge)</td>
</tr>
</tbody>
</table>

*Patients were progressed within each activity as able.

Standard of Care Intervention (both groups)

<table>
<thead>
<tr>
<th></th>
<th>Inpatient Stay</th>
<th>Home PT</th>
<th>Outpatient PT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 days</td>
<td>2 weeks (6 sessions)</td>
<td>4 weeks (6 sessions)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weight-bearing Biofeedback (RELOAD group only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 weeks (12 sessions)</td>
</tr>
</tbody>
</table>
Performance on the FTSST and quadriceps strength improved to a greater extent in RELOAD and patients found the RELOAD intervention more motivating than traditional exercise.
Utilized a custom Wii balance board program, SymSlide, verbal/tactile cues, and progressive strengthening
2-3x/week for 6-10 weeks
Led to noted improvements in standing, sit to stand and gait
Limitations of Prior Studies

- Small sample size
- Short intervention period
  - Pronounced asymmetry still present at end of intervention
- Constraints of the Wii System
  - Lack of ability to give feedback during more dynamic activities such as gait and stair climbing
  - Lack of control over feedback schedule and mode of feedback (auditory, tactile, verbal)
  - Games are not rehabilitation specific
    - Score is tracked but not difficulty of task
    - Focus on BMI
    - Rating of ‘Unbalanced’
- Lack of incorporation of motor learning principles
- Unknown how this effects contralateral progression
Advances in Biofeedback Devices

Several companies now make commercially available, consumer-oriented biofeedback insoles

- RPM²
- Andante Smart Step
- OpenGo Science Moticon
- Novel Loadsol

Novel Loadsol (formerly Pedoped)

- Relative low-cost ($2500)
- Reusable and Durable
- Thin and flexible (works with orthotics and most shoes)
- Excellent app interface (iOS and Android) – patient friendly
- Very accurate (2-5%)
- Good data capture length (limited to device storage)
- Data processing built into the app (easy to use in the clinic and at home)
- Can alter feedback parameters (audio/visual, thresholds)
- Can utilize during dynamic activities and free-living environments
- Can assess real-time response to cuing strategies
- Can detect asymmetries not visual to the naked eye
Loadsol Example

815 N  445 N  370 N
Movement Pattern Biofeedback Training after Total Knee Arthroplasty – NCT03325062

Purpose:

1. To determine if the addition of a novel movement pattern training program (MOVE) to contemporary rehabilitation improves movement pattern quality more than contemporary rehabilitation alone

2. To determine if MOVE improves long-term physical function and lessens contralateral knee OA progression
Swelling after Total Knee Arthroplasty

Michael Bade, PT, PhD, OCS, FAAOMPT

Joel Carmichael, DC, PhDc

Brian Loyd, DPT, PhD
Why is Swelling Important?

- Major complaint of patients
- Related to the development of complications (DVT)
- Potential mechanism for arthrogenic muscle inhibition (AMI)
- Alters energy availability in muscle and can cause mechanical damage
- Related to pain, ROM, quadriceps strength, and functional performance

Rice and McNair 2010, Loyd in press
How can we measure it clinically?

- Volumetric?
  - Not realistic given wound healing and burden
- Circumferential?
  - Questions regarding reliability and validity
  - Can be confounded due to muscle atrophy and bandaging
- Ultrasound?
  - Questions regarding reliability and operator error
- Bioelectrical Impedance
  - High reliability (ICC > 0.80)
  - Good responsiveness (SEM = 2%)
  - Limitations – not joint specific and cost (~$2000)

Jakobsen 2010, Pichonnaz 2015, Loyd in review
What is “normal” swelling recovery?

• Can peak anywhere from POD1-7
  • Mean swelling – 36% increase

• Swelling can persist chronically
  • Mean swelling at POD90 – 10% above baseline
  • 26% at 3 years have felt swelling in the knee in the last 30 days

• Currently working on the development of personalized reference charts for swelling recovery

Pua 2015, Nam 2016, Loyd in press
Future Directions

• Multimodal Swelling Intervention
  • Use of an adjustable compressive garment
    • Circaid Juxtafit Essentials compression garment (20-50 mm gradient pressure worn during the day)
  • Use of frequent AROM/AAROM
    • 1 min of ankle pumps can increase blood flow for up to 30 minutes
  • Use of manual lymph drainage massage
    • Performed daily at home by patient
    • Effective at pain control
    • Unknown if effective at swelling reduction

• Will also examine the relationship between activity levels and swelling recovery
Funding
Physical Therapists

• Brian Loyd, Allison Gustavson, Jennifer Ivey, Jesse Christiansen

• Derick Levy, Kurt Schulze, Michelle Kochanek, Lacy Jennings, Jill Fortney, Susan Geidt, Lucas Armstrong,

• Lisa Bradford, Casey McNitt, Susan Ducklow, Dan Hartman, Lindsay Fairchild

• Karen Backstrom, Marisa Peyerl

• Patrick Kollmyer, Kevin Johnson, Keri Windels, Casey Stoneberger, Mitzy Burden, Brad Walters, Katie Carbiener, Lara Baum
# PhD in Rehabilitation Science

## What is Rehab Science?
- Interdisciplinary field of study
- Integrates knowledge from basic and clinical sciences
- Goal: to Improve our understanding of human movement, physical function, and disability across the lifespan

## The Work We Do
- Clinical rehabilitation trials
- Health services research
- Translational research
- Exercise science research
- Implementation science research

[www.rehabsciencephd.com](http://www.rehabsciencephd.com)
RESTORE

A collaborative team committed to optimizing movement and quality-of-life in older adults through innovative research and educational excellence

www.movement4everyone.com